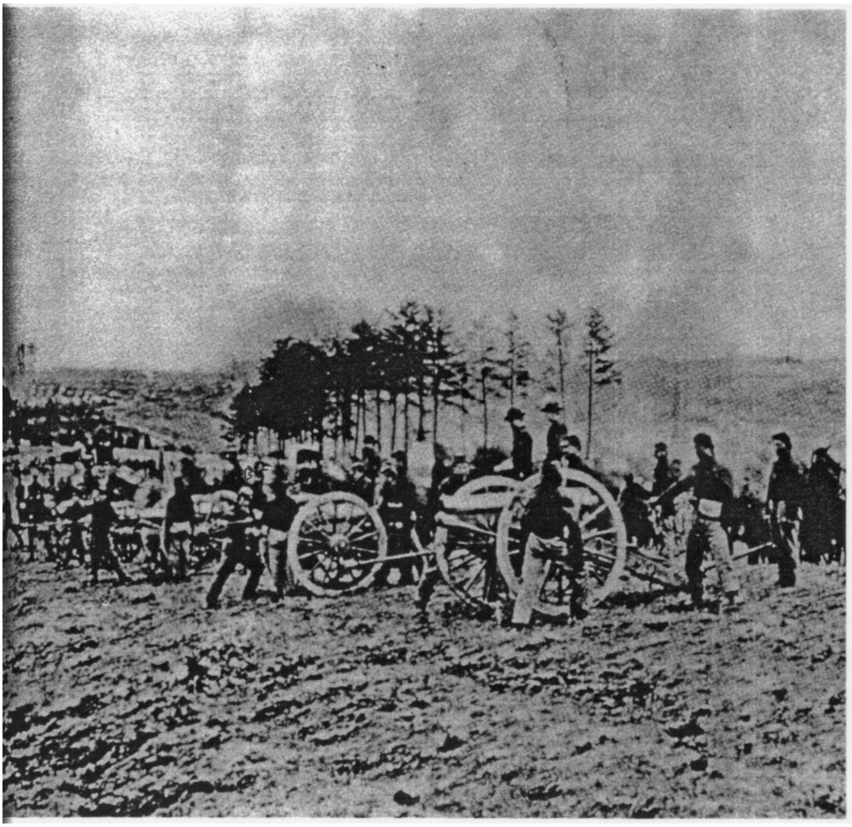
THE FIELD ARTILLERYMAN

(NAAPTB)



U. S. ARMY FIELD ARTILLERY SCHOOL

Fort Sill, Oklahoma

APRIL 1970

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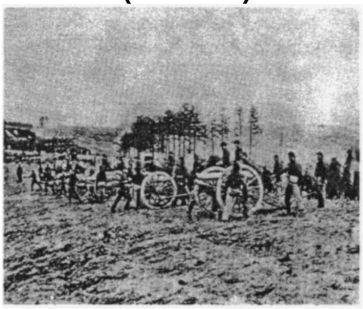

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On the cover of this issue of **THE FIELD ARTILLERYMAN** is the first known combat photograph of the U. S. Army. It shows a battery of Union muzzle-loaders preparing for action during the American Civil War. In contrast to this traditional pose of the field artillery, this issue features a diversity of articles about new field artillery equipment and techniques as well as new application of the old.

INSTRUCTIONAL AID NUMBER 45

THE FIELD ARTILLERYMAN

THE FIELD ARTILLERYMAN is an instructional aid of the United States Army Field Artillery School published only when sufficient material of an instructional nature can be accumulated. It is designed to keep field artillerymen informed of the latest tactical and technical developments in the field artillery.

In accordance with AR 310-1, distribution of **THE FIELD ARTILLERYMAN** will not be made outside the command jurisdiction of the School except for distribution on a gratuitous basis to Army National Guard and USAR schools, Reserve Component staff training and ROTC programs, and as requested by other service schools, ZI armies, U. S. Army Air Defense Command, active army units, major oversea commands, and military assistance advisory groups and missions. Paid subscriptions to **THE FIELD ARTILLERYMAN** on a personal basis may be obtained by qualified individuals by writing to The Book Store, US Army Field Artillery School, Fort Sill, Oklahoma 73503.

Primarily articles are prepared by individuals assigned to departments of the School or to field artillery units and agencies outside the School. All articles, no matter what the source, are coordinated with appropriate departments in the School and with the US Army Combat Developments Command Field Artillery Agency and the US Army Field Artillery Board collocated with the School at Fort Sill, Oklahoma. This coordination is effected in an effort to arrive at a "Field Artillery Community" position before publishing the information. The Field Artillery Community is Fort Sill's term for the center team concept of Continental Army Command, Army Materiel Command, and the Combat Developments Command. However the publication is prepared and distributed for information only. Nothing contained within it is to be considered directive in nature.

All readers of **THE FIELD ARTILLERYMAN** are invited to submit articles for publication, comment on previously published articles, or offer suggestions for the improvement of this instructional aid's content and format. Correspondence should be addressed to: Commandant, US Army Field Artillery School, ATTN: ATSFA-PL-FM, Fort Sill, Oklahoma 73503.

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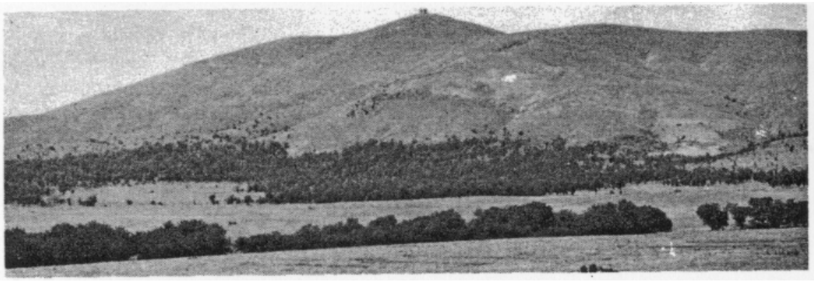
INSTRUCTIONAL DEPARTMENT NOTES



GUNNERY DEPARTMENT

BORESIGHTING WITH THE M1 COLLIMATOR

The U. S. Army Command Fire Control Maintenance Support Group at Frankford Arsenal, Philadelphia, Pennsylvania, has released information providing instructions for utilizing the infinity aiming reference collimator M1 as an emergency means of boresighting artillery pieces. The suggested procedure is as follows:

● Position the weapon so that the trunnions are level, as stated in chapter 38 of FM 6-70.

● Prepare the weapon for boresighting by installing the boresighting disk and muzzle crosshairs.

● Level the gun tube using the gunner's quadrant.

● Position the collimator M1 directly in front of the weapon, approximately 4 to 6 meters from the muzzle end of the weapon.

● Level and cross-level the panoramic telescope.

● Adjust the collimator until the crosshairs on the muzzle are alined with the zero index of the collimator reticle when viewed through the boresighting disk. It may be necessary to traverse the weapon slightly to aline both markings.

● Sight through the panoramic telescope and aline any numbered graduation with the same numbered graduation, using the proper side of both the telescope and collimator.

● Read the deflection. The deflection, as read on both scales or counters, should read 3,200 mils. If it doesn't turn the boresight adjustment shaft until 3,200 mils appears in the counter window.

This procedure is recommended for the following weapons:

Towed 105-mm howitzer M101A1 (TM 9-1015-203-12)
Towed 105-mm howitzer M102 (TM 9-1015-234-12)

Towed 155-mm howitzer M114A1, and auxiliary propelled M123A1 (TM 9-1025-200-12)

Self-propelled 175-mm gun M107, and self-propelled 8-inch howitzer M110 (TM 9-2300-216-20)

Self-propelled 105-mm howitzer M108, and self-propelled 155-mm howitzer M109 (TM 9-2300-217-20)

GRAPHICAL FIRING TABLES

Numerous units have expressed difficulty in obtaining the new slant scale GFT's due to a lack of formal authorization. This problem will ultimately be solved by the inclusion of these scales in all appropriate tables of organization and equipment (TOE). In the meantime, interim authorization has been granted by Department of the Army on DA message 916783, dated 17 July 1969, subject: Graphical Firing Scales, addressed to major commands. This message includes the Federal stock numbers (FSN) and TOE line item numbers (LIN) required for requisitioning the scales on DA Form 2765-1. All scales listed are in the supply system and are available for issue.

NONRESIDENT INSTRUCTION DEPARTMENT

TRAINING MATERIALS OFFERED

Training supervisors—unit commanders, operations officers, and other individuals concerned with training—who need a helping hand in obtaining training material for their instruction can receive assistance from the US Army Field Artillery School. The School publishes annually a Catalog of Instructional Material (unit, section, and staff training). The catalog identifies and describes materials prepared by the School that are available to support a wide variety of training needs and contains information on whom to contact to receive training materials and how to request materials. The training packets listed in the catalog include instructional material for 191 classes, covering approximately 550 hours of instruction in tactics and combined arms, communications, gunnery, artillery transport, guided missiles and target acquisition.

The Field Artillery School also provides a unique search-and-ship service for unit commanders and training officers who cannot locate the material they need in available indexes or catalogs. The unit commander or training officer may write to the Commandant, US Army Field Artillery School, ATTN: ATSFA-NIR, and state his requirements, to include a listing of subjects for which he needs training materials and an indication of the types of material he desires, such as lesson plans, special texts, and workbooks. At the Nonresident Instruction Department, education specialists will search the stocks of training materials and have those available shipped to the requestor.

The Catalog of Instructional Material may be requested from the Commandant, US Army Field Artillery School, ATTN: ATSFA-NIR, Fort Sill, Oklahoma 73503.

DIRECTOR OF INSTRUCTION

SKILL DEVELOPMENT BASE QUESTIONNAIRES

The Skill Development Base (SDB) Program was inaugurated to provide accelerated training of selected enlisted personnel in certain critical MOS skills, including 13B40, 13E40, 17B40, 17E40, 31G40 and 93F20. A field performance questionnaire, designed to improve the training program, is an integral part of the program. A questionnaire is placed in the 201 file of each graduate of the SDB course before he departs from the US Army Field Artillery School (USAFAS). The questionnaire is to be completed by the unit commander of the graduate—once after the graduate completes the on-the-job training of the program and again after the graduate completes 4 months of duty in his unit—and returned to the School.

At the present time only about 20 percent of these questionnaires are being returned from Vietnam. In an effort to improve this return rate, the Field Artillery School is using this medium to inform all field artillery commanders of this problem and to stress the importance that US Continental Army Command places on these questionnaires.

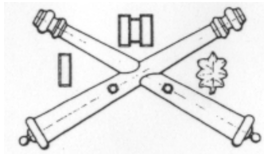
All field artillery commanders are asked to—

- Examine their personnel rosters and determine whether any of their personnel have been trained under the SDB program.
- Ascertain whether the performance questionnaires in the 201 files of personnel trained under the program have been completed and submitted.
- Complete questionnaires that have not been submitted and send them back to the Director of Instruction, USAFAS, in the envelope provided. Additional copies of the questionnaire may be obtained from the US Army Field Artillery School.

Commanders' evaluations of SDB course graduates on these questionnaires will assist the US Army Field Artillery School in providing optimum training of enlisted men under the SDB program.

RECORD ROTC COMMISSIONS

Over 16,000 new officers were commissioned from the U. S. Army Reserve Officers Training Corps (ROTC) during fiscal year 1969. This represents 60 percent of all Army commissions and a 20-year high. The figure exceeds FY 68 by 15 percent. The projected figure for next year is 17,500.

Career  *Memo*

COL Gordon Sumner, Jr.
Chief, Field Artillery Branch
Officer Personnel Directorate

As Chief, Field Artillery Branch, Officer Personnel Directorate, Office of Personnel Operations, I want to report to all field artillerymen regarding the Branch and its activities since the field artillery was separated from the air defense artillery on 1 December 1968. It is not my intention to bore you with figures and flowery prose but rather to hit some of the more important topics in the personnel field that might be of interest to all "Redlegs."

BRANCH SEPARATION

From the field artillery standpoint, the branch separation was smoothly accomplished and problems related to the separation during our first year have been minimal. We now wear the crossed field guns and can devote our full time and talents to providing the finest fire support possible.

UNFUNDED UNDERGRADUATE DEGREE PROGRAM NOW FUNDED

In January 1969, the Department of the Army introduced a new unfunded officer undergraduate degree program. This program allows selected career-oriented junior officers with between 3 and 7 years commissioned service to pursue a baccalaureate degree for a maximum of 2 years at civilian educational institutions. This program is limited and only applications solicited by the Department of the Army will be considered. Selections are highly competitive; the primary considerations are demonstrated manner of performance and indicated regular army potential. Heretofore, officers selected were assigned to the institutions on PCS (permanent change of station) orders and received normal pay and allowances to include PCS allowance. However, they did not receive tuition support. It is in this area that there has been a major breakthrough. Begining with the 1970 spring term, officers participating in the program will receive financial support in the matter of tuition, books, and other supplies. Therefore, the cost associated with the schooling will be borne by the Government beginning in 1970 and will certainly relieve the financial strain on our officers.

GROUND DUTY AVIATORS

As our flying Redlegs are probably aware, aviators are now being programmed into both military and civilian schooling. Additionally, a ground duty assignment for the field artillery aviator is now a distinct possibility. To those who felt that aviators would reach the grade of lieutenant colonel without having had ground duty, the recent decision to authorize category B assignments probably came as welcome news. Field artillery aviators should start boning up on their field artillery subjects to insure that they are prepared for ground duty. Our field artillery aviators also are expected to maintain their branch expertise.

TRANSFER OF WARRANT OFFICERS

Effective 1 January 1970, warrant officers in MOS 214E, FA missile system technician, Pershing, and 214F, FA missile system technician, Sergeant, were transferred to the Ordnance Corps. This transfer provides for centralized career management of the missile system maintenance career program. I'm sure that all field artillerymen join me in expressing our appreciation for the outstanding service the warrants have provided. We are fortunate that we will still continue to have their services even though they have exchanged the crossed field guns for the flaming pot.

REQUIREMENT FOR WARRANT OFFICERS

There remains an urgent requirement for warrant officers in MOS 211A, field artillery radar technician. Qualified enlisted technicians currently on Active duty with any of the armed services are encouraged to submit their applications to fulfill these worldwide needs. Qualifications for appointment to warrant officer, WO1. USAR, are outlined in Department of the Army Circular 601-27 and AR 635-100. If you are qualified and have been thinking about it. stop dragging your feet and submit your application. This program will not be open indefinitely.

REPETITIVE BATTALION COMMAND

In order to insure that the Army has the best possible leadership at battalion level, Department of the Army has initiated the repetitive battalion command program. Only officers who have demonstrated outstanding command ability subsequent to 1 June 1969 are recommended for second battalion-level command assignments. The program is well underway for field artillery officers. To date there have been 20 such assignments in Vietnam, 1 in Europe, 1 in Korea, and 2 in CONUS (continental United States). Prior to June 1970, 14 more are programmed in Vietnam, 1 in CONUS, and 12 in Europe.

JUNIOR OFFICER RETENTION

As of this writing, our crystal ball is cloudy. However, regardless of any possible force reduction that may be in the offing, the problem of junior officer retention will remain critical, with emphasis shifting from quantity to quality. The future of the field artillery depends on the success of our efforts.

SHORT TOURS

The outlook for short tour turnaround times is hazy at this time. Majors are presently being returned to Vietnam after 33-36 months in the sustaining base and captains after 22-24 months. Lieutenant colonels are not being involuntarily returned because of the number of volunteers. Any drawdown in Vietnam would greatly alleviate this situation.

LONG TOURS

The requirements for field artillery majors and captains in long-tour overseas areas have increased substantially. The increased requirements, and an insufficient number of volunteers for duty in these areas, have necessitated involuntary intertheater transfers of field artillery majors and captains upon completion of short-tour duty assignments. At present, Europe is significantly short of majors for duty in field artillery units. An assignment in Europe can be both professionally and personally rewarding as a follow-on tour from Korea or Vietnam.

BRANCH EXPERTISE

I cannot overemphasize the importance of maintaining branch expertise. Once you have reached the field grade ranks, branch-material assignments will be few and far between. You must seek this type of assignment whenever and wherever you have the opportunity. I assure you that maintaining your branch proficiency will improve your chances of gaining a battalion command and also improve your chances of successfully completing the assignment. You must be a qualified field artilleryman above all else.

You are urged to visit or contact the Branch whenever you feel that we can be of assistance. The officers of the Branch welcome inquiries, since they desire to maintain personal contact with field artillery officers. My door is always open to a Redleg.

———— ● ————

150th ANNIVERSARY OF ROTC

This year is the 150th anniversary of military instruction on civilian college campuses.

The 1969-1970 school year marks the anniversary of an American tradition—that of combining the development of officers for national defense with education for a degree in civilian institutions of higher learning.

This tradition began in 1819 with the founding of the American Literary, Scientific and Military Academy at Northfield, Vermont—now Norwich University. The anniversary also marks the beginning of what is now the Reserve Officers Training Corps (ROTC) program.

Battery Inspection Team

Brigadier General Allan G. Pixton
Commanding General, XXIV Corps, Artillery

It has been said that the war in Vietnam belongs to the junior officers and noncommissioned officers. Although this statement is intended to apply primarily to the maneuver forces of our Army, it applies in a lesser degree to artillery forces in Vietnam. Its application to the artillery is a result of the necessary geographic separation of the firing batteries of a battalion in order to provide the required fire support coverage for the maneuver forces.

The Vietnam war is primarily a battery war, as far as field artillery operations in XXIV Corps are concerned. The combination of extremely large areas of operations and relatively limited artillery assets has caused artillery commanders to decentralize their operations to the extent that firing batteries of all calibers normally function with fewer traditional battalion controls. Of the three major reasons for the emergence of the relatively autonomous battery—extreme variations in terrain, wide fluctuation in missions and large geographic separation between battalion elements—probably the most significant is the geographic separation. On a recent day a random sampling of XXIV Corps Artillery battalions presented this picture regarding distances between firing batteries and their parent headquarters: In one battalion one firing battery was 40 kilometers west, one was 9 kilometers north, and one was 12 kilometers northwest of the battalion headquarters; in another battalion all the batteries were at least 22 kilometers from the headquarters. Such distances effectively preclude massing the fires of the battalion and force the batteries to operate in a more independent manner in this conflict than in previous conflicts.

In effect, the battery has become the basic fire unit. This has tremendously increased the overall gunnery responsibility at the battery level, particularly in the area of fire direction. The battery has assumed many of the functions manually performed by the battalion fire direction center (FDC). The battery fire direction officer now plays an extremely critical role in the vital activities of his unit. His responsibilities are grave and his duties are demanding. He must have a thorough knowledge of gunnery theory; he must be master of the practical techniques peculiar to his environment and mission; he must be able to train his FDC personnel and detect and correct flaws in their performances; and, perhaps most importantly, he must be able to function efficiently and coolly under intense pressure.

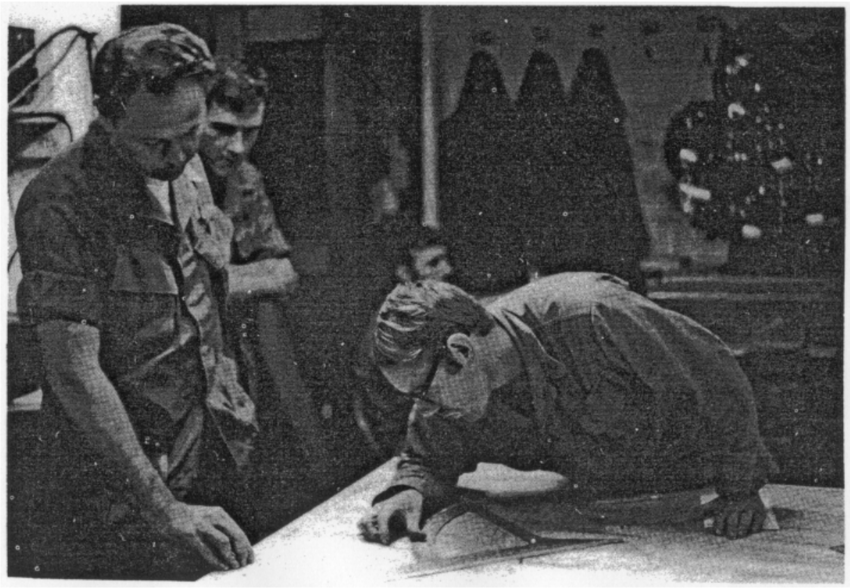


Figure 1. Firing battery inspection team chief observes FDC operations.

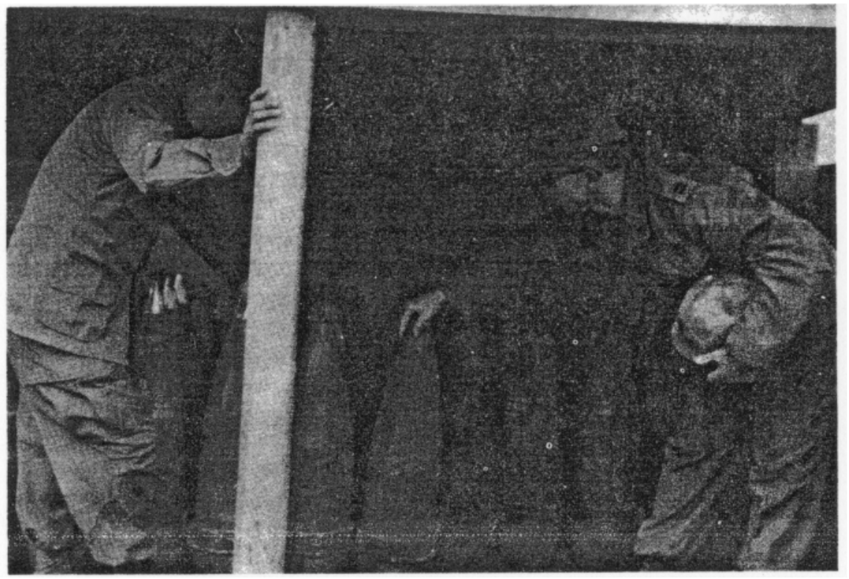


Figure 2. Team officer inspects ammunition storage with the battery executive officer.

The individual who is expected to possess these qualities and skills is a young lieutenant, an officer with perhaps 8 to 12 months of active commissioned service. He has attended the Officer Basic Course or Officer Candidate Course at Fort Sill and probably has served for a few months as a forward observer. It should be apparent that when he assumes the position of fire direction officer, he probably is not completely qualified to handle the manifold tasks and weighty responsibilities inherent in the post. He must gain experience, knowledge, and confidence before he can perform at the desired level of effectiveness. Some commanders try to solve the problem by seasoning a new battery fire direction officer in the battalion FDC for a short time. Although this is helpful, battery working conditions cannot be completely simulated, since the battalion FDC does not have primary responsibility for generating fire data; battalion FDC only provides a check of the battery's data. Other commanders attempt to have the battalion S3 supervise the new fire direction officer at the battery FDC until he approaches the requisite level of competence. This usually proves impossible in practice because of the workload of the S3 and the distance from the battalion to the battery.

The lack of experience of the young officers places an added burden on the battery commanders and the battalion commanders to insure that costly mistakes are avoided. By the same token, it is a wonderful opportunity for those commanders to train their young charges in the proper mold.

Recognizing this situation and wanting to increase and improve the technical gunnery proficiency of its units, XXIV Corps Artillery conceived and put into effect a plan that has proved remarkably successful in helping to overcome the experience gap. The heart of the plan is the firing battery inspection team (FBIT), formed in October 1968 and intended as a tool for evaluating a unit's gunnery procedures, practices, and techniques, as well as assisting the unit in areas of weakness.

The firing battery inspection team consists of two officers from the corps artillery S3 section: the assistant S3 for organization and training, who is team chief, and one of the other S3 section officers. The team visits each battery and each battalion FDC a minimum of once every 3 months; all inspections are scheduled completely at random. The team chief normally notifies the battalion S3 during the evening before one of his batteries is to be visited. The basis for inspection is a detailed checklist derived from the fire support annex to the corps SOP (standing operating procedures), FM 6-40, and other pertinent artillery publications. Whenever these publications are revised significantly, the checklist is also revised and current copies are disseminated to all XXIV Corps Artillery units.

A typical battery inspection unfolds as follows: The team arrives at approximately 0800 hours and briefly observes the battery position and orients the battery commander on what is to follow. For the next 7 or 8 hours, the team chief observes the operations of the FDC and the other team member observes the operations of the firing battery.

In the FDC, the team chief generally begins his inspection with a thorough check of the FADAC operations, to include such matters as operator proficiency, maintenance practices, and accuracy of input data. The team chief then examines the firing charts to insure accuracy and conformance to SOP, the situation maps to insure currency and accuracy of data, and the graphical equipment to evaluate operating conditions. If the FDC has received a meteorological message, the team chief observes the computation of met data and the application of the data to FADAC and graphical equipment. In all three areas, the inspector makes on-the-spot suggestions and corrections as required.

If the battery does not receive a live fire mission, the team chief gives the FDC a series of dry fire missions in order to evaluate personnel proficiency in various aspects of gunnery. The tasks may include precision registrations, including registrations with more than one ammunition lot, computation of orienting data for 01 and 02, high-burst and mean-point-of-impact registrations, danger close fire, computation of sheaf corrections for particular circumstances, use of the M10 plotting board, and firing procedures peculiar to the battery being inspected, such as high-angle fire or coordinated illumination. If a live fire mission is received during this phase of the inspection, the team chief immediately stops the practice missions and observes the FDC personnel as they respond to the call for fire. Again, the inspector makes suggestions and corrections as required.

Meanwhile, the second member of the FBIT team is observing activities at the firing battery sector of the gunnery team. He examines the performance of the executive officer and the chief of firing battery, checking their knowledge of SOP's and good gunnery procedures. He verifies the date of the most recent declination of battery aiming circles, checks the accuracy of lay of the pieces, and checks the accuracy of the orienting line. He inspects the individual gun sections, examining each chief of section on such matters as safety procedures, cutting and disposing of powder charges, standardization of ammunition storage, and night firing procedures. He also checks the accuracy of each weapon's self-defense data and its integration into the battery defense plan of the fire support base.

Upon completion of the inspection, the team presents an informal exit critique to the battery officers. The team then prepares a formal

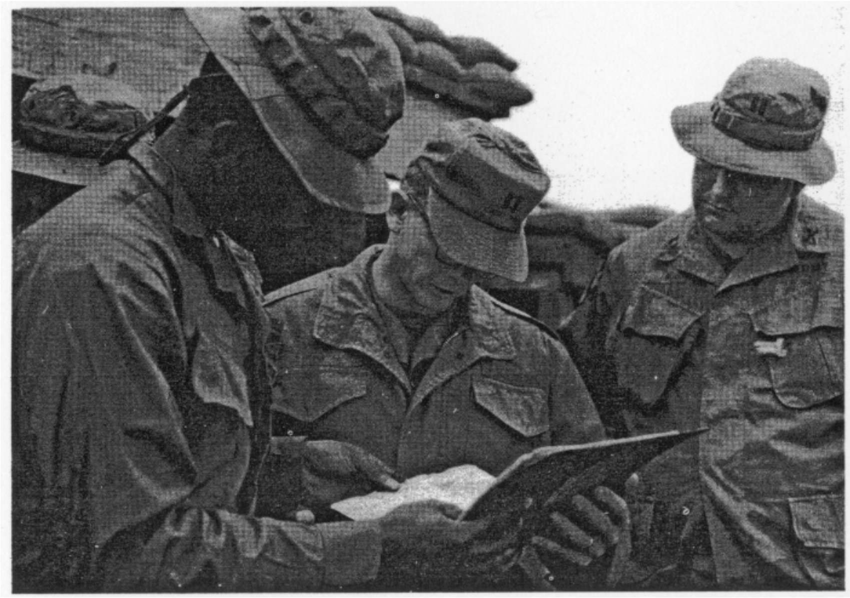


Figure 3. Team officer conducts final critique with inspected battery officers and senior NCOs.

written report, outlining proficient and deficient areas and making suggestions and recommendations. I personally review each report and make comments as appropriate for excellence of achievement and for below standard performance. The report is then forwarded to the unit through its battalion. A reply by indorsement is not required unless an unsatisfactory condition exists.

From the beginning, the emphasis of the FBIT system has been placed on helping the unit to learn where its weaknesses are and, most importantly, how to correct those weaknesses and to improve the capabilities of the unit. This emphasis is extremely important and has contributed immeasurably to the success of the system.

The visits of the corps artillery firing battery inspection team have resulted in the following tangible accomplishments: They have provided data for commanders to measure the effectiveness of units from one visit to the next; they have disseminated valuable empiracal data throughout the corps artillery; and they have caused all corps artillery units to standardize their gunnery practices so that, in effect, all units play their deadly tunes from the same sheet of music.

Initially, the firing battery inspection team visited only units assigned or attached to the XXIV Corps Artillery. However, when the benefits derived from the visits became known, artillery units outside XXIV Corps Artillery expressed keen interest in the program. As a result, the team now inspects all artillery units in the corps area of operations, including U. S. Marine units and Republic of Vietnam units.

With the recent emphasis on strengthening and modernizing the ARVN forces, the role of the firing battery inspection team has taken on new importance. Because it has access to established procedures and tested techniques, as well as the most useful and successful innovations, the firing battery inspection team imparts to ARVN artillery units valuable information and guidance which is not available to them through any other means.

The XXIV Corps Artillery firing battery inspection team has earned its spurs in a combat environment. As it carries out its mission of evaluating unit gunnery procedures, practices, and techniques, it contributes significantly to the ability of XXIV Corps Artillery to deliver timely and devastating fires on the enemy.

NEW BATTERY DEVELOPED

A new long-life, high-energy battery has been developed by the U. S. Army Electronics Command. The battery is recharged simply by dropping flat, zinc-air cells into a slightly altered battery case and then adding water. The battery powers lightweight combat equipment such as radios, front line radars, and night vision devices.

CPT David W. Hazen
Gunnery Department
USAFAS

A product improvement effort to provide greater tube life for the 175-mm gun has resulted in the use of a metal-strengthening process known as autofrettage. This process is not new. It was used extensively by cannon manufacturers from early in the 20th century until the end of World War II. After the war, however, metallurgical advances resulted in such increases in gun tube strengths that the autofrettage process was considered unnecessary and impractical.

Increased range and requirements for less weight in current and future weapons have brought about a resurgence in the technology of autofrettage application. Coupled with the use of stronger metals, the autofrettage principle allows gun tube design of greater yield strength than ever before thought possible. Most cannons developed since 1959, to include those on the M102, M108, M109 and M109E1, use this process. Initial development of the 175-mm gun tube did not utilize the autofrettage process because erosion of the tube was the primary cause of the short tube life. With the advent of the M1 wear-reducing additive jacket, erosion was minimized and metal strength became the dominant consideration in determining tube life. The autofrettage process is now being applied to the manufacture of the 175-mm gun tube to extend service life without an increase in weight or bulk.

The new autofrettage gun tube, designated M113E1, has been designed specifically to provide a greatly increased safe fatigue life in order to make full use of the wear life obtainable with the M1 wear-reducing additive jacket. This improved 175-mm tube is identical in interior dimensions and ballistic performance to the present M113 tube and is interchangeable with it in the M107 system.

The M113E1 tube should alleviate one of the largest problem areas of the 175-mm gun; that is. of the operational and logistical problems associated with the short tube life. However, unless the characteristics of the autofrettage tubes and the ramifications of using autofrettage versus nonautofrettage gun tubes are understood, the new tube's introduction into the field could add to the confusion that already exists. Hence the purpose of this article is to summarize some of the service life considerations of the standard tubes and the new autofrettage tubes.

Since the distinction between metal wear and metal fatigue is vital to any discussion of cannon tube life, the reader should understand the correct use of these terms. Both accuracy and safety are primary considerations in determining the serviceable life of a gun tube. The amount of interior metal erosion, caused by hot gun gases and abrasion from proiectile movement, directly affects the degree of range dispersion. Fatigue life, on the other hand, is primarily a matter of safety. It involves determining when firing weakens the metal to the point that the probability of metal failure becomes unacceptably high. Since wear and fatigue are variable according to charge, a scale has been developed to relate the effects of other changes to a single charge, which is designated an equivalent full charge (EFC). This EFC is assigned a value of 1.00, and all other charges are factored to it. The number of EFC rounds at which either wear or fatigue becomes unacceptable is designated as the maximum service life and the point at which the tube must be condemned.

Other attempts to improve service life have not been nearly so successful as has autofrettage. Many artillerymen remember the chrome-plated 175-mm gun tube. The chrome-plating process resulted in less wear per round fired until the plating wore off, but did nothing to relieve the metal fatigue problem. Thus, this expensive plated tube was dropped in favor of the present unplated tube. Both the plated tube and the present unplated tube are designated the M113 and are differentiated only by part number. The use of the same designation for both tubes and the lack of authoritative information in the field about the differences in the tubes has resulted in some confusion. The service life condemnation criterion for both tubes is the same but the wear characteristics and resulting muzzle velocity loss pattern of the tubes are quite different. This is due to the effect of the chrome-plating on wear.

It should be pointed out that the muzzle velocity loss chart in FT 175-A-O (Rev II), Feb 65, is for the plated tube and does not consider the use of the M1 additive jacket. The table is not valid for the unplated tube. Specific EFC wear versus muzzle velocity loss data is being developed by U. S. Army Ballistic Research Laboratories for the unplated tube, to include the effect of the additive jacket. This data will be included in the next revision of the 175-mm firing table (FT 175-A-1), which is scheduled for distribution shortly.

The following tabulation of wear and velocity loss per number of EFC rounds is useful as a comparison of the two M113 tubes. (It is emphasized that the figures for the unplated tube are preliminary and subject to revision).

	Chrome-plated M113 without M1 additive jacket		**Unplated M113 with M1 additive jacket**	
EFC rounds	**Wear (inches)**	**MV loss (meters per second)**	**Wear (inches)**	**MV loss (meters per second)**
0	0	0	0	0
100	0.001	0.1	0.006	6.7
150	0.015	1.4	0.085	9.4
200	0.067	6.4	0.102	11.3
250	0.117	11.4	0.112	12.2
300	0.151	14.7	0.122	13.4
350	0.178	17.4	0.130	14.3
*400	0.200	19.5	0.138	15.2

*Present maximum service life.

Note the negligible wear in the chrome-plated tube for the first 100 rounds. Once the chrome-plating has worn off, however, the wear and muzzle velocity loss then accrue at a much more rapid rate than in the unplated tube with the additive jacket. Although the wear limit is 0.200 inch for both tubes, it is never reached in the unplated tube when the additive jacket is used. As will be seen later, it is this additional wear life, from 0.138 inch to the allowable 0.200 inch, that the autofrettage tube makes use of.

Use of the additive jacket reduces the muzzle velocity of each round by 2 meters per second, which must be compensated for in firing data computations. This phenomenon has been interpreted by some as detrimental and, as such, a reason for not using the jacket. However, the savings in wear from use of the jacket make up for this 2-meter-per-second loss well within the first 250 EFC rounds.

The present M113 tube (plated and unplated) service life criterion is only 400 EFC rounds or 300 zone 3 rounds. However, this is based on a safe fatigue life rather than on tube wear. Since the M113E1 tube is considerably strengthened by the autofrettage process, metal fatigue is no longer the governing condemnation criterion. Tube service life is extended and is based on actual wear rather than on anticipated fatigue safety limit, and the charge 3 limitation is removed. This is portrayed graphically in figure. 1.

The strength potential is illustrated by a statistical analysis of the fatigue results from preliminary tests of four prototype tubes. The analysis, which included fired rounds plus laboratory cycles to failure, resulted in a safe fatigue life prediction (with a 0.999 reliability and 90 percent confidence level) of 2,350 EFC rounds.

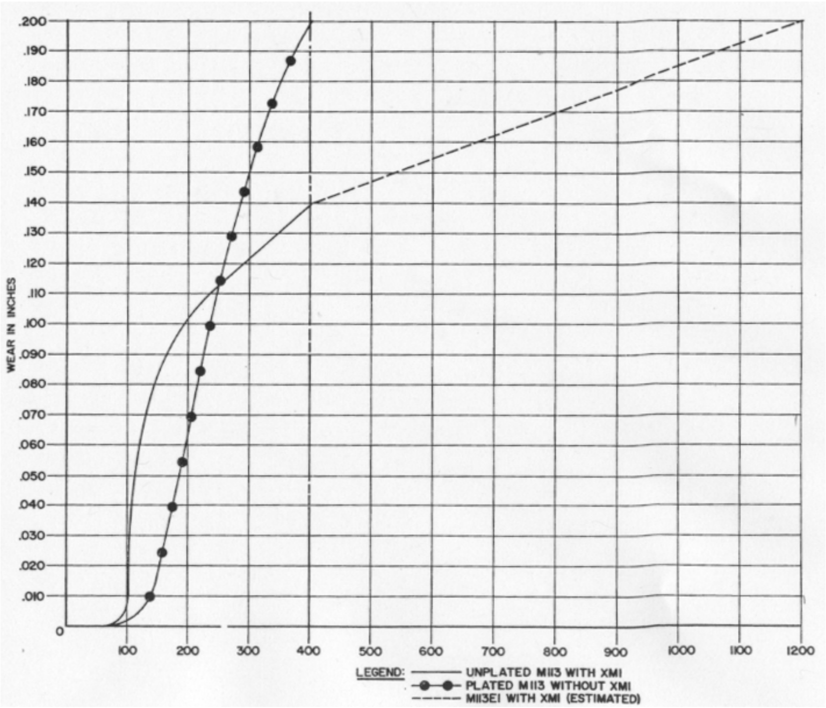


Figure 1. Tube life in EFC rounds.

Experimentation with the autofrettage process, development of the M113E1 gun tube, and management of the overall project have been underway for a number of years at Watervliet Arsenal for U. S. Army Weapons Command. Twelve of the new tubes (M113E1) were airlifted to the Republic of Vietnam in May 1969 for tube life evaluation. Testing in Vietnam is merely an expedient and has nothing to do with environmental or operational considerations. This test consists of normal combat firings with wear measurements being taken until the tube wear condemnation criterion of 0.200 inch is reached and a final number of EFC rounds determined. Thus, the full effect of the improvement will be realized only after completion of the evaluation of the test. The interim tube life rating assigned by the Weapons Command is 700 EFC rounds.

To date, firing has been completed with 8 of the 12 tubes. From the preliminary results, it is estimated that at least 1,200 EFC rounds will be a realistic service life expectation. Six of the first eight tubes exceeded this by attaining 1,228, 1,254, 1,270, 1,317, 1,330 and 1,534 EFC rounds within the 0.200-inch wear criterion. The other two were condemned at 744 and 1,040 rounds but both had fired a large number of charge 3 rounds without the M1 additive jacket. After the test, the 12 tubes will be returned to Watervliet Arsenal, where further metal fatigue tests will be conducted.

The considerably fewer EFC rounds attained when the additive jacket was not used illustrates the most important consideration with the M113E1 tube. The previous EFC values of 1.00 for zone 3 and 0.24 for zones 1 and 2 were used in service life computations based on fatigue life, regardless of whether or not the additive jacket was used. When the additive jacket is used with zone 3, the wear effect is reduced to approximately 0.35 EFC. Since fatigue life is normally reached before wear life with the M113 tube, some units fail to realize the value of the additive jacket. Its use is important in minimizing wear in present tubes and takes on added importance with the M113E1, since its service life is based on wear. Although specific EFC values are still to be determined for the M113E1 tube, the ratio of 3:1 wear for nonuse versus use of the additive jacket is expected to remain valid. In this case, a fatigue life EFC of 1.00 would hold for all zone 3 firings but an EFC value of approximately 3.00 would have to be assigned each zone 3 round fired without the additive jacket for service life computations. Even while realizing the importance of the additive jacket, some 175-mm gun units have been forced to fire zone 3 without the additive jacket—either because of lack of time due to a combat emergency or simply because the jacket was not available. There is a U. S. Army Munitions Command proposal to package charge 3 with M1 additive jacket already assembled in future M86A2 propellant production (fig 2). This should eliminate the problem of nonuse once present stockpiles are depleted.

As mentioned before, the chrome-plated and unplated M113 tubes can only be identified by part number—8767223 for the plated tube and 11577719 for the unplated tube. The designation of the autofrettage tube, M113E1, will be stamped on the tube. The autofrettage tube may also be distinguished by the stepped appearance of the muzzle as opposed to the bell shape of the muzzle of the standard M113. This difference is illustrated in figure 2.

All future 175-mm gun tubes will be produced by the autofrettage process. New production M113E1 tubes will be stockpiled at depot and issued only when the present M113 supplies are exhausted, thus minimizing the problem of having two types in the field at the same time.

So although field artillerymen may continue to debate the relative merits of the 175-mm gun, those who argue in its favor are certainly gaining ground with each improvement. And while the debate goes on, the 175 continues to provide the long-range killing power for which it was intended.

175-mm GUN IDENTIFICATION
MUZZLE ENDS

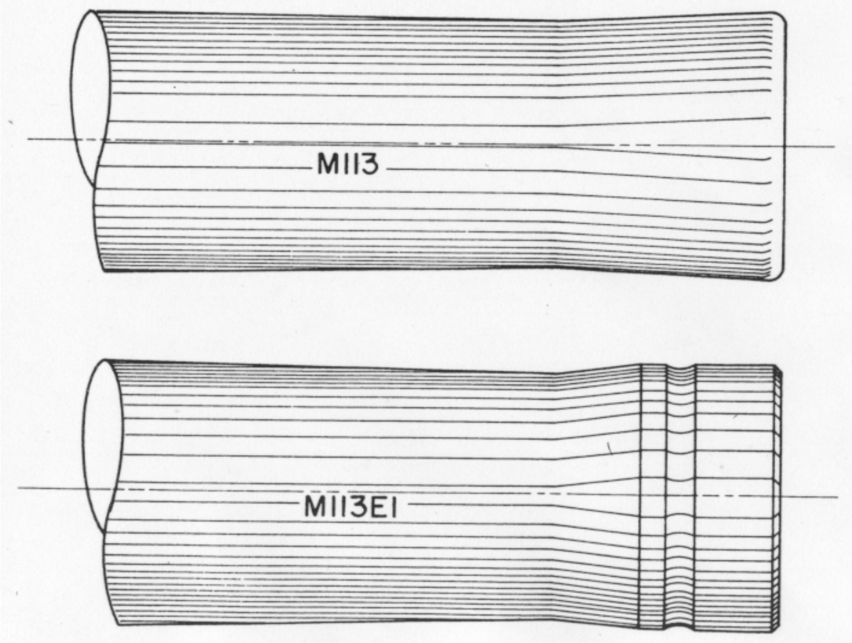


Figure 2. Muzzle ends of 175-mm gun tubes.

FAMSEG–What Is It?

LTC John A. Zalewski
CO, USAFAMSEG

The U. S. Army Field Artillery Missile Systems Evaluation Group (USAFAMSEG), known as "FAMSEG" by field artillery missilemen the world over, is a small, unique, highly skilled unit with a unique mission.

FAMSEG's mission, simply stated, is to provide technical assistance to field artillery missile unit commanders, at their request. FAMSEG renders evaluations of performance of a field artillery missile unit in preparing guided missiles for flight, and launching them to arrive on target at designated times. FAMSEG provides interested agencies with data on missile systems malfunctioning, human engineering problems, and other design deficiencies.

USCONARC Regulation 350-47 outlines the services performed by, and the procedures for requesting assistance from, the U. S. Army Field Artillery Missile System Evaluation Group.

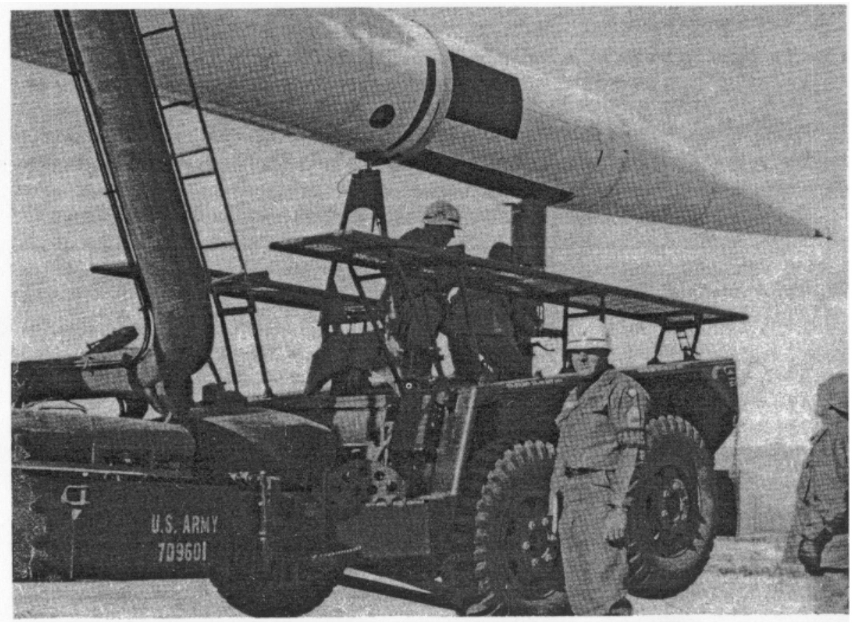


Figure 1. FAMSEG personnel evaluate pre-launch exercises prior to the firing of a Sergeant at White Sands Missile Range, New Mexico.

The USAFAMSEG is qualified to render assistance by providing—

- Technical umpires and evaluators for missile unit Army training tests and operational readiness tests.
- Technical evaluators for missile unit annual service practices and other missile firings.
- Technical assistance visits to units for the purpose of inspecting missile operations and reporting to the unit commanders on the technical proficiency of missile crewmen, on adherence to the technical procedures required by manuals and other directives, and on the maintenance and operability of missile-peculiar equipment.

USAFAMSEG performs other functions as follows:

- Furnishes the artillery test director for field artillery missile firings conducted within CONUS. The artillery test director provides the tactical control and coordination for artillery-ordnance firing programs, to include preparing firing plans, supervising tactical range operations, and writing and disseminating unit evaluations and tactical firing reports.
- Provides teams trained in the operating procedures for employment, checkout and firing of field artillery missiles for the following purposes:

  Providing on-call assistance to field artillery missile units during Army training programs (worldwide).

  Acting as umpires for operational readiness tests, Army training tests, annual service practices, and graduation firings as requested (worldwide).
- Provides assistance teams trained in maintenance procedures to include support functions, troubleshooting, and repair and checkout of missile assemblies and ground support equipment through general support maintenance.
- Assists the U. S. Army Field Artillery Board, the U. S. Army Field Artillery School, and other commands and technical agencies in their tests.
- Forwards to the appropriate agency for coordination/action recommendations regarding organization, tactics, techniques, doctrine, instruction, training literature, technical procedures, product improvement, and developmental matters pertaining to field artillery missile systems.
- Conducts conferences to include prefiring conferences and prepares tactical firing directives for each series of missile firings.
- Provides representatives or observers on missile committees for the U. S. Army Field Artillery Center and Fort Sill (USAFACFS) and other senior headquarters as directed.
- Prepares studies, plans, and informational material as directed.
- Represents USAFACFS at missile conferences as directed.
- Coordinates on USAFACFS inputs to operational requirements documents and program requirements documents.
- Updates artillery-ordnance firing plans in coordination with the technical test director and support agencies.

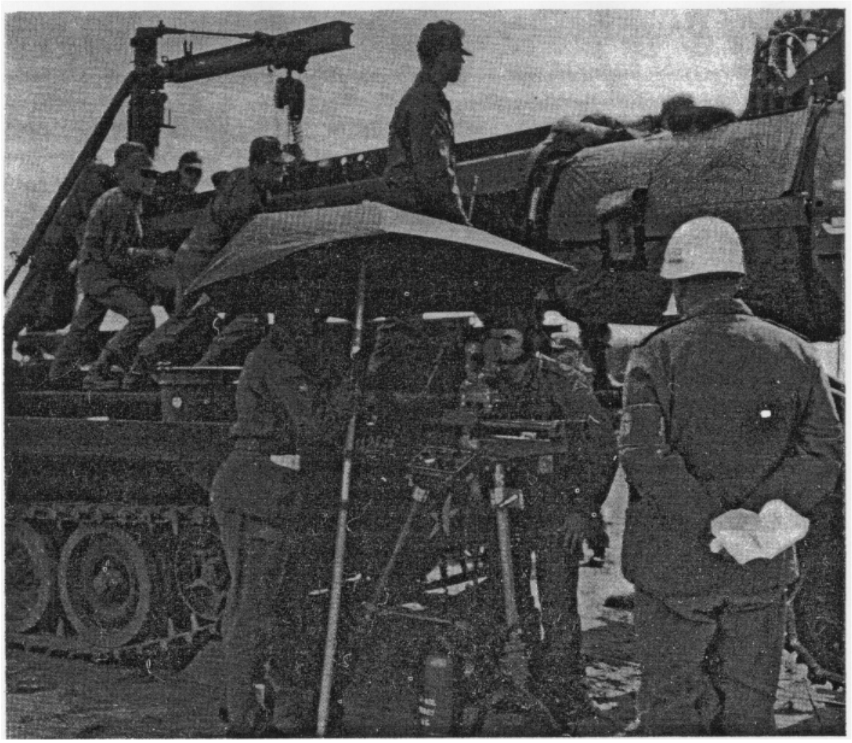


Figure 2. FAMSEG warrant officer observes pre-launch activity of Pershing crew at Gillson Butte, Utah.

The commanding officer of USAFAMSEG acts as the Fort Sill missile operations officer under the general supervision of the assistant chief of staff, G3. As missile operations officer, his principal duties are to effect liaison between the Fort Sill general staff and the Field Artillery School, the Field Artillery Training Center, missile unit commanders, technical agencies, contractor representatives, and other supporting agencies on Field Artillery Center missile matters and to take appropriate action on missile-peculiar requirements from off-post agencies and correspondence from higher headquarters.

FAMSEG performs its mission on a worldwide bases. Sergeant missile teams have evaluated firings in the Hebrides Island, Scotland, on the Island of Crete, at White Sands Missile Range in New Mexico and at Tyndall Air Force Base, Florida. In addition, a Sergeant team has acted as technical umpires for a battalion annual training test conducted somewhere in the Pacific Theater. Sergeant teams have provided technical assistance to U. S. Army Europe and U. S. Army Southern European Task Force at their request.

Pershing missile teams evaluate firings conducted by USAREUR Pershing battalions and the Fort Sill battalion at CONUS launch complexes in Utah and New Mexico. Pershing missile teams have also been called upon for technical assistance visits in Europe. In addition, Pershing teams assist the Federal Republic of Germany Pershing missile units during their annual firings.

Since its inception in 1954, FAMSEG has provided assistance to commanders at every level by evaluating the technical proficiency of their missile units. In particular, FAMSEG has provided continuity and standardization during the activation, training, testing, and deployment of missile units. This was particularly important during the difficult years of transition from first- to second-generation systems and it is anticipated that this will continue to be important as newer and better missile systems are produced.

FAMSEG is staffed with carefully selected personnel; all are graduates of missile courses conducted by the Guided Missile Department, U. S. Army Field Artillery School, Fort Sill, Oklahoma, and the U. S. Army Missile and Munitions School, Redstone Arsenal, Alabama. They have served one or more tours of duty with missile units in CONUS and overseas. All FAMSEG personnel are highly skilled professionals and recognized experts

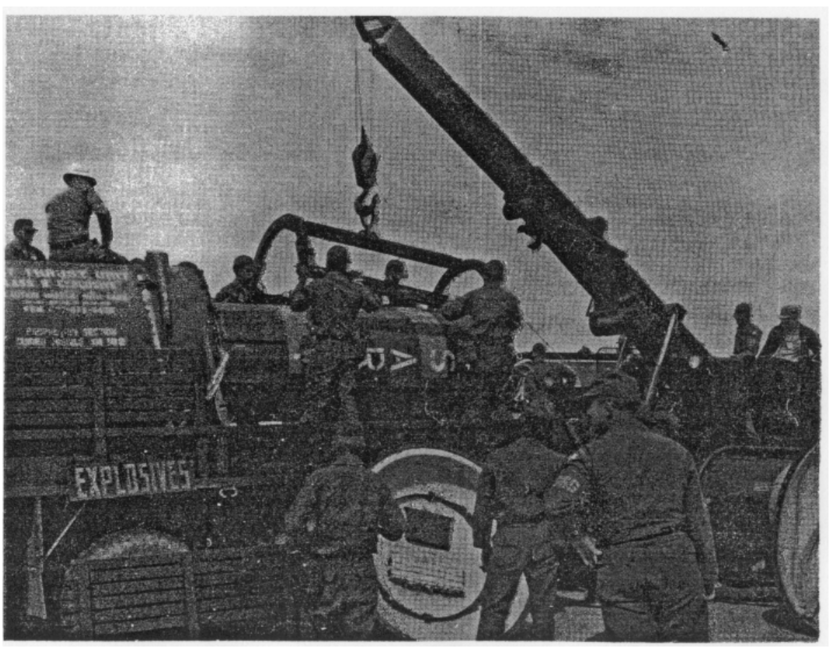


Figure 3. Pershing crew mounts the warhead as FAMSEG personnel evaluate.

on all missile subjects. They possess the latest information on training procedures and are able to detect errors or irregularities committed during crew drill. And, in the words of the chief of the Pershing Operational Test Unit in Europe, "*** only personnel conducting evaluations as a principal duty can develop the technique of monitoring and evaluating that are generated within a unit of this type. A polished technique can be almost as important as the facts developed when the total effect of an inspected unit is assessed ***."

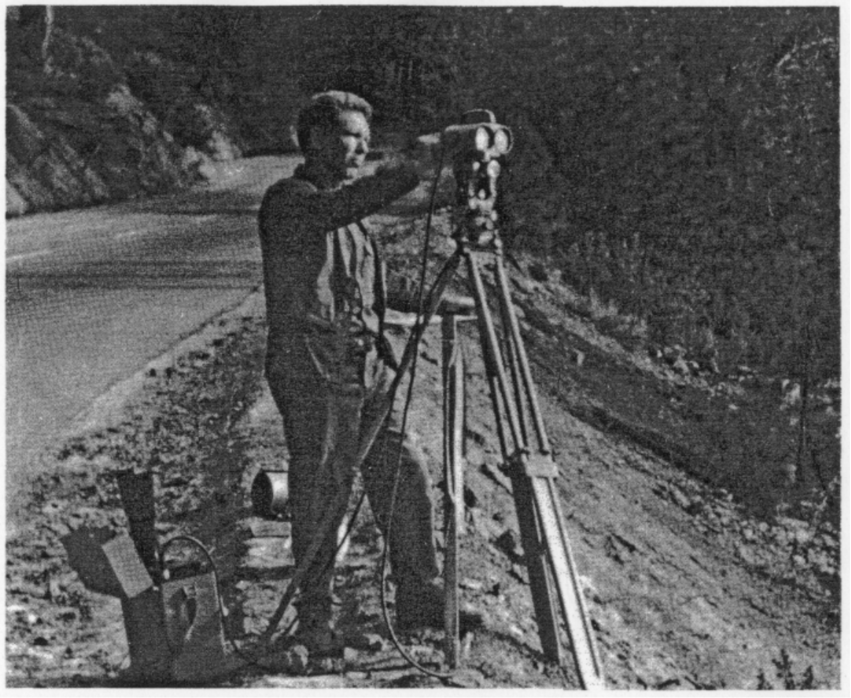
A letter from the U. S. Army Combat Developments Command Field Artillery Agency stated:

> The Combat Development Evaluation Program is not allocated the resources to conduct live missile firings for experimentation or troop testing. Nevertheless, USACDC requires data from live firings by troops for accomplishment of its evaluation responsibilities with regards to missile systems, as much as, if not more than, it does with regard to other materiel, organizational and doctrinal matters. Without FAMSEG, adequately representative of the User, USACDC would have to rely upon reports of the developer for evaluation of Annual Service Practice and their live firings of fielded missile systems. This agency's past experience in such evaluation has indicated that the reports of the developer often attribute system malfunctions to troop errors, whereas FAMSEG's reports call attention to human engineering or other design deficiencies as the true sources of the same malfunctions.

FAMSEG brings much experience and impartiality and a highly proficient organization to the task of representing the user's viewpoint in evaluating both fielded and developmental field artillery missile systems.

SPIW RIFLE TESTS

Prototypes of the U. S. Army flechette-firing Special Purpose Individual Weapon (SPIW) are being fabricated for engineering design tests at Aberdeen Proving Ground and Fort Benning this year. The SPIW is able to fire fully automatic, in control bursts of three rounds, or single shots. It is being developed to increase the firepower and hit probability of the individual soldier.



A Survey Instrument Of the Future-Now

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The technology of distance measurement has taken giant steps in the past two decades. Prior to the 1950's the only practical method of accurately measuring a distance was with a tape. Measuring distances by laying a steel tape end over end over terrain, which is usually irregular, is a costly and time-consuming process. In the not too distant future this method of measuring distance will belong to the past and, hopefully, the trusty steel tape will find its place in the museum along with other obsolete instruments.

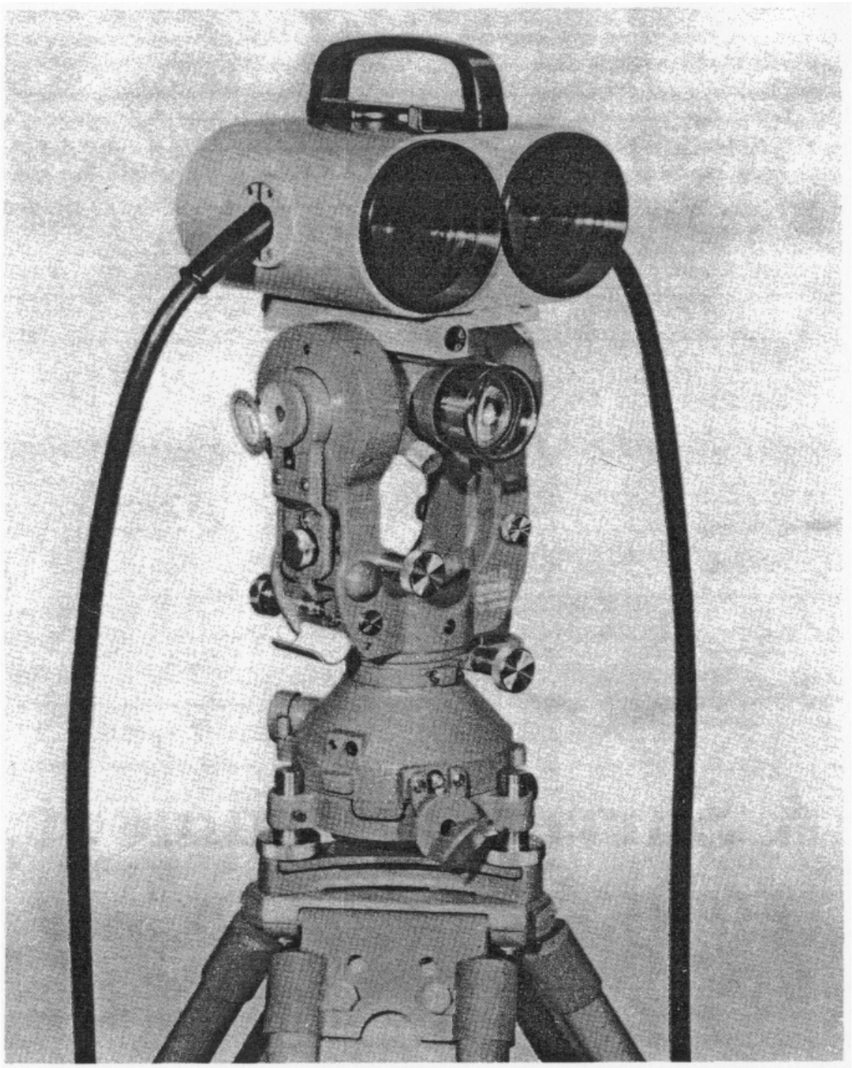

Figure 1. Aiming Head.

In the late 1950's microwave distance measuring equipment (DME) was introduced into the US Army inventory. Microwave distance measurement was a boon to medium- and long-range surveys. But since the DME is neither economical nor efficient at short ranges, traverse by steel tape has remained common in the field artillery. In fact, at lower echelons all distances are still measured with the 30-meter steel tape.

For several years, instrument manufacturing companies have been aware of the tremendous demand that exists for a distance measuring device that can efficiently measure short lines. Studies by the Wild Instrument Company of Switzerland revealed that the large majority of ordinary traverse legs are under 500 meters. This study also revealed that 1,000 meters is usually the limit to which a traverse leg can be run without time-consuming reconnaissance and special targets or beacons.

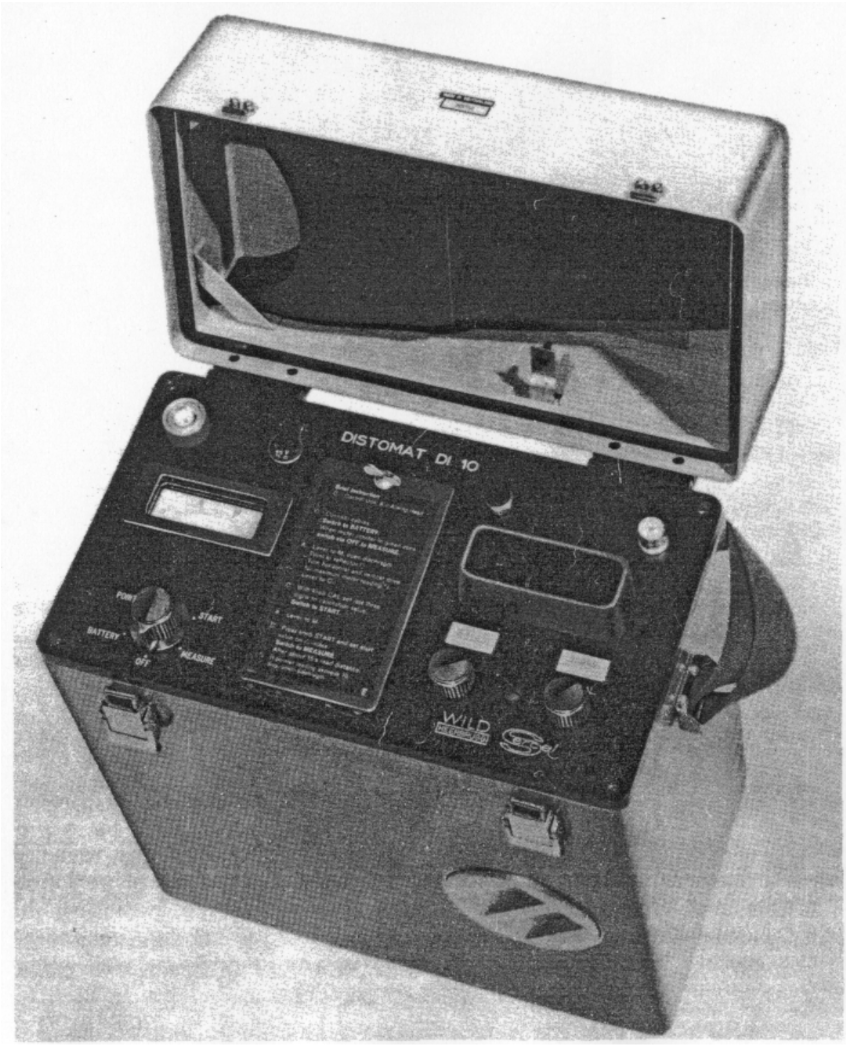

Figure 2. Instrument package.

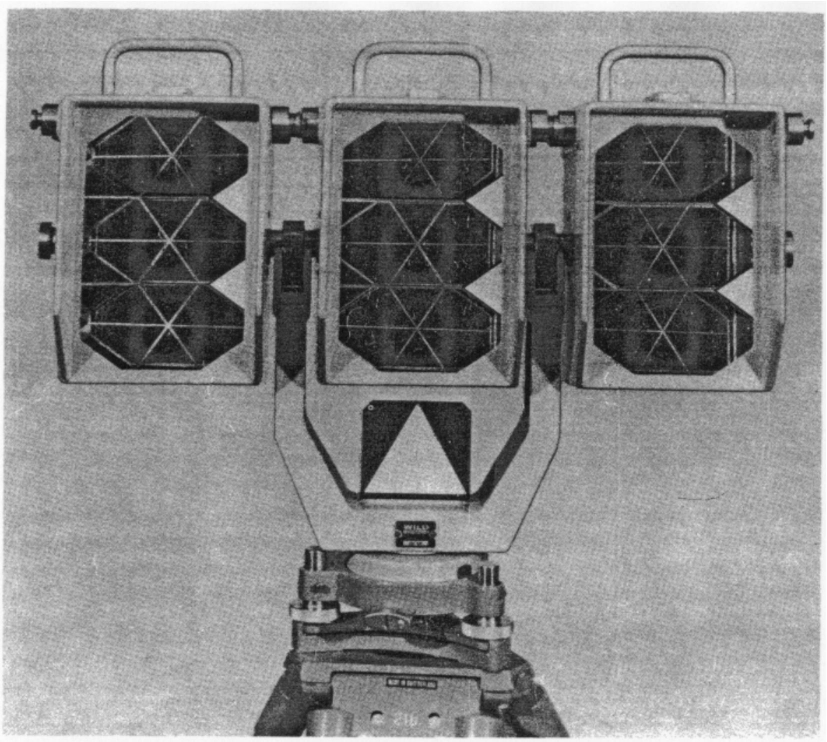

Figure 3. Reflector Prism.

At greater distances the DME is efficient and effective; at lesser distances another instrument is needed to efficiently measure distances.

A number of instrument companies have been working toward developing a distance measuring instrument that would measure distances more efficiently up to 1,000 meters. The Wild Instrument Company has successfully developed such an instrument and is currently marketing a production model.

The instrument developed by Wild is the D1-10 distomat. A distomat was sent to the U. S. Army Field Artillery School in July 1969 for a preliminary evaluation. This evaluation lasted about 60 days and revealed that the distomat has the potential of decreasing the number of personnel in a standard traverse party by at least two men while increasing the speed of the party by approximately 50 percent or greater, depending on the terrain. The accuracy of the distomat was found to be well within the requirements for all field artillery surveys.

Basically, the D1-10 distomat consists of three main components—the electronics package, the infrared aiming head, and the reflecting prisms. The single prisms mounted on a range pole can be used as a reflector for distances up to about 400 meters; for longer distances the tripod-mounted prisms are used. In measuring distances, a modulated infrared beam is emitted by the aiming head toward a reflecting prism. The beam is reflected by the prism back to the aiming head. The phase shift of the modulation, which is proportional to the distance between the aiming head and reflector prisms, is continuously measured. The length of the measured line is displayed by the electronics package, in meters. No computations are required as the displayed distance is of sufficient accuracy to meet artillery requirements. Humidity, which has a considerable effect on microwave distances, has little effect on the distomat, because it uses light in measuring. Hence, it is not necessary to apply meteorological corrections to meet artillery survey accuracies.

Distances up to 1,000 meters can be measured during periods of low visibility, provided sufficient visibility exists to make the sighting on the reflector. Electronic interference, which often interferes with DME operations, has no effect on the distomat.

The total time required for one measurement is about 1 minute, including pointing. Because of the use of solid state components, no warm up time is required. The distomat aiming head is attached to a 0.002-mil theodolite. This is a very convenient arrangement, essentially converting the standard theodolite to a distance measuring as well as an angle measuring instrument. The following technical data pertain to the distomat:

Measuring range .... 0 to 1,000 meters
Mean error .... ± 2 centimeters
Transmitter power .... 1.2 milliwatts
Power consumption (measuring) .... 10 watts
Time required for one measurement,
including pointing .... 60 seconds maximum
Power source .... 12-volt rechargeable internal nickel-cadmium battery
Number of measurements with fully charged
battery (at approximately 70° F) .... About 200
Temperature.. –25° C (–13° F) +50°C to +122° F)
Cost .... About $8,500.

It should be noted that even though the range is listed at 1,000 meters, a number of distances longer than 1,000 meters were measured accurately. The longest distance approximately 1,500 meters, was measured under ideal conditions.

This new concept in distance measuring is probably a more significant breakthrough than was the DME concept. Investigation of short-range infrared devices by the Army is continuing. The preliminary evaluation conducted by the Field Artillery School leaves little doubt concerning the adaptability of infrared short-range distance measuring equipment to field artillery survey. Hopefully, we are not too far from the day when the artillery surveyor can roll up his steel tape for the last time.

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Let's be candid. Really, how good is your maintenance? How much trust do you place in the condition of your present stock of supplies? Are you sure that your equipment will perform satisfactorily under the cold objective light of battle conditions? Do you have a comprehensive maintenance system that will guarantee, with a high order of confidence, the built-in reliability your weapon system is supposed to have? In other words, do you have an effective, responsive, and reliable quality assurance program?

If these questions cause a healthy self-examination and critical evaluation of your maintenance program, you may detect and correct some shortcomings before it is too late. If, on the other hand, you feel secure, beware, so have other commanders with rather sudden and startling results! Let us examine one such case in point and try to glean what lessons were learned.

During a recent annual service practice, a missile battalion achieved a very poor showing initially. The commander halted the service practice at the halfway point and initiated a concerted and highly detailed scrutiny of equipment and procedures in order to determine causes and correct conditions. The exercise was resumed with a corresponding sharp improvement in system performance. The contrast between the "before" and "after" results was so great that an extensive effort was made to pinpoint the culprit or culprits. It may be worthy of mention here that this evaluation of missile status was made on a very large scale and that extraordinary pains were taken to insure objectivity.

Well, what did the results show? Without going into statistical detail or delving into casual factors beyond the control of the troops in the field, it will suffice to say that the evaluation revealed three facts: One, significant deficiencies were observed in all levels of maintenance; two, these deficiencies were universally prevalent; and three, a major cause was the lack of adequate control measures in the supervision of maintenance. It is important to note that the deficiencies were mainly qualitative, not quantitative. The personnel in these units had worked long and hard, and their attitudes were remarkably conscientious. Yet, regular maintenance, periodic management checks, and timely reports were, for some reason, not good enough! Probably the most significant finding was not the cumulative deficiencies themselves but rather that these problems were not recognized during the normal course of maintenance management. One might say that many were led down that broad, rosy path of a false sense of security until that day when the buttons were pressed.

What should be done? One approach is to carefully "peak and tweak" all the missiles and ground equipment just prior to the annual service practice or other readiness exercise. We do not endorse this

"cramming for the final exam" for two very good reasons: First, it defeats the purpose of the test (vis, to ascertain actual posture) and, second, the enemy, unfortunately, does not usually give his opponent advance notice of an attack. Now that we have established what should not be done, let us examine some of the things that should be done.

Certain common denominators of management exist in any successful maintenance operation, particularly in support of complex equipment. These factors were employed at the midpoint of the service practice just described. They are certainly used in industry, where keen competition will reward substandard performance with ruin. Reduced to simplest form, these factors may be termed quality assurance and quality control. Like love and marriage, they are inseparable functions. Let's define them:

> **Quality assurance (QA)**—A management discipline consisting of a planned and systematic program covering all functions and actions necessary to provide adequate confidence that the end item or service will perform satisfactorily in actual operation.
>
> **Quality control (QC)**—The management, methods, techniques, and physical acts employed to insure that the quality of workmanship, materiel, and maintenance operations conform to the standards, criteria, or specifications established by the quality assurance program.

In other words, quality assurance prescribes the ends that must be achieved and quality control is the means of attaining those ends. The main job of quality assurance/quality control is to bring to the surface conditions of substandard quality and prescribe corrective actions or preventive measures before the situation gets out of hand. Let's be specific. What are some of the factors which tend to lie beneath the surface and, like icebergs, are totally deceiving in appearance until detected and identified?

One factor is a lack of emphasis on long-range maintenance. A coat of paint may cover a multitude of sins, but true system reliability is evolved only by an integrated program of careful preventive and corrective maintenance. Thus, thinking and priorities must be reoriented. Actions must be taken to expend less energy on stamping out fires and more on detecting the sparks that ignite those fires. Such actions include close attention to the actual manpower and materiel requirements of maintenance elements and command action on the little problems that may be precursors of big problems.

Another factor is an overdependence on paperwork. The famous Maginot line looked great on paper. So does the readiness posture of many military units. Personnel in responsible positions need to be aware of the unadulterated facts, not carefully edited reports. How does one extract the truth? By creating an atmosphere that is conducive to honesty and candidness, by recognizing and rewarding those who "tell it like it is" and then follow through on corrective actions, and by providing a check and balance system to guarantee factual, frequent, and accurate reporting.

A third factor relates to the conduct of inspections. It is axiomatic that a unit will naturally pay closest attention to those items that they know will be inspected most closely. Emphasis on cleanliness and record-keeping will always yield clean shop floors and neat files. Important as these things are, it is more important to have a feel for such items as support test equipment condition, a calibration status, logbook posting, personnel proficiency, and product quality. Often deficiencies in these and other areas are acute but tend to be submerged under comparatively irrelevant details. Particularly during command visits to maintenance areas, the commander has a golden opportunity to evaluate these essential things.

Finally, it must be recognized that there is a vast degree of difference between the world of environmental testing of missile systems in CONUS under relatively optimum (or at least controllable) conditions and the average field circumstances. Equipment, or the components of a piece of equipment, that is bounced across rough terrain, exposed to excessive moisture and dust, or subjected to extremes of weather does not perform in the same manner as laboratory or newly produced items. Unusual circumstances should be met with extraordinary procedures, and these techniques should be made an integral part of unit policy. Don't pin your future on a particularly competent individual who may be here today and gone tomorrow. Establish a system by which continuity of control and standardization of operations is maintained regardless of the turnover of personnel or a change of command.

Indeed, the preceding paragraphs may sound a bit like paeans in praise of motherhood, but maybe they should. We need to have the broad objectives in sight before we take a bead on the specific solutions. A review of the preceding factors (i.e., long-range maintenance, meaningful paperwork, realistic inspections, and compensatory procedures) should suggest that the requirement exists for fashioning a more readily identifiable quality assurance program and implementing a more effective quality control system. There are two ways of doing this: One, evolving an Army-wide system complete with the necessary training, personnel, doctrine, organization, and equipment and, two, taking more limited but immediate corrective action in the field.

Let us examine the former area first. What measures are currently under consideration by CONUS commands toward possible actions to effect the longer range solution? Briefly they are as follows:

- Integration of enhanced instruction on quality assurance/quality control into service school training programs.
- Development of procedural doctrine (i.e., field manuals, technical manuals, and special texts) on quality assurance/quality control.
- Authorization of sufficient TOE personnel and equipment assets to provide appropriate and adequate resources for repair and quality control operations.
- Development and publication of pertinent quality assurance and quality control standards and criteria for maintenance.

- Improvement of system maintainability and reliability through design innovations and equipment modifications.
- Elimination of the electronic repair apprentice MOS and substitution of the journeyman-level repairman MOS in missile support tables of organization and equipment.
- A requirement for service school training prior to the award of an MOS in all critical and highly technical specialties (warrant officer and enlisted).
- Development of a total on-the-job training (OJT) program (e.g., commander's guides, qualification standards, correspondence courses, and supporting materials) to continue the training of service school graduates.
- Provision of second-level advanced technical training for career-committed enlisted personnel.
- Continuous emphasis on command support of quality assurance program development.

Now comes the obvious question: When do we get such things and how will they be provided? Unfortunately, there is no simple answer to this question. The details will differ with each type of weapon system, and some items will require more extensive analysis and staffing than others. For the purpose of this article, it will suffice to say that all of these areas are being explored actively and some of the results of this increased emphasis on quality in maintenance may become evident in the near future.

So much for the future. The problems are here right now, and some of them cannot wait for total program implementation. What, then, can field commanders and maintenance activities do in the interim with the existing personnel, doctrine, organization, and resources? Obviously, the situation differs from unit to unit and depends on numerous variables. Therefore, each responsible individual must exercise originality in tailoring the system employed to conform to unit needs and available assets. However, certain common denominators can be applied in the development of any quality assurance/quality control program. The following represents a seven-point program that is designed to significantly improve most maintenance operations; and, in addition, it will prepare for forthcoming developments:

ESTABILSH A QUALITY ASSURANCE PROGRAM

Any effective management system must have a basis, or charter, which identifies pertinent information in general terms, such as objectives, responsibilities, priorities, and procedures. A brief but definitive quality assurance program document is essential as guidance upon which to base an effective quality control system. Ideally, such a program should be established at all command levels and closely interfaced. For the purpose of this article, however, we shall concentrate on the quality assurance program at the battalion, battery, and company levels. To have maximum utility and validity, the program should be jointly developed by key command, staff, and technical personnel who are involved in

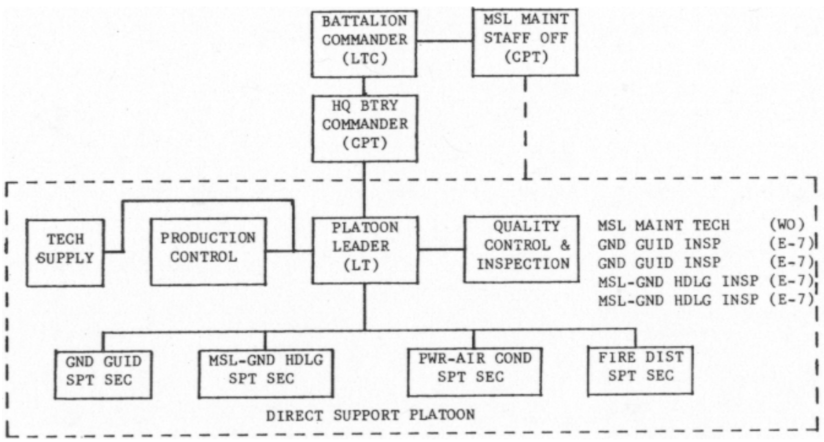
unit maintenance operations. The format employed can be that of an SOP or a command policy letter. It must be recognized that the purpose of this document is to establish broad command guidance for the accomplishment of quality control and to cite responsible activities/individuals. Therefore, simplicity, brevity, and practicality are keystones of a good program. The minimum recommended coverage should include the following:

- Purpose.
- Application.
- References.
- Rescissions.
- Definitions.
- General objectives and goals.
- Responsibilities and functions.
- Procedures. (Cite the actions and interactions between the quality control activity and command staff elements, tactical elements, and service support elements and portray the general methodology to be used in accomplishing quality control.)

FORMALIZE THE QUALITY ASSURANCE PROGRAM

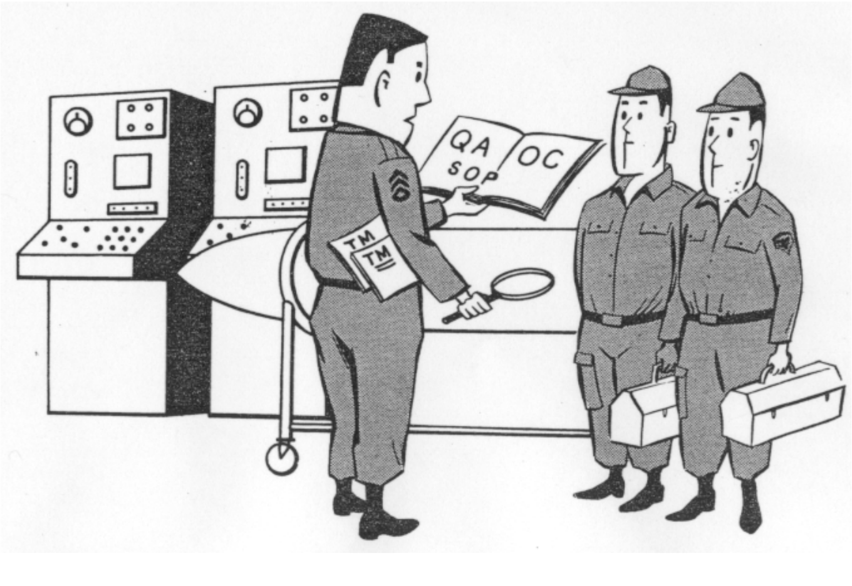
After the development of a brief but definitive written quality assurance program, it will be necessary to translate these goals and objectives into specific procedures and actions. Generally speaking, this means designating personnel responsible for quality control and giving them the authority for, and providing them with the means of, accomplishing this mission. Great care must be exercised in determining the positioning of the quality control element in the organization and in designating the types of personnel to be used. This can best be illustrated by reviewing a quality control structure proposed for the HAWK missile system direct support element. The HAWK missile system is offered as an example primarily because the quality control structure has been rather thoroughly explored as a result of a recent study on HAWK maintenance support. It is believed that the fundamental principles developed for HAWK will have, to a large degree, direct application to the maintenance of artillery missile systems and other complex materiel. Currently, HAWK maintenance inspectors are authorized at grade E-6, skill level 20, and are located within the repair sections of the direct support platoons. Based on an analysis of workload densities, job skill and knowledge requirements, and unit organization, it is believed that the following organization would be a preferable arrangement.

HAWK DIRECT SUPPORT MAINTENANCE PLATOON (PROPOSED)

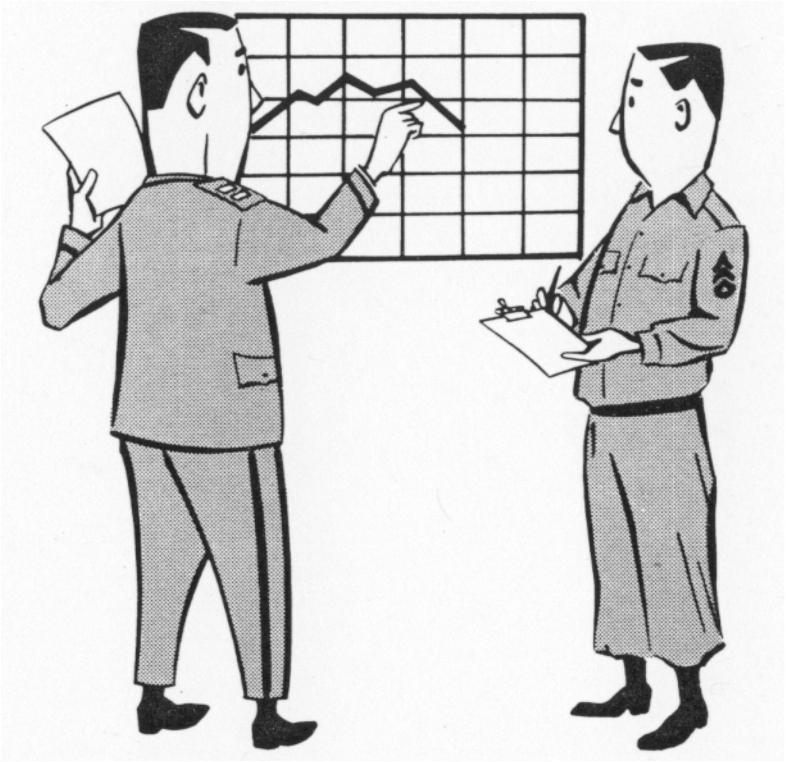


Note that the quality control and inspection function is segregated from production, and administered by a separate and dedicated element of the support platoon. In order to maintain a dynamic continuity of the quality program to battalion headquarters level, the missile maintenance staff officer is designated to exercise operational control of the direct support platoon. In this capacity, he would have a direct responsibility and vested interest in the conduct of the quality assurance program.

The personnel composition of this element is equally important. Inspectors at grade E-7, skill level 50, authorized for each functional maintenance area (i.e., radar repair, computer repair, missile repair, etc.) will provide individuals who are both technically competent and management oriented. This group should be supervised by a warrant officer missile system repair technician, who will coordinate maintenance quality control activities and perform vital liaison services both within the support shop and between the support shop and supported batteries. It may be necessary to augment the present equipment authorizations with additional items required to conduct quality control inspections or to perform critical or sensitive repair operations. Examples of such specialized equipment that may not be presently available are illuminated magnification devices for inspectors and flashlights with flexible extension devices and safety wire pliers for repairmen. The basis for maintenance quality control must be approved standards and criteria. These are normally available in equipment technical manuals and bulletins and other specialized publications, such as MIL-S-45743C for soldering standards and TM 750-245-4 for missile quality control inspection criteria. It is often advantageous to fabricate models for acceptable versus unacceptable workmanship in order to settle interpretative disputes. The foregoing description briefly portrays some of the constituent elements of an effective quality assurance program. The process of formalizing this program is necessarily an evolutionary one. Optimum results are achieved only through periods of trials and refinements and by progressive and flexible attitudes. The results of an effective program



STATUS SCHEDULE



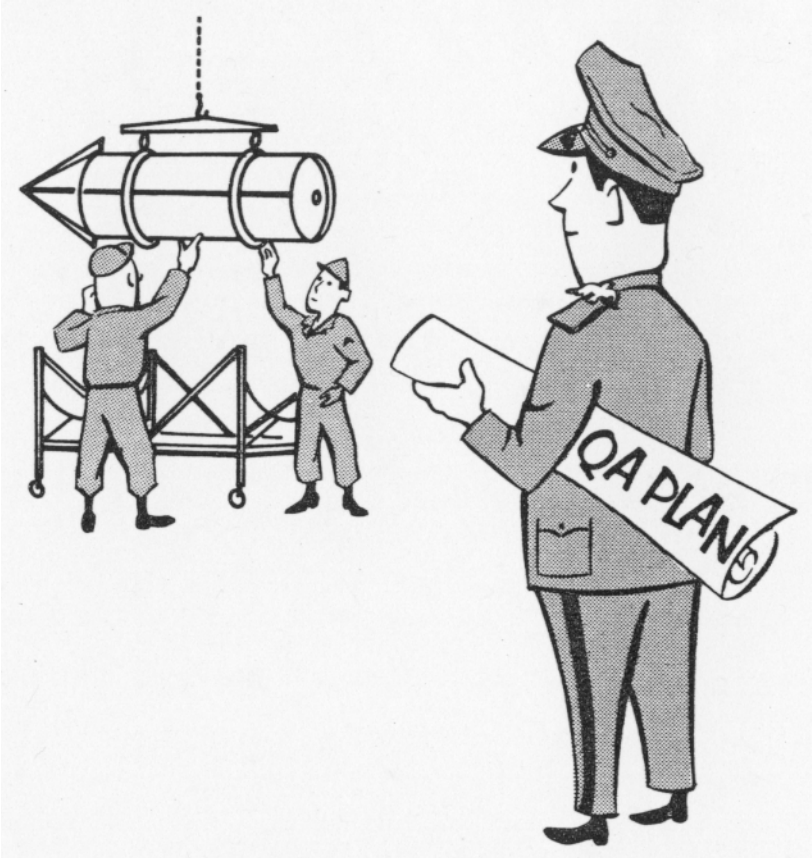
are more efficient utilization of resources and a higher readiness condition of equipment. Until these goals are fully realized, it must be recognized that "the journey of a thousand miles begins with the first step."

FULLY INDOCTRINATE PERSONNEL

Not only must the inspectors be trained in quality control techniques and procedures but also the repairmen must be apprised of the system of which they are a vital part. It is particularly important to stress the need for quality control in the maintenance of complex equipment, the individual responsibilities for everyday application, and the specific techniques used for quality workmanship. Examples of common and typical unacceptable conditions or practices should be cited, and the practical remedy and proper technique should be clearly demonstrated. Training sessions of this type should always be constructive in nature and should be administered as often as required to insure that quality control becomes an instinctive habit of each man. As much as time and circumstances permit, a free and frequent exchange of ideas between operator personnel and maintenance personnel should be encouraged in order to reach a better understanding and resolve mutual problems.

KEEP RECORDS OF VITAL DATA

It is never popular to suggest the creation of new records, charts, or reports, especially for maintenance and tactical units that are often already overburdened. However, the whole concept of quality control is that an ounce of prevention is worth a pound of cure. Therefore, it is only logical that some method be devised to keep records of vital data for effective quality control and to portray this information graphically. Specific formats are determined by individual unit requirements; however, the important thing is to show trends and developing problems. Such records must be kept simple, meaningful, useful, and accurate. Whenever they fail to meet this fourfold test, it is time to abolish or modify the formats used or change the methods of data collection.



MAKE THE PROGRAM DYNAMIC

There are few things more depressing to observe than a well-intentioned program that falls into disuse or impotence through neglect or failure to keep pace with the times. Like a muscle, the quality control program draws strength through continuous exercise and close attention. Procedures and methods should be kept under constant surveillance and should be reviewed periodically for effectiveness and responsiveness. When it can be shown that new or revised techniques are preferable to established ones, corrective action should be immediately taken. Commanders and supervisory personnel should be receptive and responsive to proposed innovations or changes when such are constructive. The entire quality assurance program and quality control system must be a living thing—flexible, adaptable, and responsive to changing circumstances.

PROVIDE CONSISTENT COMMAND EMPHASIS

In the final analysis, the lifeblood of the unit quality assurance program is the command emphasis given it. To be effective instruments, the designated quality control personnel must have consistent command level backing on their decisions, actions, and recommendations on those matters which affect quality control. But this backing is more than endorsement; it also involves the provision of command level technical assistance and guidance. The commander and his key staff personnel should have an open door and a willing ear for all matters affecting quality and thereby encourage a two-way exchange of ideas and problems with quality control personnel. It has already been pointed out that the quality control inspectors will need command support in order to effectively discharge their duties, many of which may involve judgment and arbitration. Correspondingly, these men and the systems, procedures, and records they employ must be thoroughly evaluated during all command inspections, and appropriate followup actions must be taken when required to make the program more workable. Quality control is just as much a condition of the mind as it is inspection checksheets, standards, and physical verifications. With consistent command emphasis and support, the program will receive the attention it deserves at the subordinate levels and correspondingly will be an effective management tool. If neglected at the command level, it will quickly degenerate to just so many words and SOP's.

MAINTAIN CONTACT WITH DEVELOPMENT ACTIVITIES

Army-wide establishment of a quality assurance/quality control system for the field is still largely in the genesis stages. Aside from the obvious disadvantages of this, there are some tangible benefits. You can have the opportunity of influencing and helping develop the system ultimately to be adopted by submitting written comments and recommendations based on your experiences. Of particular value to personnel involved in the planning, training, and doctrine and literature development are reports of your progress, successes, problems, or failure in implementing a program such as that portrayed. Correspondence should be addressed to any or all of the following activities:

Commandant
U.S. Army Missile and Munitions Center and School
ATTN: AJQ-ND
Redstone Arsenal, Alabama 35809

Commandant
U.S. Army Field Artillery School
ATTN: ATSFA-PL-FM
Fort Sill, Oklahoma 73503

Commanding General
U. S. Army Missile Command
ATTN: AMCPM-HAQ
Redstone Arsenal, Alabama 35809

DELAY IN AMMUNITION PRODUCTION

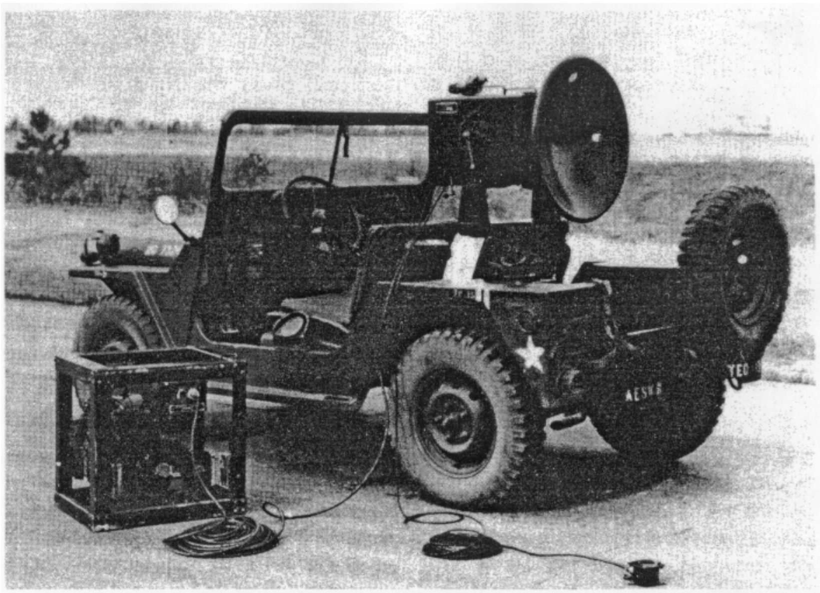
The Department of the Army will permit Chrysler Corporation to continue as contractor-operator of the Government-owned Gateway Army Ammunition Plant at St. Louis, Missouri.

Previously, the Army issued a show cause letter to Chrysler Corporation requesting an explanation of its failure to meet delivery schedules under a fixed-price contract for the production of 263,000 175-mm artillery projectiles.

The Army conducted extensive discussions with Chrysler Corporation and, after careful consideration of the Army continuing requirements for 175-mm artillery projectiles, determined that continuance of the present contract is in the best interests of the Government at this time.

The Army has established a new delivery schedule for the balance of the contract and has agreed to provide $1,079,000 to purchase tooling and equipment which Chrysler recently requested for the Gateway plant.

Getting the Most from . . .



The M36 Chronograph

LTC (Ret) Merlyn H. Smith
Gunnery Department
USAFAS

When Neal Armstrong stepped from his space vehicle onto the surface of the moon, a dream of man was fulfilled. Among thousands of incredible engineering feats that culminated in this first step was the ability to determine accurate trajectory data at every stage of the one-fourth-million-mile trip to the moon. Critical to these trajectory computations was the ability to accurately determine velocity at specific times. The velocity of a space missile or a field artillery projectile must be accurately known if we are to determine how far such a missile will travel under a set of known ballistic conditions. With the advent of the digital computer and the development of the chronograph, the dream of the field artilleryman to hit a target without prior registration can be fulfilled provided he can accurately measure all of the ballistic parameters that affect a projectile in free flight.

The efficiency projectile design, the weather conditions, the weight of the projectile design, the effects of gravity and rotation, and the temperature of the propellant can be determined. Muzzle velocity (MV), however, has always been difficult to determine. In the manual system a velocity error (VE) is derived by subtracting all calculated known corrections from the total corrections determined from registration and assuming that the residual is a result of the unknown velocity. Today after years of development, the M36 chronograph gives the field artilleryman a means of accurately measuring the muzzle velocity of a particular weapon while the weapon is firing an ordinary mission. The M36 chronograph works on the doppler principle. It has recently been deployed to Asia and will soon be available in Europe.

The M36 chronograph can be used for relative calibration for the purpose of grouping pieces by battery (para 22-2, FM 6-40); however, this is a secondary function. The primary function of the chronograph should be to measure actual developed muzzle velocity for each lot of propellant and each charge normally used. These data can be measured while a battery is engaged in harassing/interdiction missions during periods of relative inactivity. This ability to determine velocity gives the fire direction center equipped with the gun direction computer M18 (FADAC) the final item of data needed to fire without registration.

A projectile's efficiency in traveling through atmosphere depends on its aerodynamic design. The factor used in ballistics to describe air resistance is called drag. If two projectiles which have the same drag but carry different payloads, high explosive (HE) and white phosphorous for example, weigh the same and leave the tube at the same velocity, they will travel the same distance. Most projectiles for a specific caliber of weapon have these characteristics. For example, the HE M107, WP M110, smoke M116, gas M121A1, illuminating, M485 and HE M449 series projectiles for the 155-mm howitzer have the same aerodynamic characteristics. It would appear that if the same propellant lot were used, the developed muzzle velocity for one projectile could be directly applied to all the others and they would achieve the same range using identical firing data. However, the effects of internal ballistics are not the same and the resultant developed velocity will differ for different projectiles as shown in the following tables of standard velocities:

STANDARD MUZZLE VELOCITIES

Source: US Army Ballistic Research Laboratories

105-mm howitzer M101A1

Projectile	Type	Charges 1	2	3	4	5	6	7
HE	M1	195.1	211.8	233.2	262.1	301.8	365.8	464.8
WP	M60	"	"	"	"	"	"	"
Smoke	M84, M84B1	"	"	"	"	"	"	"
Gas	M360	"	"	"	"	"	"	"
HE	M444	196.5	212.5	232.4	260.8	299.1	361.7	459.5
Illum	M314	187.5	203.9	221.9	246.9	284.4	343.8	433.7
CS	XM629	191.3	207.9	226.2	251.5	289.6	349.8	441.0

105-mm howitzers M108 and M102

		Charges						
Projectile	Type	1	2	3	4	5	6	7
HE	M1	205.0	223.0	247.0	278.0	325.0	393.0	494.0
WP	M60	"	"	"	"	"	"	"
Smoke	M84, M84B1	"	"	"	"	"	"	"
Gas	M360	"	"	"	"	"	"	"
HE	M444	206.5	223.7	246.7	276.6	322.1	388.6	488.4
Illum	M314	187.0	208.0	232.0	263.0	309.0	374.0	468.0
CS	XM629	190.8	212.1	236.4	267.9	314.5	380.4	475.8

155-mm howitzer M114A1

		Green bag propellant charges					White bag propellant charges				
Projectile	Type	1	2	3	4	5	3	4	5	6	7
HE	M107	207.3	234.7	274.1	317.0	374.9	274.3	316.4	374.6	463.3	563.9
WP	M110	"	"	"	"	"	"	"	"	"	"
Smoke	M116	"	"	"	"	"	"	"	"	"	"
Gas	M121A1	"	"	"	"	"	"	"	"	"	"
Illum	M485	212.0	241.0	281.0	324.1	384.0	279.0	322.0	382.0	472.0	576.0
HE	M449	206.7	234.1	273.7	316.3	374.0	274.3	316.1	374.0	462.3	562.6
HE	*M449A1	206.1	233.6	273.2	316.0	374.1	273.3	315.4	373.8	462.7	563.5
HE	M449E1	206.7	233.6	272.6	315.6	371.3	272.5	313.9	371.0	458.2	557.0
AE	M454	310.9	374.9	547.1	Propellant XM72						

*Also M449E2

155-mm howitzer M109

		Green bag propellant charges					White bag propellant charges				
Projectile	Type	1	2	3	4	5	3	4	5	6	7
HE	M107	213.0	240.0	279.1	319.1	378.0	280.0	319.0	378.0	463.0	561.0
WP	M110	"	"	"	"	"	"	"	"	"	"
Smoke	M116	"	"	"	"	"	"	"	"	"	"
Gas	M121A1	"	"	"	"	"	"	"	"	"	"
Illum	M485	218.0	246.0	286.1	327.1	388.0	284.0	325.0	384.0	472.0	573.0
HE	M449	214.5	241.1	279.6	319.0	376.9	280.4	318.8	376.9	460.5	556.9
HE	*M449A1	211.8	238.9	278.1	318.1	377.2	279.0	318.1	377.2	462.4	560.6
HE	M449E1	212.4	238.9	277.4	316.7	374.4	278.2	316.5	374.4	457.9	554.1
AE	M454	310.9	374.9	545.6	Propellant XM72						

*Also M449E2.

8-inch howitzers M115 and M110

		Green bag propellant charges			White bag propellant charges			
Projectile	Type	1	2	3	4	*5	6	7
HE	M106	249.9	274.3	304.8	3505	420.6	499.9	594.4
HES	M424	254.5	359.7	547.1				
AE	M422	251.5	356.9	543.9				
HE	M404	249.9	274.3	304.8	349.3	418.2	497.1	591.3
Gas	M426	249.9	274.3	304.8	350.5	420.6	499.9	594.4

*White bag and green bag charge 5 have the same muzzle velocity.

175-mm gun M107

		Charges		
Projectile	Type	1	2	3
HE	M473	510.5	704.1	914.4

The difference in standard muzzle velocity between projectile types is caused by differing internal ballistic effects. These differences can be applied to the muzzle velocity measured by the chronograph for one projectile to determine muzzle velocities for other projectile types without firing the projectiles. (The same lot of propellant must be used to fire, since muzzle velocity is charge/lot/gun associated.) For example—

During a night harrassing mission, Battery B (155-mm howitzer M109) used the M36 chronograph to measure the developed muzzle velocity for projectile HE M107, charge 6, propellant lot A. The average muzzle velocity of six rounds—458.2 meters per second—was entered in the M18 computer. If the battery fires the WP, smoke, or gas projectile, the computer will automatically apply the same measured muzzle velocity since these projectiles have identical standard muzzle velocities. If the battery fires the M485 illuminating projectile or the M449 series of improved conventional munitions (ICM), the difference in standard velocity must be applied manually as shown in the following table:

Projectile	**Standard MV Charge 6**	**Difference**	**FADAC Input MV**
HE M107	463.0	–	458.2
Illum M485	472.0	+9.0	467.2
HE M449	460.5	–2.5	455.7
HE M449A1, M449E2	462.4	–0.6	457.6
HE M449E1	457.9	–5.1	453.1

The battery used the M36 chronograph to measure the muzzle velocity for projectile HE M449A1, charge 5 green bag, propellant lot A. The average muzzle velocity for a group of six rounds was 352.8 meters per second. The differences in standard muzzle velocity can be applied

Figure 1. M36 chronograph emplaced to measure muzzle velocity of a 105-mm howitzer.

to the measured muzzle velocity of the M449A1 to determine muzzle velocities for other types of projectiles as shown in the following table:

Projectile	Standard MV, Charge 5 GB	Difference	FADAC Input MV
HE M449A1	377.2	–	352.8
HE M449	376.9	–0.3	352.5
HE M449E1	374.4	–2.8	350.0
HE M107	378.0	+0.8	353.6
Illum M485	388.0	+10.8	363.0

The M36 chronograph team should be used continually to determine muzzle velocity data for each lot of ammunition to be used in unobserved fires and for as many different charges as possible. Valid muzzle velocity input data for other projectiles can be determined as illustrated in the above example.

The accuracy of the firing data produced by FADAC will depend primarily on the validity of met data, since all of the other parameters, including muzzle velocity, can be accurately measured. Whenever there is doubt as to the validity of met data, check rounds should be fired or a registration conducted. If a registration is conducted, the K (correction factor) computed by the M18 computer will most likely reflect the error in met.

With the M36 chronograph to measure developed muzzle velocity and with the M18 gun direction computer, field artillery units can now engage known target locations with accurate surprise fires without wasting a single round in registration.

Artillery Employment In Mountain Warfare

MAJ Jean G. Digier
Swiss Army Artillery

Whatever the nature of a future conflict may be, tactical problems to be solved by the ground forces, in the attack and in the defense, depend to a very high degree on the mobility of these forces. However, in mountain operations the search for this mobility is limited by the impenetrability of the mountain mass. Roads are scarce; most trails are usable only by pack-animals; and the terrain is broken into numerous isolated compartments by rivers, streams, ridges, and valleys. The meteorological conditions are subject to many changes, with and without snow, so that the mountain cannot be analyzed from one point of view but from many, according to the practicability of the communications means and the evolution of the seasons.

This restraining influence of the terrain and the difficulty in mastering it limit the speed and efficiency of the operations. The coordination of actions is often difficult and the execution of command is seriously hindered by the difficulty of displacing command posts. Since it is impossible for the commander to guide his subordinates at each moment, he is obliged to leave to them a high degree of initiative. Logistical problems must also be solved in the mountains. To carry to the front the necessary supplies and to evacuate casualties and materials along poor and vulnerable routes is not easy. Any lack of agreement between tactical needs and logistical possibilities makes the situation praticularly difficult. Nevertheless, the introduction of airmobile facilities has modified certain factors, considered permanent until now, and the old tactical principle "He who controls the passes, controls the mountains" is no longer true. However, the final decisive combat will still be fought above the limits of vegetation, around the main terrain features.

BACKGROUND

The general considerations enumerated have great influence on the employment of artillery in the mountains. In the year 1800, from the 15th to the 20th of May, Napoleon Bonaparte accomplished a tremendous feat in crossing the Great Saint Bernard Pass (7,535 feet in altitude) with his dismounted artillery pieces fixed on dug out tree trunks. It was the only practical means of carrying the tubes on the snow with some chance of success. At the end of the last century and in the first half of this century, almost every army in the world had mountain artillery, the guns of which could be disassembled and carried into position on the backs of mules. These special guns and mules have disappeared, but similar difficulties remain.

It is virtually impossible to analyze all the problems of the employment of artillery in mountainous areas in so short an article. "Drill Regulations for Mountain Artillery, US Army, 1908," determines the frame of the elements we will consider. "The special qualifications required of field artillery in war are the ability, first, to reach the position for action at the proper time and in effective condition; and, second, to deliver an effective and overpowering fire upon any designated part of the enemy's position." Using this concept, we will analyse the following main points:

- The selection and occupation of position areas.
- The requirements for target acquisition and the selection of the objectives. (In French the word "objective" is a synonym for target.)
- The judicious use of the trajectories, (in this case the capabilities of bringing the projectiles anywhere).

POSITION SELECTION

The selection of firing positions involves special difficulties due to the extreme variations in the altitudes of the targets against which the guns must be fired. The lack of large flat, surfaces limit considerably the number of available battalion-size positions, even positions for a single battery. The nature of the terrain, numerous valleys and ridges, necessitate excessive minimum quadrant elevations and must be seriously considered before making a decision to occupy a position. Therefore, it is essential to establish detailed plans at division level, even at corps level, to determine in which areas it is possible to position the artillery—first, by map reading, and second, as soon as possible, by reconnaissance. This planning must take into consideration all types of current operations—attack, defense, withdrawal, and delay—because the needs will vary with each type of operation. The plans must include not only the selection of main positions but also the alternate positions. In most cases, the confining nature of the area will require different locations for the various elements of the unit, for example, command posts and FDC's may be located away from the battery in a sector that offers the best possibilities for camouflage against aerial observation. Regardless of the type of operation, the echeloning of the positions in the depth must provide for continuous fire, even when batteries have to be moved. When tank approaches exist, the artillery batteries must also provide for antitank defense. Finally, the enemy's capabilities to isolate or destroy any artillery formation with nuclear weapons must be considered.

Very often, it will be necessary to use helicopters to bring the pieces into position and thus to eliminate the major part of the difficulties. However, certain limitations of the helicopter—decreased lifting capability in high altitude and vulnerability to ground fire—and rapidly changing meteorological conditions in the mountains must be considered.

For all these reasons, it will be necessary in most cases to position only one battery in a definite sector. Sometimes a platoon may be adequate if the action is limited in time or space. In fact, the possibility of emplacing a complete battalion in one position area will be the exception. Therefore, the organization and equipment of these battalions must provide for sufficient decentralization of firing means so that subordinate elements can operate independently.

TERRAIN CONSIDERATIONS

The mountain gives to the expert the opportunity to use the terrain and the natural shelters in order to move himself without being observed and, thus, to take advantage of surprise. On the other hand, the barriers of the crests and the streams do not permit the deployment of large forces. Generally, we will have to contend with alpine detachments of platoon or company size. The infantry battalion will occupy so large a portion of terrain that it can be considered an unusual target for an artillery fire unit. Targets to be fired by artillery weapons will be difficult to spot and locate. This difficulty can be eliminated by using two principles in the conduct of combat: security and observation. Security is essential for the preservation of combat power. It is achieved by measures taken to prevent surprise and gives time to switch from an administrative activity to a combat activity. For the field artilleryman, this security gives him the necessary time to spot and locate the target by an accurate grid and to deliver fire. The observation has to be well organized and constant. The first impression of good visibility is frequently misleading. Summits and ridges following one after another appear to merge and create the impression of a continuous field of observation. A visibility diagram of this field will produce unexpected surprise. From a certain observation post one may be able to see no more than 30 to 40 percent of the actual terrain before him. Therefore, observation must be taken from several different points in order to cover the largest portion of terrain. In the mountain snow, each movement in the open is visible; a radio antenna standing out above the crest can be observed at a great distance; and effective camouflage is hard to achieve above the limits of vegetation. The good forward observer must know all these elements in order to accomplish his mission in a satisfactory manner.

The geography also influences the method of firing on targets. Seldom will targets be fired on standard large dimensioned surfaces. More often it will be necessary to adapt the sheaf of the firing unit to the peculiarities of the relief; for example, gorges, valleys, defiles, and rivers. In the present case, it will be judicious to describe the target by two different sets of grids: one for the right side and one for the left side of the target. Determining firing data for both sides makes it possible, by computing the difference and dividing by 5, to give individual corrections for each gun in deflection, fuze setting, and quadrant elevation.

This will adapt the sheaf, the height of burst, and the range of the firing unit to the linear geographical form of the target. This method does not offer many technical difficulties to a well-trained fire direction center; furthermore, for obvious reasons, it saves many rounds of ammuntion. The very special nature of the artillery target in mountainous areas, as explained above, combined with the size of the enemy formations requires once more the employment of smaller firing units; e. g., one battery or, if need be, one 2-gun platoon.

DEAD SPACE

However, it is useless to bring artillery pieces into position under difficult conditions and to train the forward observers in the secrets of mountain gunnery if portions of key terrain features cannot be attacked. Dead space results from the following three basic factors:

- The great difference in altitude between the fire unit and the target, which decreases the ranges.
- The great angle of incline of the slope compared to the angle of fall of the trajectory, as a result of which certain sections of the slope may prove to be beyond the reach of fire.
- The presence of separate gorges extending perpendicularly or obliquely to the forward edge of the battle area and at times emerging far in the rear of the defense position.

Elimination of the dead space in most cases will be possible only by employing flanking fires, by changing the propelling charge, and by using high-angle fire. Concurrently with the planning of the possible position areas, the corresponding dead space maps must be drawn. After being reproduced, these maps must be distributed to the forward observer so that he will be able to inform the supported unit commander of the capabilities and limitations of the supporting artillery. If many dead spaces still exist in spite of the measures taken, the best solution would consist of decentralizing the firing means, either in depth or laterally. A concentration of fire by a battalion or a battery on one or more critical targets would certainly not be possible but, at least, the main portions of the essential terrain features would be covered by artillery projectiles. Here a tactical decision must be made: whether to establish a main effort by artillery in the most significant or probable avenues of approach of the enemy and deliberately leave some portions of terrain without any artillery support or to operate with a large dispersion of the means, setting aside the possibility of concentrating firepower, but having the confidence that in each point of the battle area the artillery is able to deliver fire.

SUMMARY

In conclusion the mission of the field artillery remains unchanged, even if the artillery is employed in the mountains. It is possible to solve the problems of terrain difficulties by carefully planning the occupation of successive or alternate position areas. This depends on the practicability of these zones and the capability to reach the largest part of the battle area with the trajectories (or projectiles as American terminology says). Adequate decentralization of the firing elements as well as specialized training of the forward observers will permit the delivery of the appropriate ammunition at the right time and with the correct volume and accuracy on all available targets. Finally, the employment of airmobile transportation and the adoption of modified firing techniques will give the field artillery committed in the mountain warfare environment the needed flexibility so that, even on the high summit, it will remain "the last argument of kings."

COMBAT VEHICLE DEVELOPED

A military prototype of an all-purpose combat vehicle is currently being developed by Lockheed Missiles and Space Company under a developmental contract with the U. S. Army-Tank Automotive Command. The vehicle, called the Twister, has two bodies joined by a pivotal yoke and eight driving wheels which give it a high speed, all-terrain, all-weather capability.

Figure 1. Twister test combat vehicle.

A Neglected Giant

New Look for Sound Ranging

MAJ Alex J. Johnson
Maxwell R. Conerly
Target Acquisition Department
USAFAS

Although few field artillerymen are aware of the fact, approximately 75 percent of all enemy artillery that was located in World War II and Korea was located by means of sound ranging techniques. A study based on records and files of World War II entitled "Sound Ranging for the Field Artillery" was conducted by the Operations Research Office of Johns Hopkins University. It stated that in the field of artillery target intelligence, sound ranging was more important than all other means combined. The study further stated that sound ranging platoons located the majority of those German batteries that were on the Western Front. Available documentation indicates that essentially the same results were achieved in Korea. Yet, in spite of this enviable record, few artillerymen today realize the capability of sound ranging to locate hostile artillery or even know the basic principles of sound ranging. Some questions

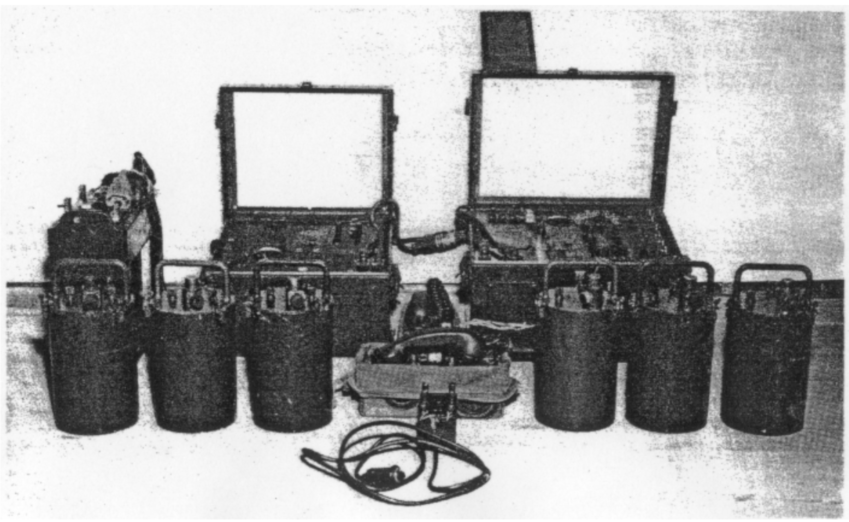


Figure 1. Sound ranging set GR-8.

field artillerymen might raise are: What is the status of our sound ranging capability today? How much has it improved since World War II? Could sound ranging achieve the same results in combat today as it achieved in World War II and Korea? Is sound ranging being used in current conflicts? What are the limitations of sound ranging? What is the future of sound ranging in the field artillery? Perhaps the best way to answer these questions is to take a thorough, objective look at the entire realm of field artillery sound ranging.

SOUND RANGING EQUIPMENT AND PRINCIPLES OF EMPLOYMENT

Sound ranging equipment and techniques have remained essentially unchanged since their introduction in World War I. Although the importance of sound ranging as a means of counterbattery target acquisition was clearly established in World War I, World War II, and Korea, little has been done to adapt new and changing technologies to the sound ranging problems.

Basically, sound ranging is the procedure used to locate the source of a sound by calculations based on the relative times of arrival of the sound wave at several accurately located positions on the ground. The firing of a weapon produces sound waves in the atmosphere which are very similar in configuration to the waves produced when a pebble is dropped into a quiet pool of water. These waves are generally circular in nature so that, if the sides of the pool are straight, any given wave will strike different points on the side at different times. This same basic principle is true of sound waves. In addition, a sound wave has a constant rate of speed of approximately 337 meters per second under normal conditions. Therefore, the differences in times of arrival of a sound wave at selected points on a relatively straight line can be determined. These time differences can then be used to compute the center of the circle (target location) which is the origin of the sound wave created by a weapon firing.

The present method of locating enemy artillery by sound ranging involves emplacing four to six microphones laterally along the front and employing two observation posts in front of the microphones. The microphones and the observation post equipment are connected to the recording equipment at the sound ranging central by long wire lines. When an observer hears an enemy gun fire, he closes a switch, thus placing the recording equipment in operation and energizing the microphones. The relative times of arrival of the sound wave at each microphone position are recorded on a paper tape. Personnel at the sound ranging central process the data manually by determining and applying weather and asymptote corrections and then plotting this information on a gridded chart.

ADVANTAGES AND DISADVANTAGES OF SOUND RANGING

Any target acquisition system that can produce the results credited to sound ranging must have some capabilities that other systems do not have. Some of the **advantages** of sound ranging are as follows:

● Sound ranging can be used to quickly and accurately adjust fire onto enemy batteries when there is no survey or meteorological data available and when the target cannot be visually observed.

● Sound ranging can be used to register friendly artillery as well as to locate hostile artillery.

● Sound ranging can be used to locate hostile artillery as far as 20,000 meters from the sound ranging base dependent upon the width of the base.

● Sound ranging can be used to locate weapons deep in defilade, regardless of visual or electronic line of sight.

● Sound ranging is passive and is not subject to jamming.

● Under favorable conditions targets can be located by sound ranging to an accuracy of 0 to 150 meters.

● The location of a weapon can be determined by sound ranging within 5 to 20 minutes after the weapon fires.

It can be seen from these characteristics that sound ranging provides a capability of locating hostile artillery with sufficient accuracy for rapid, effective counterfire under all visibility conditions and at an adequate range to support most friendly field artillery weapons. It also provides a capability of registering and adjusting friendly artillery during periods of limited visibility. This alone can effect substantial ammunition savings as well as provide a continuous counterfire capability.

"Nothing can be this good," some may say. Well, the truth of the matter is that sound ranging does have some limitations. Some of the **disadvantages** of sound ranging are as follows:

● The accuracy of sound ranging target locations is impaired by strong or gusty winds. A strong wind blowing away from the sound base may prevent the sound of hostile artillery from reaching the sound base.

● When a base is being used to locate targets by coordinates, each of the microphones of the sound ranging base must be surveyed to an accuracy of 1:3,000.

● If adjacent microphones of the sound ranging base differ by more than 200 feet in altitude, unacceptable errors are introduced into the solution of the sound ranging problem.

● If some of the microphones of the sound ranging base are located immediately behind a large hill mass, the arrival times of sound waves at these microphones will be disproportionally delayed when compared to the arrival times at the other microphones, thus producing an unacceptable error in the solution of the sound ranging problem.

● Currently the directional capability of sound ranging is limited to 3,200 mils. This almost requires that the sound ranging base be parallel to the FEBA.

● Friendly forces must control the terrain between the microphones of the sound ranging base as well as the microphone positions because of the requirement for wire lines from each microphone to the sound ranging central.

ZONE OF COVERAGE

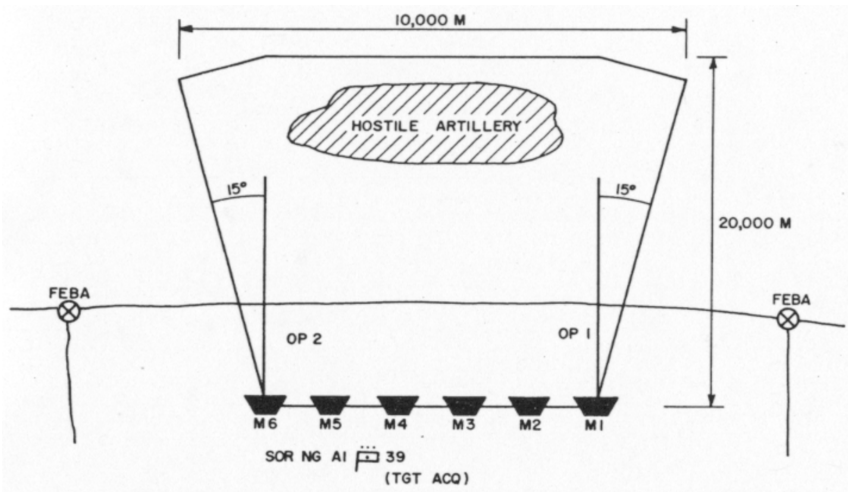


Figure 2. Tactical employment of sound ranging set.

In view of these limitations, it is evident that current sound ranging equipment and techniques of operation are not compatible with other more advanced tools of combat designed for employment in the fluid tactical environment of the modern battlefield. The GR-8 sound ranging system is cumbersome, takes many hours to deploy, relies on extensive and unreliable wire lines, and depends on manual plotting and empirical assessment of the accuracy of locations. The existing method of computing and applying meteorological corrections is coarse and produces inconsistent results. Manpower requirements are excessive. Furthermore, most of the sound ranging sets in the inventory are so old that they are difficult to maintain.

PROPOSED IMPROVEMENTS

There is a critical need to improve the current sound ranging system if the potential of this target acquisition means is to be realized on today's battlefield. Therefore, two immediate basic improvements have been recommended.

The first improvement is the addition of a radio data link to transmit data from each microphone to the sound ranging central, thus eliminating the need for extensive wire lines. The US Army Electronics Command (USAECOM) at Fort Monmouth, N.J., has developed and successfully evaluated the radio data link, sound ranging, AN/GRA-114. This radio data link should be in the hands of troops by January 1972. Use of this radio data link could also result in the elimination of some spaces in the communications platoon.

The second improvement is a method of automatically processing the sound ranging data to produce a target location. The US Army Field Artillery School (USAFAS) has developed a sound ranging program tape for the gun direction computer M18 (FADAC). With this tape, the FADAC can process the sound ranging data in the location phase or in sound-on-sound adjustment. The Target Acquisition Department, USAFAS, has unofficially evaluated this tape. Results obtained with FADAC during this evaluation showed an increase in accuracy of approximately 30 percent over results obtained by manual processing. This is possible even when the manual processors are highly trained. Results obtained with FADAC during this evaluation were approximately 25 percent more consistent than results obtained by manual processing, thus indicating more reliable target locations. The time required to process the data with FADAC was 23 seconds as compared to approximately 3 minutes for manual processing. As a bonus, use of the FADAC by sound platoons may allow the elimination of some spaces from the sound platoon. These improvements are immediately available and would increase the responsiveness of sound ranging even in a counterinsurgency environment.

In addition, the US Army Combat Developments Command Field Artillery Agency (USACDCFAA) is preparing a Small Development Requirement (SDR) for improved recording equipment to replace the Sound Ranging Set GR-8. The new equipment will contain eight channels which will provide a limited omnidirectional (6,400-mils) capability as well as the ability to concurrently employ an artillery base and a mortar base. The set will provide a magnetic tape signal storage capability, a selective stabilized speed chart drive, and a dry recording technique which permits instantaneous data presentation. It is anticipated that the improved recording equipment, the radio data link, and the FADAC will improve sensitivity and accuracy, reduce the time required to process data, and significantly enhance reliability and maintainability. This is a very low-risk, low-cost project that will greatly enhance the capability of the field artillery to locate enemy artillery by means of sound ranging.

THE ULTIMATE SYSTEM

Even though the suggested improvements to the sound ranging set GR-8 would provide a better sound ranging capability than ever before, there is still an urgent need for a completely automatic sound ranging system with improved capabilities. This system should have the capability of covering wide fronts in conventional warfare and should have a complete omnidirectional capability when employed in relatively small defended areas in counterinsurgency warfare. It should provide significant improvement in the radio data transmission system and in data recording, reproducing, and processing. It must be significantly lighter in weight and easier to emplace and must be capable of being deployed very rapidly. Such a system should also have an improved range capability.

Several sound ranging systems incorporating many of the needed improvements of the ultimate sound ranging system were tested at Fort Sill, Oklahoma, during the summer of 1969. Due to the limited time available to the developers, none of the systems operated satisfactorily. All of the candidate systems will require additional research and development before an acceptable system is fielded. However, these tests did indicate that the requirements listed for the ultimate sound ranging system are within the capability of current technology.

SOME CANDID OBSERVATIONS

Sound ranging has been used with limited success in current combat operations even though there has been no substantial system improvement since World War I. Much of the blame for this lack of improvement is due to the failure of some to recognize the potential of sound ranging. This attitude shows strong signs of imminent change. Such a change is a healthy sign. Although sound ranging is not a panacea for all target acquisition requirements of the field artillery, it does have a unique, effective artillery locating capability which is critically required by the field artillery. To continue his outstanding support, it is imperative that the modern field artilleryman be knowledgeable of and make use of as many effective target acquisition means as possible.

OVER 193,000 VOLUNTEERED FOR ARMY

Over 193,000 men and women volunteered for Army duty during fiscal year 1969. A recent compilation of recruiting figures indicated that in addition to having the highest number of volunteers among all the services, the Army recorded its second highest number of volunteers for any year since World War II. Only fiscal year 1968 enlistments were higher with almost 199,000.

Of all new personnel entering the Army during fiscal year 1969, 44 percent were volunteers. This is the highest percentage of volunteers since the buildup of forces in Southeast Asia began in 1965.

Volunteers included some 5,000 young women who enlisted in the Women's Army Corps, more than 6,000 young men who joined the Warrant Officer Flight Program and more than 11,000 college men who signed up for Officer Candidate School.

Mini-Training

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USAFAS

So you have heard about the 14.5-mm artillery trainer M31, but you have never used it. It is a training aids item and may be drawn by any CONUS Active, Reserve, or National Guard unit that is supported by a training aids center. The 14.5-mm trainer was designed and manufactured by the Germans as a forward observer trainer; however, it can also be used for training FDC personnel, gunners, assistant gunners, survey personnel, and radiotelephone operators.

The M31 trainer is a bolt action, single-shot, rifled barrel assembly coupled to a tripod by a mount assembly. When drawn from the training aids center, it will probably be packed in a shipping chest, which also contains all the necessary tools and equipment to maintain and operate it except for a panoramic telescope sight (M12 series) and a gunner's quadrant.

The major components of the trainer are a tripod, mount assembly, barrel assembly, and telescope socket assembly. The tripod has three telescoping legs which can be lengthened or shortened by turning the sleeve portion of the legs. Three rings are painted on the upper part of each leg—two red rings that indicate the limits of the threads and one yellow ring that marks the center of the thread. One of the three legs has a 15-inch extension on the end of it and is known as the rear leg. When set in the center position, the two front legs are 45 inches long and the rear leg extended is 60 inches long. The mount assembly houses the elevating and traversing mechanism and has two level vials which permit the mount to be leveled. The barrel has trunnions and an elevating arc attached. The rifled portion of the barrel is 13¼ inches long and has a uniform right-hand twist, one turn in 8½ calibers. The telescope socket assembly has a receptacle for the M12 series panoramic telescope sight and is the link between the sight and the mount assembly.

The trainer will enable the using unit to teach the rudiments of target location, calling for and adjusting field artillery fire, conducting impact and time registrations, and operating a flash base either for flashing high-burst or mean-point-of-impact registrations. In the case of registrations, some prior planning is required to derive maximum benefit from the use of the trainer in that the missions fired are schoolbook solutions and are "canned." However, the students are required to apply correct procedures in conducting the adjustment and fire-for-effect phases.

To obtain the maximum benefits from the trainer, the unit should make at 1:5,000 map of the impact area and superimpose a 1:50,000 grid on the map. The forward observer could then use the same equipment that he uses during other service practices and could also report target locations by any of the three methods. To determine the observer-target (OT)

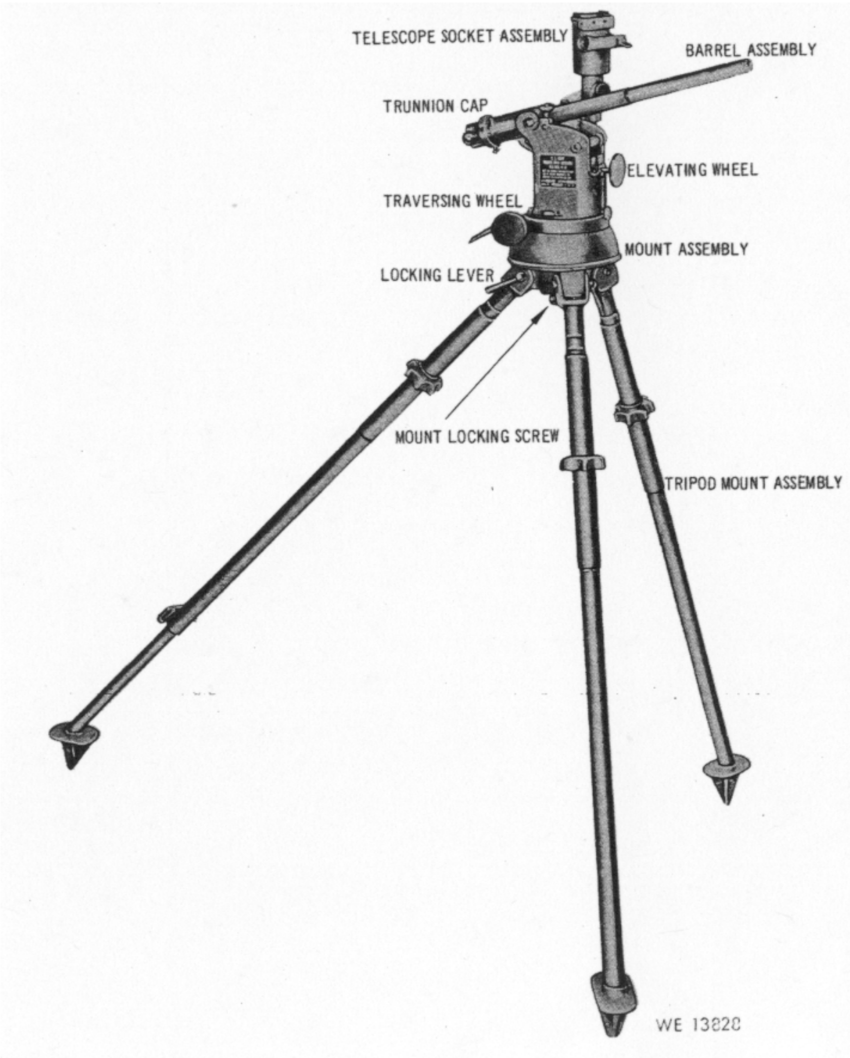

Figure 1. 14.5-mm Field Artillery Trainer M31.

factor, the observer uses the nearest 100 meters rather than the nearest 1,000 meters. For example—

OT range (meters)	**OT factor**
100	1
300	3
450	4

During the adjustment phase the observer corrects for deviation, using the OT factor. However, for range he must mentally multiply the amount of desired correction by 10; that is, if he thinks he needs to add 40 meters in order to bracket the target, he announces ADD 400. The fire direction center (FDC) chart will be set up the same as that for a 105-mm or 155-mm howitzer except that the spaces between gridlines will represent 100 meters. The target grid is oriented in the same manner as that for other weapons. The horizontal control operator (HCO) reads the range and deflection from the range-deflection protractor and announces them to the computer. The computer announces the deflection to the weapons, sets the range on the GFT, and then reads the elevation and announces it to the weapons.

HCO: (To computer) DEFLECTION 2820, RANGE 4780

COMPUTER: (To weapons) DEFLECTION 2820, QUADRANT 291

Three fuze actions can be obtained with the nonfragmentation high-explosive projectile—a point-detonating (PD) fuze which will cause a burst appearance when the projectile impacts, a 3-second preset time fuze, and a 6-second preset time fuze. Either of the preset time fuzes can be used for a high-burst registration to train personnel to man an 01-02 base. The time fuzes and the PD fuze can be used to teach the observer how to conduct a time registration by presenting graze bursts with the PD fuze, high airbursts with the 3-second preset time fuze, and low airbursts with the 6-second preset time fuze.

PLANNING FOR THE RANGE

If you are planning to use the 14.5-mm trainer, the following considerations should be valuable in constructing a range:

- An area 1,200 × 500 meters will provide ample space for the entire range. Requirements for the range are maximum range plus 420 meters.
- The location of the OPs should be outside the lateral safety limits. The burst is visable for approximately 1,000 meters during daylight. Personnel should not be permitted between the weapon and the near limit of the impact area.
- Normal survey operations are required; however, each 1 meter established is equivalent to 10 meters on the firing chart or special map.
- Level terrain should be improved with constructed terrain features and manmade features to provide the most effective training. After the area is prepared, maps should be constructed for use on the range.
- The mapboard should be approximately 16 inches square, including the border with the gridline numbers.

● Observed fire fans, scale 1:50,000, should be used with the prepared maps.

EMPLACING THE TRAINER

To emplace the trainer in position—

● Spread the two front legs of the tripod about 55 inches apart and lock in place.

● Extend the rear leg to its full length (60 inches) and lock in the spread/extended position.

● Secure the mount assembly to the tripod by tightening the mount locking screw into the base of the mount assembly.

● Lock the barrel assembly to the mount assembly by placing the trunnions in the receivers and locking the trunnion caps.

● Attach the telescope socket assembly to the mount assembly by tightening the telescope locking screw.

● Rough level the mount by moving one of the front legs and the rear leg in or out.

● Center the cross-level bubble by extending one front leg and shortening the other. Center the longitudinal level bubble by lengthening or shortening the rear leg. When both bubbles are centered, the mount is level.

● Place the panoramic telescope in the telescope socket.

Like other indirect fire weapons, the trainer should be boresighted before it is fired—the distant aiming point method of boresighting is used.* The distant aiming point should be at least 700 meters from the trainer. The same steps in boresighting any other field artillery weapon are followed in boresighting the trainer, except that the bolt less the firing pin is used for the rear boresight disk. A breech boresighting disk can be made by drilling a hole in the center of a used cartridge case. This saves the time required to disassemble and assemble the bolt.

TM 9-6920-221-13 contains all the necessary information to set up, use, and maintain the 14.5-mm field artillery trainer, including Federal stock numbers for ordering repair parts. A crew of two can service the trainer during firing—a gunner, who lays the weapon for direction and fires the piece, and an assistant gunner, who levels the mount, loads the piece, and lays for elevation.

Under those conditions where space is limited or there is no training area nearby, the 14.5-mm field artillery trainer M31 will be invaluable in training the forward observer if you prepare the range and provide the observer with a special map. The savings in ammuntion cost and manpower will more than offset the time and manpower required to develop a good training facility for the 14.5-mm trainer, and this facility can also be used to train or familiarize supported infantry or armor personnel in the adjustment of field artillery fire.

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* *A related article titled "Shoot Without Shell" appeared in the July 1965 issue of* **Artillery Trends**.

For Intrabattery Communication

Radio/Wire Integration

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In order for a field artillery firing battery to provide effective fire support, it must have an efficient and reliable communication system. This system must provide the means for controlling the battery and exercising supervision over fire direction. At present, the firing battery is controlled by a field telephone intercommunication system that links together the FDC, executive officer, and each howitzer section.

This system is restrictive because the executive officer must remain near his telephone set in order to retain control of the firing battery. Under the roving executive officer concept, the battery recorder carries the telephone which is connected into the wire system by a long wire

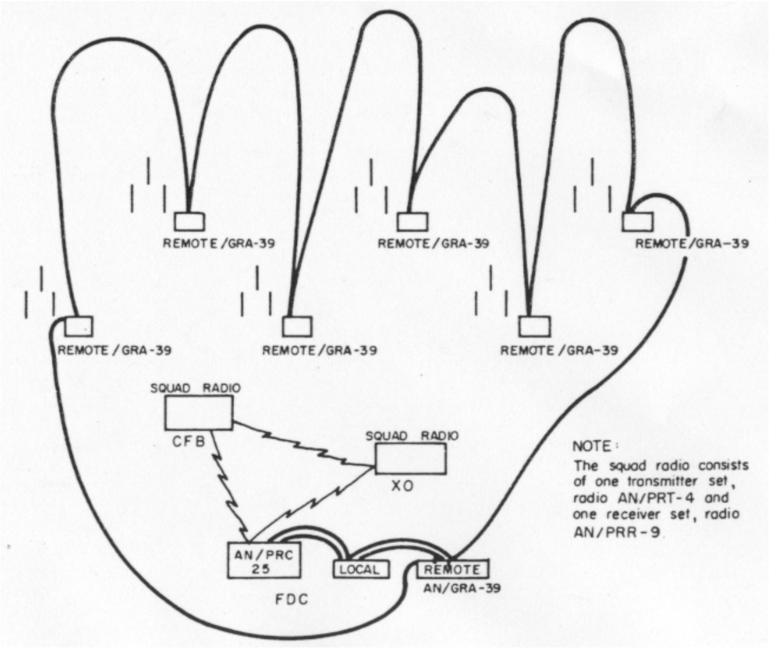

Figure 1. Battery System AN/PRC-25 and squad radio used with radio set control group AN/GRA-39.

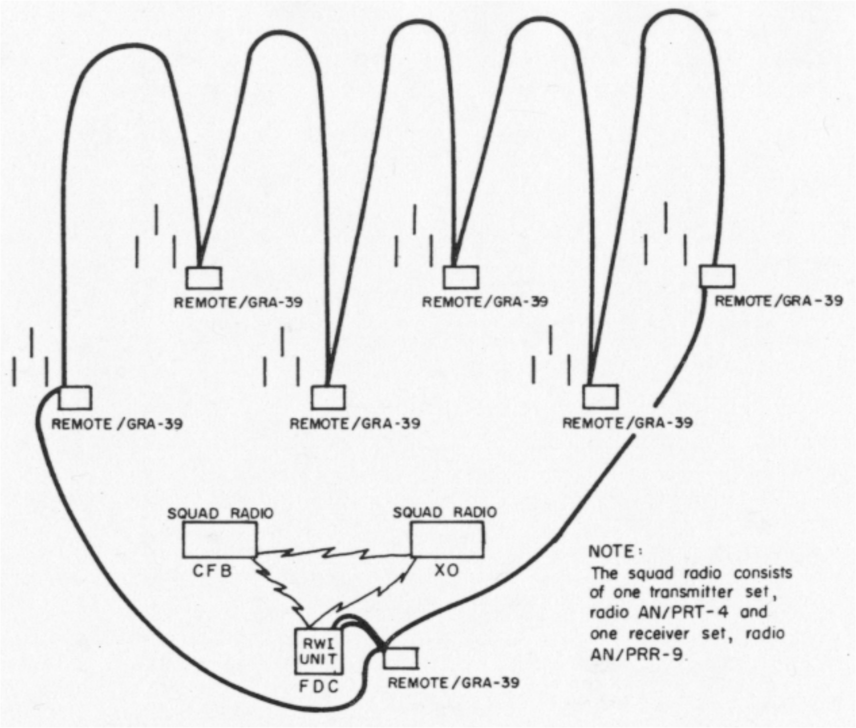

Figure 2. Bilateral retransmission device and squad radio used with remote unit of the radio set control group AN/GRA-39.

line. Additionally, this system allows only the personnel using the telephone at each location to monitor fire commands.

Now, with the advent of new electronic equipment, systems have been developed which allow the executive officer to move about freely and which provides sufficient audio to enable all personnel within the howitzer sections to hear each fire command. Figures 1 and 2 show the interim and proposed systems that are expected to replace the current field telephone system.

The interim system (fig 1) is composed of equipment that is currently standard A. This system requires one radio set AN/PRC-25, two transmitter sets, radio, AN/PRT-4, two receiver sets, radio, AN/PRR-9, one radio set control group AN/GRA-39, field wire WD-1/TT and six controls, radio set C-2328/GR (the AN/PRT-4 and AN/PRR-9 together are known as the squad radio).

The proposed system (fig 2) is composed of two transmitter sets, radio, AN/PRT-4, 2 receiver sets, radio, AN/PRR-9, seven controls, radio set C-2328/GR, field wire WD-1/TT, and one bilateral retransmission unit C-7772. The C-7772 is a developmental device that provides not only a radio/wire integration capability, but also a retransmission means for the squad radio. It also may be used with either the radio set AN/PRC-25, remote unit AN/GRA-39, or the AN/VRC-12 series radios. The retransmission unit is currently undergoing tests and is being toughened at the U. S. Army Limited War Laboratory, Aberdeen Proving Grounds, Maryland.

The advantages of the two systems over the standard wire system are as follows:

- Allows the executive officer to control the battery from any location within operating range of the squad radio.
- Amplifies the audio signal at each howitzer section, enabling all personnel to hear the commands and thereby minimizing errors.
- Provides a more rapid and effective method of laying the battery during initial occupation of position prior to installing field wire to each howitzer. This is especially true under high noise conditions where voice relay can be ineffective.
- Allows the chief of firing battery to actively assist in controlling conduct of fire without having to rely on voice relay when simultaneous missions are in progress.

It is anticipated that the equipment will be added to the Tables of Organization and Equipment of Field Artillery units in the near future. The systems are discussed in detail in a Reference Note, CCS 10, which was recently prepared by the Communication/Electronics Department, United States Army Field Artillery School. Units may obtain this reference note by writing to the Non-Resident Instruction Department, USAFAS, Fort Sill, Oklahoma, 73503.

HELICOPTER RECORD

The UH-1 Research Compound Helicopter set an unofficial world speed record of 316 miles per hour during recent testing. The aircraft is currently being developed under contract with the Army Aviation Material Laboratories.

XM164 Howitzer

CPT David E. Knop
U.S. Marine Corps

The need for a lightweight, helicopter-transportable, direct support artillery piece capable of firing both standard- and rocket- assisted ammunition has existed for some time. Ideally, such a weapon would replace the relatively heavy 105-mm howitzer M101A1 and the short-range 4.2-inch mortar M30.

The first weapon developed with these required characteristics was the US Army's M102. The M102, developed specifically for airmobile units, failed to meet the US Marine Corps requirements calling for, not only a lighter piece, but one which could operate efficiently under all climatic and soil conditions. Therefore, after service testing the M102 in 1966 the Marine Corps began the development of its own 105-mm howitzer. This first attempt at developing a lightweight howitzer resulted in the XM154, a stripped-down version of the M101A1. An aluminized version of the M101A1 (the XM153), which weighed only 3,500 pounds, was also designed and built. Both versions of the redesigned M101A1 were found to be unsuitable for field artillery use; therefore, the Commandant of the Marine Corps authorized the development of a completely new howitzer, the XM164.

The XM164 prototype is a split-trail howitzer constructed of lightweight aluminum on a high-strength steel support mechanism. Its cannon and fire control equipment are similar to that of the M102, but the breech mechanism is similar to the breech mechanism on the older M101A1. The variable-recoil mechanism eliminates the requirement for a high-angle pit. A unique quick-release lock allows the recoiling parts to be moved out of battery to the rear of the piece, thus permitting the overall length of the howitzer to be shortened 52 inches. This characteristic

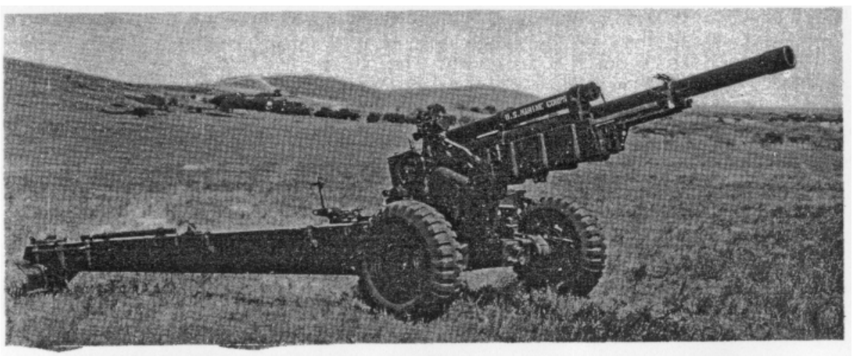

Figure 1. 105-mm lightweight towed howitzer XM164.

greatly increases the weapon's ease of handling in cramped spaces and decreases the clearance required for many of the Navy's shiploading ramps.

Another advantage over the M101A1 is the reduction of weight by 1,300 pounds. Although the XM164 weighs 400 pounds more than the M102, this will not decrease its transportability by today's modern helicopters. The elevation limits of the XM164 are the same as those of the M102. The traverse capability of the XM164 is the same as that of the M101A1; however, because of its aluminum construction, the XM164 is easier to manhandle throughout a 6,400-mil sector of fire in all types of terrain.

In March 1967, service testing of the XM164 began at Camp Lejeune and Fort Bragg, North Carolina. A total of 1610 rounds, including 100 rounds of charge 8 ammuition, was fired. (The original prototype was equipped with a muzzle brake for this purpose.) The prototype was also tested for trafficability and salt water durability. Two crews were used to fire the experimental howitzer and the control M101A1 howitzer that accompanied the test weapon. The aluminum howitzer offered a significant advantage in maintenance over previous artillery pieces. The need for a high-angle pit for the XM164 was found to be nonexistent because of the variable-recoil system. During the tests, crew members were enthusiastic about the new series of fire control instruments used on the XM164. Throughout the firing tests, the XM164 proved to be generally as stable as the M101A1. In a direct fire situation, the XM164 proved to be extremely accurate. Later tests conducted at Aberdeen Proving Grounds indicated that the XM164 is at least as accurate and stable as the M101A1.

The tests at Camp Lejeune and Fort Bragg uncovered undesirable features as well. For example, excessive overpressure was experienced by the crew members while firing charge 8 ammunition. It was felt, however, that the efficiency of the crew would not be significantly diminished unless the firing of charge 8 was continued for several hours.

Six XM164 prototypes have been constructed for service and environmental tests by the US Army Test and Evaluation Command; one is under evaluation by the Australian Army.

At Fort Sill an XM164 prototype was recently service tested for durability, transportability by air and land, and ease of maintenance. The test weapon fired 10,000 EFC rounds of standard and experimental ammunition under various actual and simulated conditions, was towed to total of 2,000 miles, and was air and helicopter lifted to test its transportability. The ultimate purpose of the tests was to determine whether the XM164 howitzer was a suitable replacement for the M101A1 and M102 howitzers for the Marines. An additional phase of service tests is scheduled to begin at Fort Sill early this year.

The XM164 **could** be fielded in 1972, however several problems must be resolved prior to its adoption. Among these are cost considerations, radically new developmental concepts that deserve prior consideration, and the present stockpile of 105-mm howitzers.

Locating Sensors With Q-4 Radar

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Recognizing that unattended ground sensors are excellent target acquisition means when they are accurately emplaced, the Target Acquisition Department of the United States Army Field Artillery School tested the feasibility of using the countermortar radar set AN/MPQ-4A to position-fix and vector a helicopter to a preselected area and to accurately locate the impact point of a sensor dropped from the helicopter. Test results confirmed the feasibility of the concept. Accuracies averaging less than 35 meters in radial error were attained.

During the tests the AN/MPQ-4A radar crew vectored the helicopter to preselected points and then determined the sensor impact point when the sensor was dropped from the helicopter. Changing the direction of flight and the aspect angle appeared to have no appreciable effect on the accuracy of sensor location.

When the AN/MPQ-4A is used in this role, three techniques must be understood—position fixing, vectoring, and sensor location. Accurate position fixing, vectoring, and sensor location require communication and electronic line of sight between the radar and the aircraft.

MISSION PREPARATION

Prior to the flight the pilot is briefed on the procedures to be used during the mission. Instructions should include the altitude of the flight (1,000 to 1,500 feet), speed between the rendezvous and drop points (80 knots), radio frequency, call sign, and identification of the pickup point. The radar crew plots on the radar chart (fig 2) the radar position, the approximate pickup point, the rendezvous point, the countdown point, the sensor release point, and the impact point and connects the rendezvous point and impact point with a line. The polar coordinates of all points except the pickup point are determined and recorded. The rendezvous point may be any convenient point near the sensor drop zone provided the radar beam can cover both the rendezvous point and the sensor release point. The sensor release point is plotted 200 meters from the impact point along the line connecting the rendezvous point and impact point. The countdown point is plotted 250 meters from the sensor release point along the same line and represents the distance the aircraft travels in 6 seconds at a speed of 80 knots. The approximate heading from the pickup point to the rendezvous point is determined and recorded. The actual heading is determined after the radar acquires the aircraft in flight over the pickup point. Next, the heading in degrees from the rendezvous point to the drop point is determined and recorded. These headings will be given to the pilot during flight.

Each set of polar coordinates recorded above is placed on the weapon location coordinate counters, using the lower beam azimuth and range handwheels. As each set of polar coordinates is set on the counters, the intersection of the azimuth and range strobes is plotted on the B-scope. A line connecting the rendezvous and impact points is drawn on the B-scope (fig 3).

Figure 1. AN/MPQ-4A countermortar radar set.

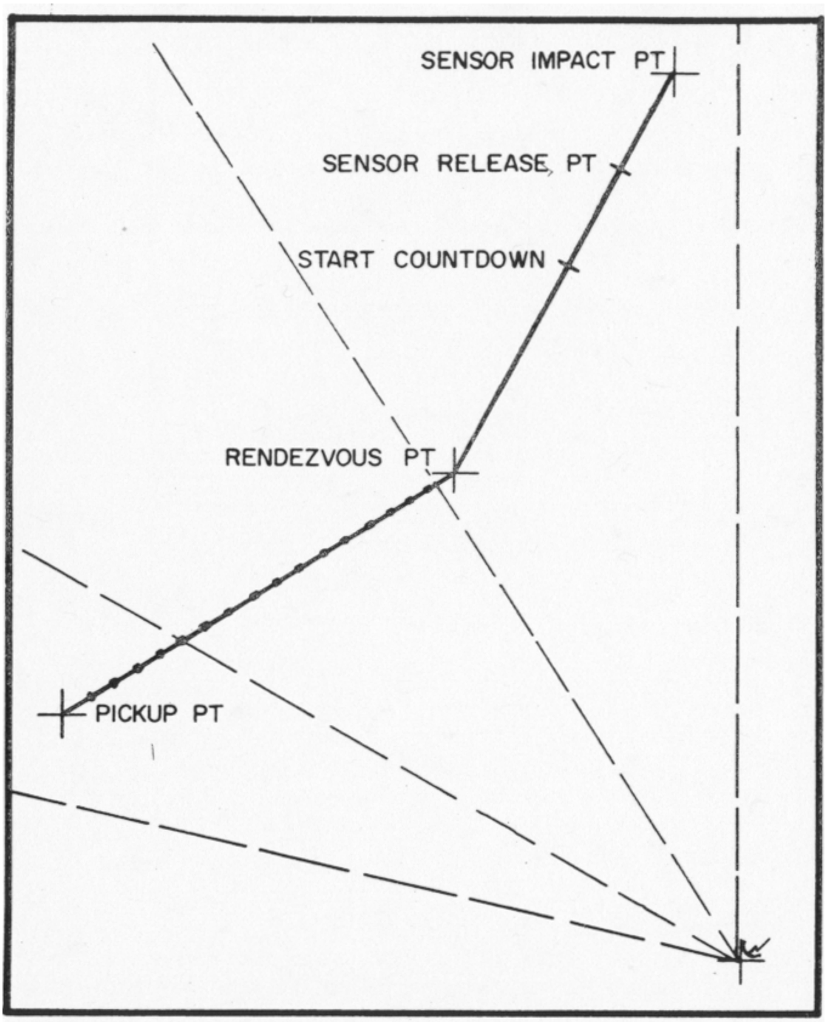


Figure 2. Plotting on the radar chart.

POSITION FIXING

A prominent terrain feature identifiable by both the radar section and the pilot is selected as the radar pickup point, and the pilot is directed to fly to that point. The set is placed in the RANGE SHIFT OFF position, beam video switch in the lower position, and the radar beam is laid over the selected area. The area is then scanned in azimuth and elevation until the helicopter appears on the B-scope. Positive identification of the helicopter is required and may be accomplished by having the pilot fly in a "racetrack" pattern. When the helicopter is identified, the helicopter position is determined (position fixed) by placing the azimuth and range strobes over the leading edge of the aircraft echo on the scope. The coordinates are then read directly from the coordinate counters.

VECTORING

Vectoring is a technique used to direct the aircraft to a desired point in space. The true aircraft position is plotted on the radar chart, and a true heading in degrees from the aircraft to the rendezvous point near the sensor impact area is determined and transmitted to the pilot.

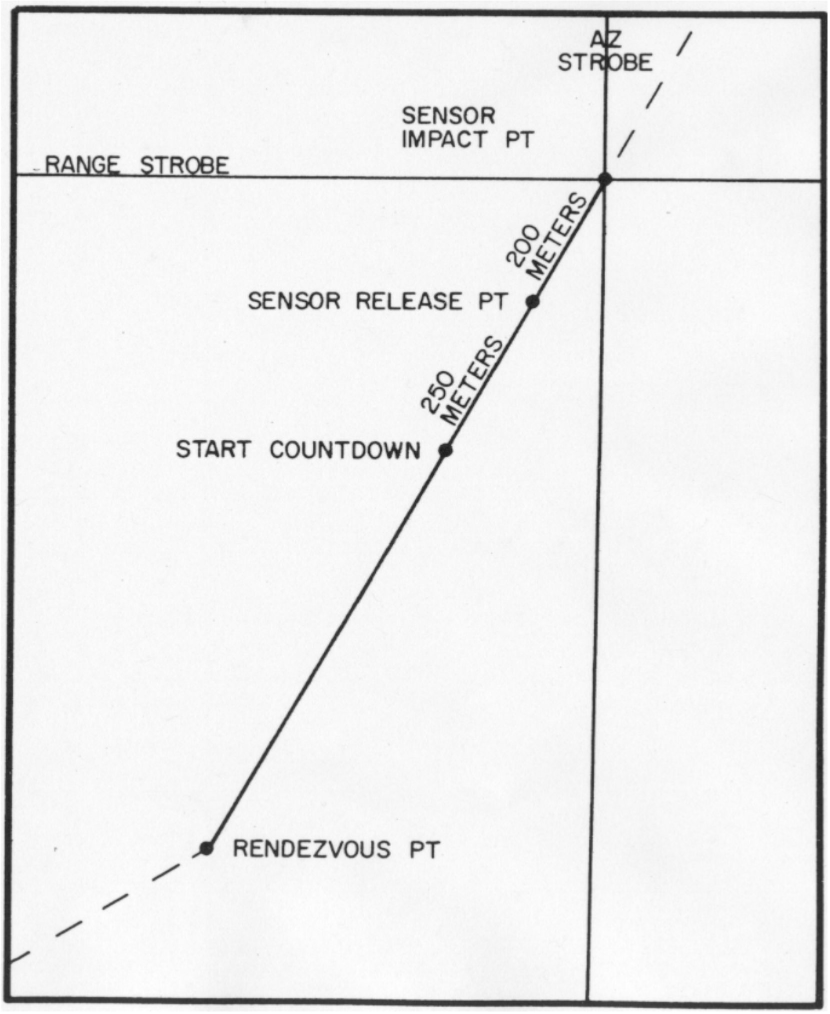


Figure 3. Lines drawn on B-scope.

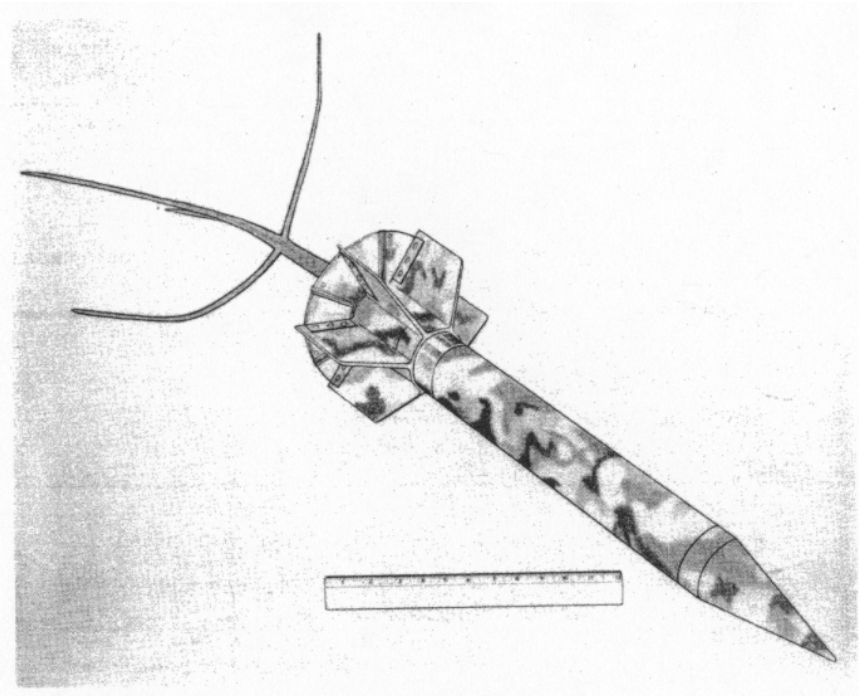


Figure 4. Airdropped sensor.

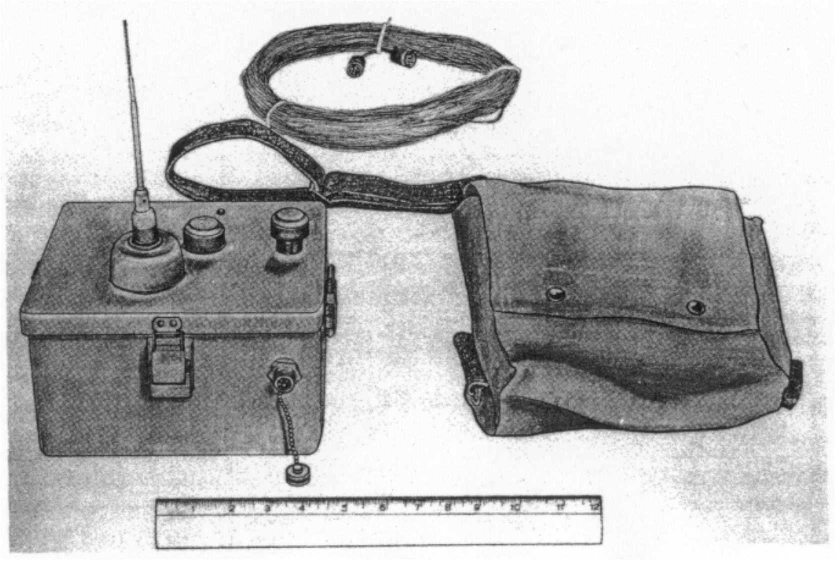


Figure 5. Hand-emplaced sensor.

At the expected time of arrival of the helicopter over the rendezvous point, the radar crew searches in elevation until the helicopter is detected. The pilot is then given the heading from the rendezvous point to the impact point, which was determined during mission preparation. The aircraft echo will be seen as it follows along the line drawn on the B-scope between the rendezvous point and impact point. Simple left and right corrections may be necessary to keep the pilot on the precise course to his destination.

DROP TECHNIQUE

When the target is well defined, visual drop procedures may be employed and no special instructions are necessary. However, when the target is ill defined, at night, or when a precise drop is required, the following procedures should be employed:

- When the helicopter arrives at the countdown point, the radar timer is started and the countdown begins—5, 4, 3, 2, 1, DROP.
- During the countdown the radar beam is lowered to minimum elevation to detect and locate the sensor as near to the impact points as possible.

LOCATING AIRDROPPED SENSORS

In locating a sensor dropped from an aircraft, only the single beam is used. The beam is set to the lowest elevation which will allow electronic line of sight between the radar and the drop zone.

When the sensor is detected on the B-scope, the point at which the echo disappears is strobed, using the lower beam range and azimuth handwheels. The coordinates to this point are read and recorded as the sensor location.

LOCATING HAND-EMPLACED SENSORS

Hand-emplaced sensors may be quickly and accurately located, using any of the following procedures:

- Fire a rifle grenade from the sensor site at maximum safe elevation and use the AN/MPQ-4A to locate the position.
- Attach a corner reflector to a weather balloon tethered by a string at the sensor site. The AN/MPQ-4A can locate the position within 50 meters.
- Have a helicopter hover over the sensor and use the AN/MPQ-4A, the AN/TPS-25, or the AN/PPS-5 to determine the coordinates.
- If line of sight between the sensor and radar exists, have a man at the sensor swing a steel helmet and use the AN/TPS-25 or AN/PPS-5 to locate the position.

If you are in the sensor business and need help in determining coordinates, see if one of these radar sections is near you. Perhaps there is one in your area just waiting to help you.

SAMODEAD

The growth and success of airmobile operations in Vietnam has shown the value of airmobile operations in an unconventional (guerrilla and/or jungle) war. Since the US Army must be prepared for all types of warfare, the Army is conducting various studies to determine how airmobile tactics and organizations could best be applied in conventional warfare. One of these studies is entitled "Support of Airmobile Operations Through Destruction of Enemy Air Defense Systems" (SAMODEAD).

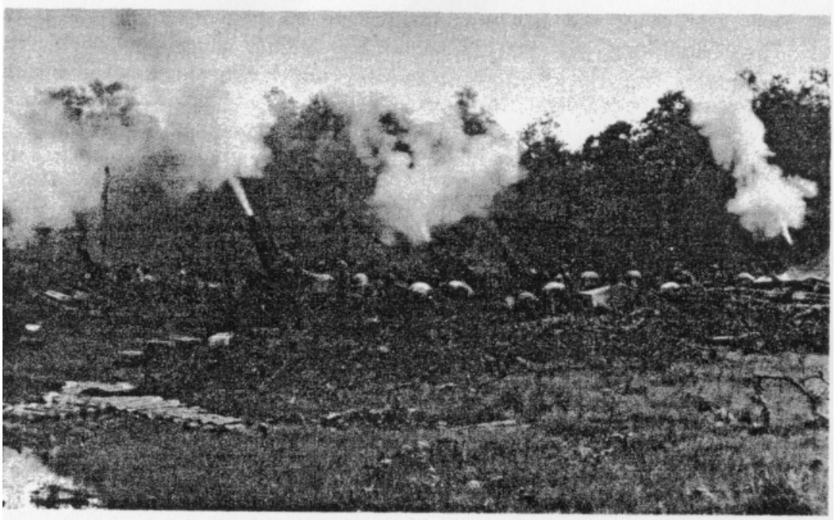
As the name implies, SAMODEAD is directed toward determining the ability of fire support organizations to support airmobile operations by neutralizing or destroying the enemy's air defenses. This ability of support units is very important to the staying power of airmobile forces against sophisticated forces in a conventional combat situation. The findings and requirements of the SAMODEAD study should prove to have a great deal of influence on future doctrine and materiel for fire support weapon systems.

The SAMODEAD study is designed to relate to and have impact on other studies involving airmobile operations or helicopter employment. Related studies include the Aerial Reconnaissance and Surveillance Survivability Analysis (ARSSA), the Airmobility in the Mid/High Intensity Environment study (AM/HI), the Utility Tactical Transport Aircraft System study (UTTAS), the Family of Army Aircraft Systems study (FAAS-85), and the Aviation Organization Requirements for the Army study (AORTA). The U.S. Army Combat Developments Command Field Artillery Agency, Fort Sill, Oklahoma, is conducting the SAMODEAD study and receives input from the U.S. Army Combat Developments Command Combat Support Group, the U.S. Army Combat Developments Command Infantry Agency, the U.S. Army Field Artillery School, and the U.S. Army Combat Developments Command Air Defense Agency.

The Field Artillery Agency is being supported by the Combined Arms Research Office, a division of Booz-Allen Associates, which will provide systems effectiveness data for all fire support weapons in the attack of enemy air defense systems. Based on analyses of this data, the Field Artillery Agency will determine the optimum organizations and weapon systems to support airmobile operations and will then evaluate these cannon, missile, and aircraft systems in simulations against the actual enemy air defense threat in the tactical air defense computer simulation model (TACOS II), developed by the Air Defense Agency, Fort Bliss, Texas. The Field Artillery Agency will then analyze the results of computer simulations to provide an effectiveness spectrum reflecting the range of fire support capabilities which can be achieved to counter enemy air defense.

Finally, the Field Artillery Agency will conduct sensitivity analyses of new weapon systems which may be introduced near the end of the 1970-1975 period to measure their impact on the overall SAMODEAD picture. The Field Artillery Agency will identify changes required in current tactics and doctrine along with materiel requirements.

Southeast Asia



LESSONS LEARNED

The following material is extracted from correspondence from US field artillery units in Southeast Asia and from after action reports distributed by the Department of the Army. However many of the items are field expedients adaptable only to stability operations, and therefore do not always represent official US Army Field Artillery School doctrine.

CONCEALMENT OF THE AN/MPQ-4A RADAR

The enemy apparently is aware of the limited sector of scan of the AN/MPQ-4A radar. On numerous occasions, an enemy attack has been launched while the radar was pointed in a direction other than that of the attack. A method of denying the enemy knowledge of the direction of scan without degrading the capabilities of the radar has been devised. Four uprights extending above the top of the antenna are erected on the radar platform and a parachute is draped over the uprights and antenna. Additionally, the unit in control of the radar should relocate the radar periodically and leave the camouflage covers in place as a dummy site.

LOCATION AND PROTECTION OF MEDIUM OR HEAVY ARTILLERY

Medium and heavy artillery pieces should not be placed in position on a fire support base perimeter, since they are intended for long-range heavy fires. The high-explosive ammunition used by medium and heavy artillery is not as effective as the beehive ammunition used by the light artillery (for close-in defensive fires), and the large silhouette causes medium and heavy artillery to be an almost certain target in a perimeter attack. These pieces are best employed in an interior central location in the fire support base, with the SP crew compartments open toward the interior of the position for ease of movement during an attack. Their positions can be enhanced by shields of earth constructed with a bulldozer and by chain link fences, which detonate enemy projectiles before they strike the metal of a weapon.

A SEAT FOR THE M102 GUNNER

Switching from the M101 105-mm howitzer to the new lightweight M102 howitzer has posed few problems for using units. However, there has been one complaint expressed by almost all gunners using the piece. Because of the new howitzer's low silhouette, which is essential to stability and ease of concealment, the gunner must constantly crouch or squat to take up a proper sight picture through the panoramic telescope.

Expedient seats, such as fuze cans and ammunition crates, have proved less than satisfactory. It was noted by one unit that the British 25-pounder is equipped with a gunner's seat. A unit in the field set out to design and build a comparable item, bearing in mind, among other requirements, that no permanent alteration of the howitzer is authorized. The end product is the seat shown in the figures. The seat itself is a salvaged jump seat from an M113 armored personnel carrier and is the only standard item. The rest of the material is simply scrap metal normally available in a local salvage yard.

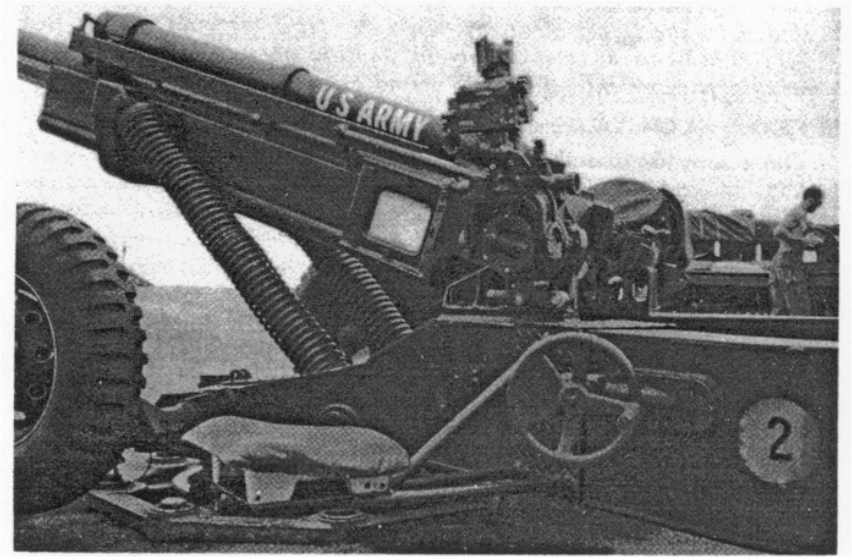


Figure 1. M102 with gunner's seat.

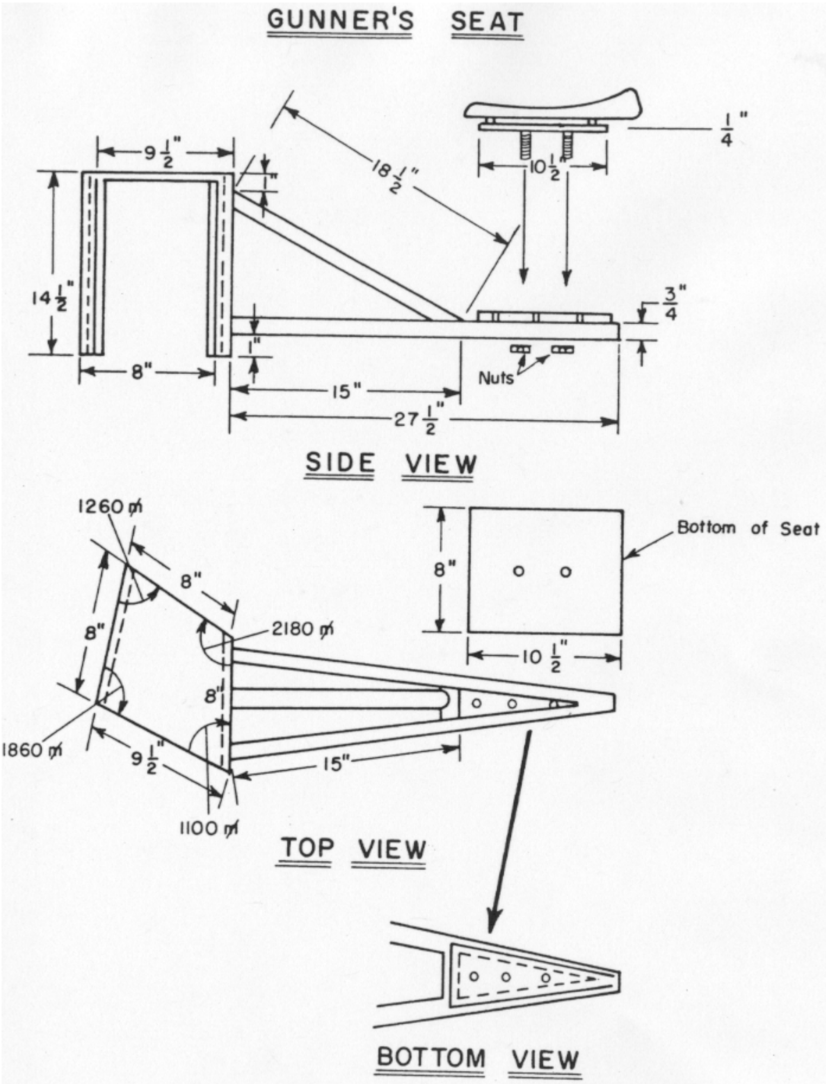


Figure 2. Gunner's seat parts detail.

The seat is attached to the howitzer by means of a mounting bracket made from three pieces of steel plate cut to conform to the shape of the box trail. The mounting bracket is slipped over the trail member and is secured by means of a slip-on strap crossing underneath the trail. The seat weighs about 25 pounds and can be mounted or removed in just a few seconds. The four fiberglas "feet" on the salvaged seat are bolted to another piece of steel plate, which is in turn affixed to a smaller plate by two bolts. The smaller plate contains a 6-inch slot in which the bolts travel, making the seat adjustable backward and forward for about 4 inches. Three lengths of ordinary lightweight steel pipe form the connection between the seat mounting and the trail bracket. Arc welds are used throughout.

The seat has reduced fatigue among gunners and has permitted a much more uniform sight picture. Although the increase in accuracy and the safety gained are clearly not measurable, they appear to be significant. The users are enthusiastic about the device, commenting particulary on its value in the considerable deflection changes required by zone sweeping fires.

Status of Firing Tables And FADAC Tapes

The use of the correct and current firing data source is, of course, essential for accurate and safe delivery of field artillery fires. Numerous materiel developments and product improvements which have vastly expanded possible weapon/ammunition combinations have been introduced in recent years. Since many of these combinations are ballistically dissimilar, separate firing data are required for each combination; therefore, several different firing tables are required in each unit. Additionally, published tables and tapes must be revised with each materiel or procedural improvement,

The U. S. Army Field Artillery School has received numerous requests for information regarding the status of firing tables and FADAC tapes. The School has therefore prepared a list of firing tables and FADAC tapes to be used for specific weapon/ammunition combinations. This list should assist field artillerymen in selecting the correct and current firing data source. Similar information will be included in future issues of **THE FIELD ARTILLERYMAN.** Except as noted, tabular firing tables (TFT) should be requisitioned through AG publication channels and graphical firing tables (GFT) and FADAC tapes should be requisitioned through normal supply channels.*

**A related article titled "Graphical Firing Tables" appears in the Instructional Department Notes of this issue.*

GRAPHICAL FIRING TABLES

Weapon	Based on TFT	Description	FSN	Number of Rules	Line Item Number
105-mm Howitzer					
M101A1	105-H-6	GFT for M1 HE (LA & HA)	1220-815-6192	2	S45365
	105-H-6, wC2	GFT for M314 Illum	1220-978-9585	2	S45502
	105-H-6 wC7	*GFT for M1 HE	1220-937-8279	3	S45450
	105-H-6	GST	1220-815-6190	1	S45639
	105-H-6	**GFT for HA only	TBA	1	TBA
M102/M108	105-AS-1	GFT for M1 HE (LA & HA)	1220-764-5419	2	S47881
	105-AS-1	GFT for M314 Illum	1220-764-5418	2	S47891
	105-AS-1	GST	1220-764-5422	1	S45664
	105-AS-2, wC1	*GFT for M1 HE	1220-937-8280	3	S45435
	105-AS-2	**GFT for HA only	TBA	1	TBA
155-mm Howitzer					
M114A1/ M123A1	155-Q-3	GFT for M107 HE (LA & HA)	1220-789-2985	2	S46187
	155-Q-3	GFT for M118 Illum	1220-898-4212	2	S46324
	155-Q-3	GST	1220-789-2986	1	S46461
	155-Q-4, wC2	*GFT for M107 HE	1220-937-8281	3	S45475
	155-Q-4	GFT for M485 Illum	1220-133-6219	2	TBA
	155-Q-4	**GFT for (GB & WB)	TBA	1	TBA
	155-AH-1	GST	1220-764-5421	2	S47911
	155-AH-1	GFT for M118 Illum	1220-764-5420	2	S47901
	155-AH-1	GFT for HA (GB)	1220-764-5423	1	S46237
	155-AH-1	GFT for HA (WB)	1220-764-5426	1	S46262
	155-AH-2	*GFT for M107 HE	1220-937-8282	3	S45465
	155-AH-2, wC1	GFT for M485 Illum	1220-442-2444	2	Z64992
	155-AH-2	**GFT for HA (GB & WB)	1220-113-7435	1	TBA
8-inch Howitzer					
M110/M115	8-J-3	GFT for M106 HE (LA & HA)	1220-898-4213	2	S46872
	8-J-3	GST	1220-898-6786	1	S47009
	8-J-4	*GFT for M106 HE	1220-937-8283	3	S45482
	8-J-4	**GFT for HA only	TBA	1	TBA
	8-0-3	GST	1220-876-8573	1	S46735
	8-0-4	*GFT for M424 HES	1220-937-8284	2	S45487
175-mm Gun					
M107	175-A-0 (Rev II)	*GFT for M437 HE	1220-937-8285	2	S45492
	175-A-0 (Rev II)	GST	1220-937-9522	1	Z65189
***14.5-mm trainer		GFT	1220-442-2446	1	Z65194

* Denotes slant scales
** Available third quarter FY 70
***Requisitioned through local training aids support center

CANNON TABULAR FIRING TABLES
105-mm Howitzer

M101A1

Current

FT 105-H-6 (Nov 61)
(basic FT)
C2 (Apr 62)
(For subzone & M314 illum & M327 HEP)
C6 (Jun 66)
(for M314A2E1 illum w fuze MT M565)
C7 (Dec 67)
(for fuze MTSQ M564)
C8 (Feb 69)
(for fuze VT M513 series w cap XM5)
C9 (Jun 69)
(for beehive XM546 w fuzes XM563E2, E3, & E4)

FT 105 ADD-B-2 (Nov 68)
(for M444)
C1 (Nov 68)
(close-in support card)

[1]FT 105 ADD-A-O (Rev) (Mar 68)
(for M413)

FT 105 ADD-D-O (Rev II) (Jun 67)
(for beehive XM546 w fuze XM563E1 only)

FT 105-H-6 WC (Apr 69)

[1]FT 105-AV-O (C)
(for RAP XM548E1)

FT 105-H-6 (prov supp 1) (Nov 67)
(for CS XM629)

To be published

FT 105-H-6, C10 (May 70)
(for HEAT XM622) (interim)

FT 105-AV-1 (Jun 70)
(for RAP XM548) (interim)

M102 and M108

Current

FT 105-AS-2 (Nov 67)
(basic FT)
C1 (Nov 67)
(to use w M102)
C2 (Feb 69)
(for fuze VT M513 series w Cap XM5)
C3 (Jun 69)
(for beehive XM546 w fuzes XM563E2, E3, & E4)

FT 105 ADD-E-O (Rev II) (Jan 67)
(for beehive XM546 w fuze XM563E1 only)

FT 105 ADD-F-1 (Aug 68)
(for M444)
C1 (Sep 68)
(close-in support card)

[1]FT 105-AR-O (Rev II) (Dec 63)

[1]FT 105-AU-O (Sep 67) (C)
(used with 105-AR-O for RAP XM548E1)

FT 105-AS-2 WC (Sep 68)

FT 105-AS-2 WC (prov supp 1) (Nov 67)
(for CS XM629)

To be published

FT 105-AS-2, C4 (May 70)
(for HEAT XM622) (interim)

FT 105-AU-1 (Jun 70)
(for RAP XM548E1) (interim)

[1]Requests for these tables should be made to: Commanding Officer, Ballistic Research Laboratories, ATTN: AMXRD-BED, Aberdeen Proving Ground, Maryland 21005.

155-mm Howitzer

M114A1 and M123A1

Current

FT 155-Q-4 (Mar 68)
(basic FT)
C2 (Apr 69)
(for prop chg M3A1 & M4A2)

FT 155 ADD-C-1 (Apr 68)
(for M449A1 (M449E2)
C1 (Apr 68)
(close-in support card)
C2 (Apr 68)
(for prop chg M3A1 & M4A2)

FT 155 ADD-A-1 (Aug 62)
(for M449)
C2 (Sep 65)
(for M449E1)
C4 (Oct 66)
(close-in support card)
C5 (Jan 68)
(for fuzes MTSQ M548 & MT M565)

FT 155-A1-2 (May 69)
(for XM454 nuc)

FT 155-Q-4 WC (Aug 69)

To be published

FT 155-ADD-F-1 (Mar 70)
(to replace ADD-A-1 & ADD C-1 w changes for M449, M449E1, & M449A1)
C1 (Mar 70)
(close-in support card)

M109

Current

FT 155-AH-2 (Jul 65)
(basic FT)
C1 (Jun 67)
(for M485 series illum)
C2 (Oct 67)
(for fuzes MTSQ M564 & MT M565)
C4 (Apr 69)
(for prop chg M3A1 & M4A2)

FT 155 ADD-B-1 (Nov 67)
(for M449A1 (M449E2))
C1 (Nov 67)
(close-in support card)
C2 (Apr 68)
(for prop chg M3A1 & M4A2)

FT 155 ADD-D-1 (Aug 68)
(for M449)
C1 (Aug 68)
(close-in support card)

FT 155 ADD-A-1 (Aug 62), C2 (Sep 65)
(used w FT 155 ADD-D-1 for M449E1)

FT 155-AJ-2 (May 69)
(for XM454 nuc)

Aiming Data for XM549 with M109 (C)

FT 155-AH-2 WC (Rev) (Feb 68)

To be published

FT 155-AK-1 (Mar 70)
(for XM483E1) (Interim)

FT 155-AN-1 (Mar 70)
(for RAP XM549)

FT 155 ADD-E-1 (Mar 70)
(to replace ADD-B-1 & ADD-D-1 w changes for M449, M449E1, & M449A1)
C1 (Mar 70)
(close-in support card)

[1]Requests for these tables should be made to: Commanding Officer, Ballistic Research Laboratories, ATTN: AMXRD-BED, Aberdeen Proving Ground, Maryland 21005.

8-Inch Howitzer and 175-mm Gun

M110	M107
Current	**Current**
FT 8-J-4 (Jun 67) (basic FT)	[1]FT 175-A-O (Rev II) (Feb 65) (basic FT)
FT 8-0-4 (Jun 67) (for M424 HES & M422 nuc)	[1]C1 (Jan 66) (gives MV corr for prop M86 series w additive jacket)
FT 8 ADD-A-1 (Nov 67) (for M404)	
C1 (Nov 67) (close-in support card)	
FT 8-J-4 WC (Jul 68)	
To be published	**To be published**
FT 8-0-4 WC (Mar 70)	FT 175-A-1 (Mar 70) (to replace FT 175-A-O (Rev II)
FT 8-P-1 (Mar 70) (for XM509) (interim)	C1 (Apr 70) (for WP XM510E1)
FT 8-ADD-B-1 (Mar 70) (for XM509) (interim)	

[1]Requests for these tables should be made to: Commanding Officer, Ballistic Research Laboratories, ATTN: AMXRD-BED, Aberdeen Proving Ground, Maryland 21005.

HONEST JOHN TABULAR FIRING TABLES
762-mm rocket MGR-1A (M31) series

FTR and changes	Launcher	Warhead	Remarks
762-E-1 (Apr 59)	M386		C1—Corrects FTR errors.
Change 1 (Sep 59)		M27	C2—E1, E2 and LLW tables.
Change 2 (Jul 60)		M47	C3—Conversion of NATO
Change 3 (Feb 61)		M48	met to US format.
762-F-1 (Apr 59)	M386	M6E1	C3—Conversion of NATO
Change 3 (Mar 67)		FSM38 MODS	met to US format.
		M144	
		M186	

762 ADD-A-1 (Nov 60) Change 2 (Mar 67)	M33 M289 M386	M144 M186	Applicable to FTR 762-A-2, FTR 762-D-1, and FTR 762-F-1. Instructions for use and an illustrated example are included in the introduction. C2—Adds warhead M186.
762 ADD-B-1 (Feb 61)	M386 M33 M289	M6E1	Applicable to FTR 762-A-2, FTR 762-D-1, and FTR 762-F-1. Instructions for use and an illustrated example are included in the introduction.

762-mm rocket MGR-1B (M50) series

FTR and changes	Launcher	Warhead	Remarks
762-G-1 (Jan 64) Change 1 (Jan 68)	M386	M27 M47 M48 M190	C1—Adds propellant weight correction factor table.
762-H-1 (Jul 63) Change 1 (Apr 66)	M386	M6E1 M144 M186 FSM38 MODS	C1—Makes certain corrections and adds M186 and M6E1 warheads to table and changes fuze setting correction table.
762 ADD-C-1 (Aug 63) Change 1 (Apr 66)	M33 M289 M386	M186 M144	For an example illustrating procedures, refer to 762-ADD-A-1. C1—Adds M186 warhead.
762 ADD-D-1 (Oct 64)	M33 M289 M386	M190	Applicable to FTR 762-G-1, FTR 762-I-1, and FTR 762-K-1. Instructions for use are included in the introduction.
762 ADD-E-1 (Nov 66)	M33 M289 M386	M6E1	Applicable to FTR 762-H-1.

FADAC PROGRAM TAPES

The following list of current FADAC tapes are designated issue 2 (revised) and supersede all other program tapes.

1. Cartridge assembly 8213330-64, FSN 1290-179-5347, for 105-mm M101A1 and 105-mm M102/M108.

2. Cartridge assembly 8213330-65, FSN 1290-179-5348, for 105-mm M101A1 and 155-mm M114A1.

3. Cartridge assembly 8213330-66, FSN 1290-179-5349, for 105-mm M101A1 and 155-mm M109.

4. Cartridge assembly 8213330-67, FSN 1290-179-5350, for 105-mm M102/M108 and 155-mm M114A1.

5. Cartridge assembly 8213330-68, FSN 1290-179-5351, for 105-mm M102/M108 and 155-mm M109.

6. Cartridge assembly 8213330-69, FSN 1290-179-5352, for 155-mm M109 and 155-mm M114A1.

7. Cartridge assembly 8213330-70, FSN 1290-179-5355, for 8-inch M110 and 155-mm M114A1.

8. Cartridge assembly 8213330-71, FSN 1290-179-5356, for 175-mm M107 and 155-mm M114A1.

9. Cartridge assembly 8213330-72, FSN 1290-179-5357, for 155-mm M109 and 8-inch M110.

10. Cartridge assembly 8213330-73, FSN 1290-179-5358, for 155-mm M109 and 175-mm M107.

11. Cartridge assembly 8213330-74, FSN 1290-179-5359, for 8-inch M110 and 175-mm M107.

12. Cartridge assembly 8213330-75, FSN 1290-179-3984, for 105-mm M101A1 and 8-inch M110.

13. Cartridge assembly 8213330-76, FSN 1290-179-3985, for 105-mm M102/M108 and 8-inch M110.

14. Cartridge assembly 8213330-77, FSN 1290-179-3986, for 105-mm M101A1 and 175-mm M107.

15. Cartridge assembly 8213330-78, FSN 1290-179-3987, for 105-mm M102/M108 and 175-mm M107.

16. Cartridge assembly 8213836-18, FSN 1220-016-0058, for 762-mm rocket (Honest John).

17. Kit, program tape, survey, cartridge assembly 8213315-36 (tape Nr1, Rev A) and cartridge assembly 8213315-37 (tape Nr2, Rev A), FSN 1220-999-6301.

L1136 Army-Fort Sill, Okla.