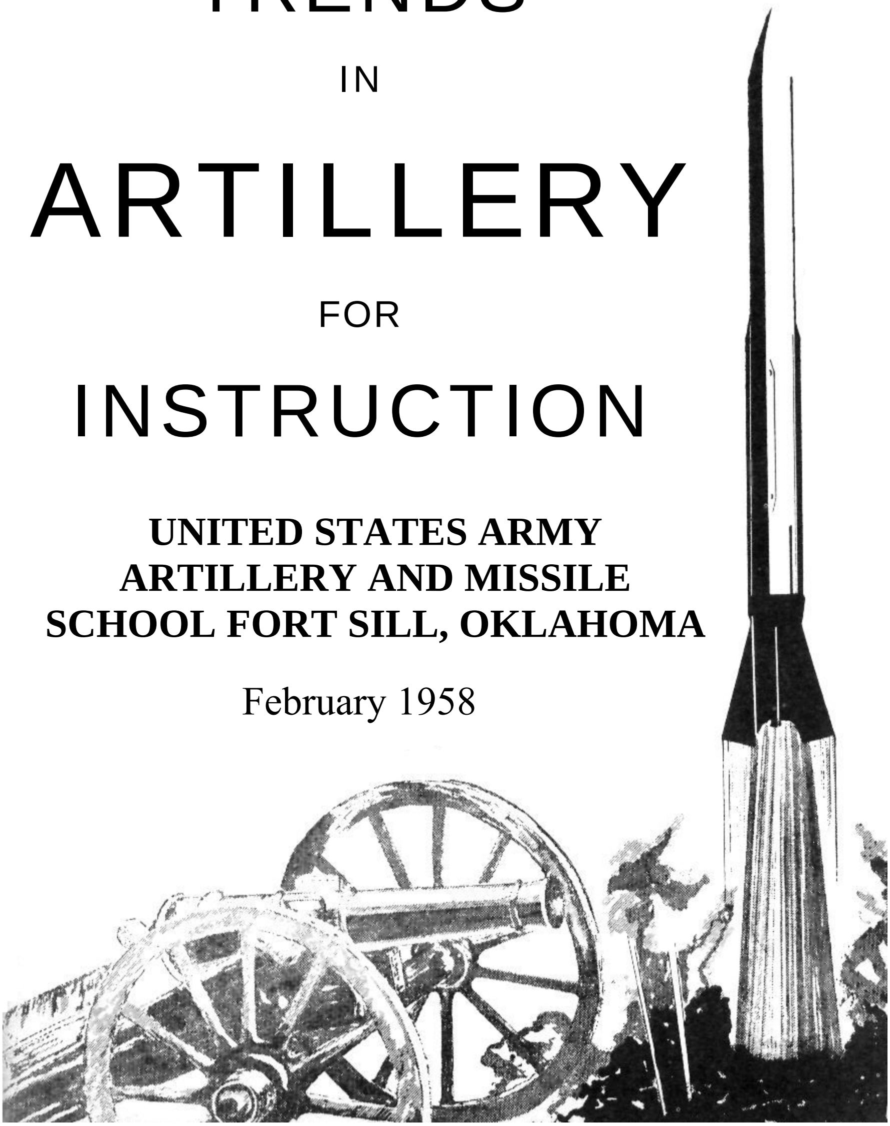
**T**actical and **T**echnical

# TRENDS IN ARTILLERY FOR INSTRUCTION

**UNITED STATES ARMY ARTILLERY AND MISSILE SCHOOL FORT SILL, OKLAHOMA**

February 1958



# UNITED STATES ARMY ARTILLERY

# AND MISSILE SCHOOL

1 February 1958

Trends in Artillery for Instruction is designed to provide tactical and technical information and data of importance to the artilleryman. The U. S. Army is currently going through its greatest tactical reorganization since 1940. Concurrently with this reorganization, new weapons and new tactics, to fit the atomic age, are being introduced and tested.

Through this training aid, the School endeavors to bridge the gap between the revision of manuals and other texts in order to keep artillery personnel abreast of new developments.

The School has no copyright on new ideas or on better methods and means to accomplish the artillery mission. Articles for publication as well as comments and suggestions are invited. Address all communications directly to: Assistant Commandant, U. S. Army Artillery and Missile School, Fort Sill, Oklahoma.

TACTICAL AND TECHNICAL

# TRENDS IN ARTILLERY FOR INSTRUCTION

Edited and published by the Department of Publications and Nonresident Training, U. S. Army Artillery and Missile School, Fort Sill, Oklahoma.

SHOOT MOVE COMMUNICATE

## CONTENTS

## NEW OFFICE ESTABLISHED

### *DEPUTY ASSISTANT COMMANDANT, RESEARCH AND DEVELOPMENT*

A recent addition to the organization of the U. S. Army Artillery and Missile School is the office of Deputy Assistant Commandant, Research and Development. The mission of this office is as follows:

Responsible to the Assistant Commandant for the coordination of the overall research and development program of the U. S. Army Artillery and Missile School; to supervise the long range development program of the Combat Development Department and the research and review activities of the academic departments; to present a coordinated School position to the Assistant Commandant on all Research and Development matters and to coordinate liaison activities between the U. S. Army Artillery and Missile School and other military and civilian research and development agencies. The Deputy Assistant Commandant, Research and Development, will not be an office of record or an operational office but rather a director type staff with a primary responsibility of supervision and coordination.

Colonel Corneiis de W. W. Lang is the new Deputy Assistant Commandant, Research and Development, and Lieutenant Colonel Dean E. Painter is his assistant.

Any questions or suggestions in the research and development field may be directed to his office.

## STUDENT COUNSELING SYSTEM ESTABLISHED

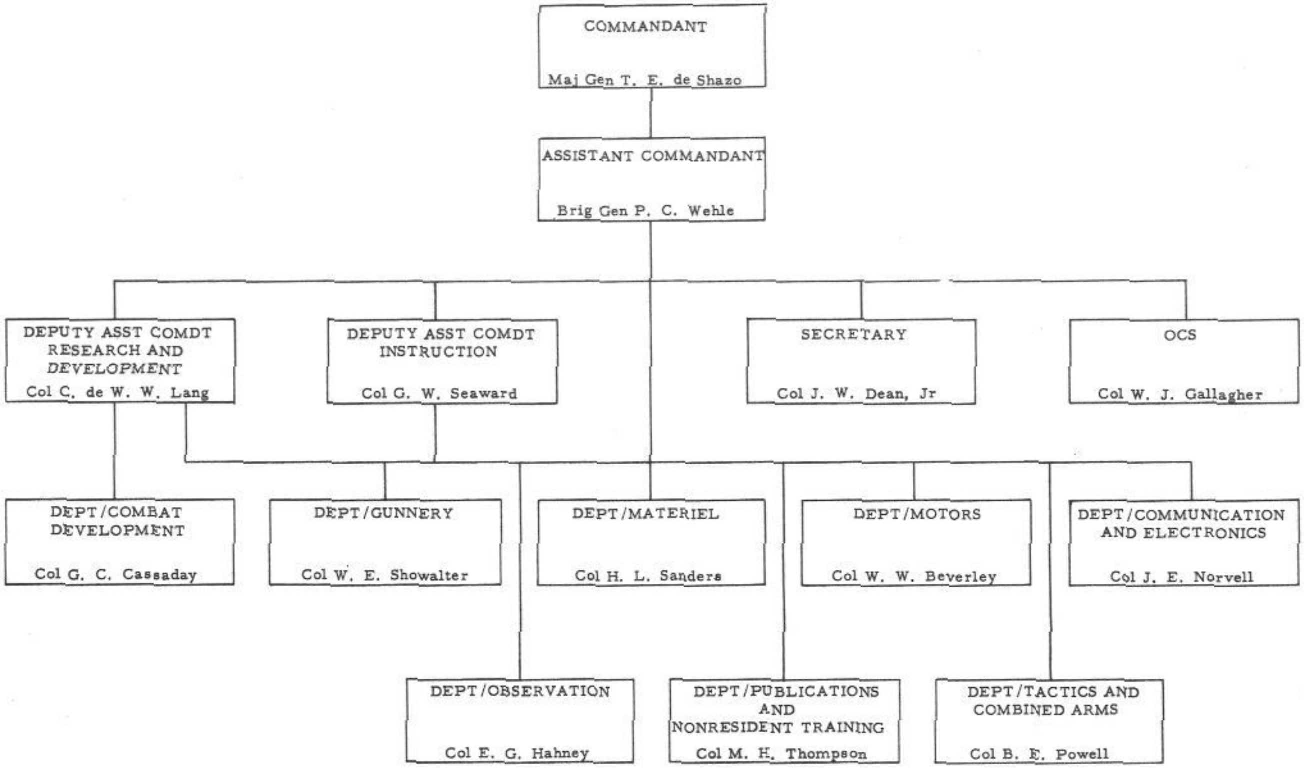
The lack of a direct relationship between the student and the instructor has been a handicap to study by correspondence methods.

In an attempt to partly overcome this handicap, we have encouraged student inquiries and comments.

For some time, answers to student questions have been prepared by several members of the staff as an additional duty.

To provide better service to students and to care for our ever increasing enrollment (now over 15,000), we have set up a system for student counseling. Counseling and answering students' inquiries will now be the full time duty of two officers.

U. S. ARMY ARTILLERY AND MISSILE SCHOOL



Student inquiries and comments are always welcome. Much of the planning and direction of the Extension Course program comes from this source.

Do you have a problem? Write directly to the Chief, Extension Courses Division, Fort Sill, Oklahoma.

## ELECTRONICS PLACEMENT TEST

**MAJOR JOHN C. TAMALIS**

**DEPARTMENT OF COMMUNICATION AND ELECTRONICS**

Attrition in the Army's specialist courses has always been a problem for Army service schools. Prerequisites for these courses are constantly under study for assurance of adequacy and validity. In recent months, with funds and personnel at a premium, even more effort is being put forth to reduce attrition in service schools.

A continuous study has been made of the attrition rate of the Artillery Radio Maintenance Course and other electronic courses taught by the Department of Communication and Electronics. The primary causes of academic failure are the student's inability to cope with technical material even though he meets the presently established prerequisites, failure to meet established prerequisites, and a lack of motivation in cases where the course is forced on the student.

At present, a standard score of 100 in the Electronic Aptitude Area (EL) of the Army Classification Battery is the prime requirement for attending the Artillery Radio Maintenance Course and other electronic courses. All students arriving at the School with an EL score of 100 or better must be enrolled in the Artillery Radio Maintenance Course. Those who fail to meet the prerequisites may be returned to their parent unit or returned to the pipeline stream at the discretion of the School or department after an interview with the student.

In addition to the EL score, a locally developed test is available for identifying those students who have a good chance of successfully completing the Artillery Radio Maintenance Course or the basic electronics portion of various missile and radar courses. This test is called the Electronics Placement Test (EPT) and has been used with considerable success by the Electronics Division of the Department of Communication and Electronics.

Presently, all students arriving for the Artillery Radio Maintenance Course are given the EPT the day before the first class session. All those lacking established course prerequisites and who fail to attain a grade of 50 percent or above on the EPT are rejected. Those who attain a score of 50 percent or above on the EPT but do not meet the established prerequisites are screened and accepted if there is evidence of sufficient motivation.

During the 1957 fiscal year, a total of 606 students reported for the Artillery Radio Maintenance Course classes. Of that number, 111 (18.3 percent) prospective students did not meet the EL aptitude score prerequisite. During interviews, the majority of those lacking prerequisites claimed they were not interviewed at their home station before being selected for the course. Many said they did not desire the course. Of the 111 who did not meet the EL aptitude requirement, 66 were rejected. Of the remaining 45 students who failed to meet the prerequisites but who were selected on the basis of the EPT, 32 successfully completed the course and were made available to the Army for assignment. Had the criterion for selection on the EPT been raised, a smaller number of students would have been accepted, but the percentage graduating would probably have been increased. In this regard it should be remembered that factors other than ability are undoubtedly contributing to attrition. One of these factors is motivation. Whenever students are selected for a course which they do not choose and do not desire, the attendant low motivation of some students may cause them to fail the course regardless of the aptitude they possess.

In April 1957, an analysis of data obtained from students in Artillery Radio Maintenance Course 10-56 through 4-57 was conducted by the Director of Instruction, U. S. Army Artillery and Missile School, Fort Sill. The data consisted of student scores on three separate aptitude tests (Electronic Aptitude (EL), General Technical (GT) of the Army Classification Battery, and the locally developed Electronics Placement Test (EPT)) along with student achievement in the course expressed in terms of passing, failing, or turnback. The analysis was designed to determine the effectiveness of the aptitude tests in predicting student successes singly and in combination. The results of this analysis are summarized below:

a. The EL, GT, and EPT scores in combination are highly related to success in the Artillery Radio Maintenance Course, thus providing good prediction.

b. Dropping GT from the combination does not reduce the predictive effectiveness of the EL and EPT scores.

c. The EPT is the best single predictor of success.

d. A probability table based on the relationship of the EL and EPT scores can be devised and used to evaluate a student's probability of successfully completing the Artillery Radio Maintenance Course. From this table the attrition rate for any particular group of students can be estimated fairly accurately.

Present records show that of the students scoring 50 to 59 percent on the EPT, 75 percent pass the Artillery Radio Maintenance Course regardless of their EL scores; of those with scores between 60 and 69 percent, 85 percent pass the course, and of those with scores above 70 percent, over 95 percent pass the course. Of those students who scored above 70 percent on the EPT and still failed the course, there was, in each case, either a disciplinary cause or the student stated that he did not wish to complete the course; i.e., lacked motivation.

The EPT, although presently being used as an unofficial predictive instrument only, has been an efficient aid to the Department of Communication and Electronics during the past fiscal year in reducing the number of unqualified students entering the Artillery Radio Maintenance Course. The test also aided in the selection of 32 students who did not meet the prescribed prerequisites for the course but who entered and successfully completed the course. The Department of Communication and Electronics is continuing its study of this test and its possible uses in reducing attrition. Indications are that the EPT can be used in conjunction with the EL score in many courses where the EL score is the prescribed prerequisite.

## DO YOU HAVE AN INSTRUCTIONAL PROBLEM IN YOUR UNIT?

CAPTAIN EDWARD E. MEDFORD

DEPARTMENT OF PUBLICATIONS AND

NONRESIDENT TRAINING

"Please send me one copy of all the communication instructional material produced at the United States Army Artillery and Missile School." This is an easy sentence for the individual in the field to write in a letter when he is looking for instructional material with which to present a class in communications.

The example used above is typical of requests received, vague, but no more vague than many requests received for instructional material. The individual writing this sort of letter is probably hoping that he will receive something which may cover the particular class he has to instruct.

The purpose of this article is to state what the United States Army Artillery and Missile School can do to help the military instructor in the field to present a complete and excellent period of instruction, whether he be in an active Army unit, a National Guard unit or a U. S. Army Reserve unit. The U. S. Army Artillery and Missile School publishes catalogs, letters, and other printed matter which list instructional material produced. Some examples of these are the Reserve Components Staff Training Catalog, the Extension Courses Catalog, the Book Department Catalog, Tactical and Technical Trends in Artillery for Instruction, and The Monthly List of Instructional Material. For those desiring instructional material to present a class within their unit, much material can be furnished. However, the requestor must avoid vague blanket requests, such as the example given in the first paragraph of this article. "Fishing expeditions" result in wasted time whereas a request for material for a specific class may result in the material being dispatched by return mail. Requests should include such information as when the material is needed, what type of unit (headquarters battery, 105-mm battalion; firing battery, 8-inch howitzer battalion), what type of class is desired (wire splicing, fire direction battalion team drill, duties of battery safety officer, etc.), what level of training (basic, advanced, individual, etc.), and what training aids are available to the unit (blackboard, 16-mm projector and screen, Vu-Graph, etc.)

One major source of information on instructional material available at this school is the Reserve Components Staff Training Catalog. Distribution of the latest edition of this catalog was made during September 1957, in sufficient quantity to enable each battalion size field artillery unit of the active Army, National Guard and United States Army Reserve to have two copies. Distribution was also made to Military Assistance Advisory Groups, Military Missions, and Commissions. Copies of this catalog are still available on request.

Material is listed in the Staff Training Catalog as Staff Training Classes and as Reference Classes. Material found under the Staff Training Classes section is designated primarily for the training of staffs at battalion, group, division artillery, and corps artillery levels. By using this material, classes may be conducted on organization and tactical employment, tactical missions of the field artillery, artillery fire planning, operation orders and the fire support plan annex, fire support coordination, records, supply, etc. Maps and practical exercises of various levels of units in different combat situations are included.

The instructional material listed as References Classes is readily adaptable to advanced individual, section, and battery training and garrison or troop schools. In addition, these classes provide background knowledge of a technical nature. This material, paralleling resident department instruction, includes such classes as radio and wire nets, radiotelephone procedure, and communication systems and equipment (Department of Communication and Electronics); firing battery, fire direction, and observed fire (Department of Gunnery); description, characteristics, functioning, operation, care, maintenance and tests of various artillery weapons, ammunition, and mines and booby traps (Department of Materiel); organization of the Army system of maintenance, organization of battery and battalion maintenance sections, inspections, forms and records, driver selection and training, field expedients, and emergency repairs (Department of Motors); survey planning, traverse, taping, target area base, connection area survey, computations, position area survey, 20-inch transit, aiming circle, etc. (Department of Observation); techniques of employment of an artillery battery, planning fire support, organization and employment of forward observer sections, liaison, operation orders, administration and supply, and considerations of offensive and defensive combat (Department of Tactics and Combined Arms).

Each class unit consists of material for 1 instructor and 10 students, including sufficient outlines, advance sheets, instructional notes, illustrative problems, and similiar materials. Also included are Vu-Graph transparencies of teaching points and of blank forms (when possible and appropriate) and an instructor's manuscript. This instructor's manuscript gives all the information necessary for the period of instruction, including class presentation instructions and a word-for-word presentation of the class with cues for insertion of appropriate training aids or Vu-Graph transparencies. With the instructors manuscript, the inexperienced military instructor with an average background in his subject, after reading and rehearsing the class a few times, should be able to put on an excellent period of instruction.

Staff training instructional material is specifically designed to meet the needs for nonresident group instruction. The tedious job of preparing a detailed lesson plan has been accomplished for the instructor. This material is rewritten annually, bringing the contents of the class up to date with the newest concepts of tactics, techniques, and equipment.

Another media of instructional material produced at the U. S. Army Artillery and Missile School is the Monthly List of Instructional Material distributed to all artillery units. The instructional material for resident instruction is constantly being revised and brought up to date as new developments are made, new materials put in the hands of troops, and tactical concepts are changed. This list compiles the material produced for resident instruction at the school during a given month. It will indicate whether the material is an Instructional Note, an Instructional Guide, Practical Exercise, Illustrative Problem, Instructional Writ, Advance Sheet, etc. The material may not be complete within itself to present to a nonresident class, therefore, the instructor must prepare his own detailed lesson plan, using the new material for reference or to revise and supplement other prepared material.

"Tactical and Technical Trends in Artillery for Instruction" will list from time to time classes or material that are new and available. This material can be found mentioned in many articles on new development, new doctrines, and new techniques; or it may appear in a short insert between articles.

Paragraph 7h, AR 310-1 prohibits the shipment of material gratuitously to individuals for their own use. However, the Book Department Catalog lists instructional material which may be purchased for individual use. Enrollment in the Extension Course Program is another means of increasing personal knowledge without charge. The Extension Course Catalog lists the courses available and the method of enrollment. These courses are programmed into the Battery Grade Course and the Advanced Extension Course which parallel the respective associate resident courses. In addition, related subcourses have been integrated into special extension courses such as FA Gunnery, Army Aviation, Communication, Intelligence, Missiles, Motors, Observation, Administration, Survey, and Electronics. Special extension courses are available to commissioned officers, warrant officers, and enlisted men of all components who may enroll subject to the provisions of AR 350-60 and DA Pamphlet 350-60.

<u>It should be borne in mind that extension courses are designed as a teaching vehicle for individuals, and that Army regulations prohibit the use of this material for classroom instruction. However, the knowledge gained by completing extension course work will better qualify the student to be an instructor.</u>

Instructional material produced by the school is the best material available on artillery. <u>In order to help us help you, be specific in your request for instructional material.</u> Each of the media listed above has administrative instructions for ordering listed material. <u>If you do not have access to any of the media listing the material available, give us as much information as you can about your particular need; we will do the rest. Queries should be addressed as follows:</u>

Commandant
U. S. Army Artillery and Missile School
Fort Sill, Oklahoma
ATTN: AKPSIDA-TP/DS

## THE SOLAR PRISM - MISSILE ACCURACY FROM SUN SHOTS

MAJOR KENNETH P. DUNN

DEPARTMENT OF OBSERVATION

The new weapons and tactical concepts have greatly increased the requirement for accurate, quickly determined directional control disseminated throughout the battle area. One solution is greater use of astronomic observations. Star shots are necessary for units requiring extremely accurate directional control when adequate prior survey has not been accomplished in the immediate firing area.


Figure 1. Solar prism attachment.

The solar prism attachment (fig 1) is a simple, reliable instrument designed to increase the accuracy of sun observations. Developed by Professor R. Roelofs of the Delft Technical University in Holland, the device has been recommended by the Survey Division of the Department of Observation for use with theodolites and transits. It consists of a pair of small prisms mounted perpendicular to each other in a short tube. The device is attached to the objective end of an instrument telescope by means of a thumbscrew. For sighting on ground marks, the tube swings clear of the telescope lens. The attachment has been used by US Coast and Geodetic Survey personnel and was favorably reported on in an article in Surveying and Mapping, July-September 1954.

The obvious advantage of sun observation over star observation is positive identification of the heavenly body. Despite that advantage, current sun observation techniques are relatively difficult to perform and require considerable training of instrument operators in pointing procedures. In addition, pointing errors may be introduced because of the difficulty of adjusting the crosshairs exactly tangent to the edge of the sun. Informal tests by the Survey Division substantiate the manufacturer's claims for the solar prism: (1) An easily read target is produced which permits quick, precise alignment of crosshairs (fig 2); (2) the crosshairs are clearly visible; (3) observations refer directly to the center of the sun obviating the need to compensate for semi-diameter or prismatic angle. Other significant advantages are: The elimination of tangency errors and confusion in the choice of crosshair quadrants for sun position, faster observations, and less time required for training instrument operators.

Accuracies obtainable with the solar prism are indicated by the results of a single day's limited tests:

| | |
|---|---|
| INSTRUMENT: | T2 theodolite with a solar prism. |
| TIME: | Morning observations only. |
| METHOD: | Hour angle with a one-tenth second chronometer. |
| STATION: | Lawton North Base, first order baseline station established by US Coast and Geodetic Survey; geodetic azimuth to marker on Signal Mountain 297° 06′ 30. 18″. |
| OPERATORS: | One skilled operator (S), and two inexperienced operators who had never taken sun shots and had no instruction in precise methods ($UNSK_1$ and $UNSK_2$). |

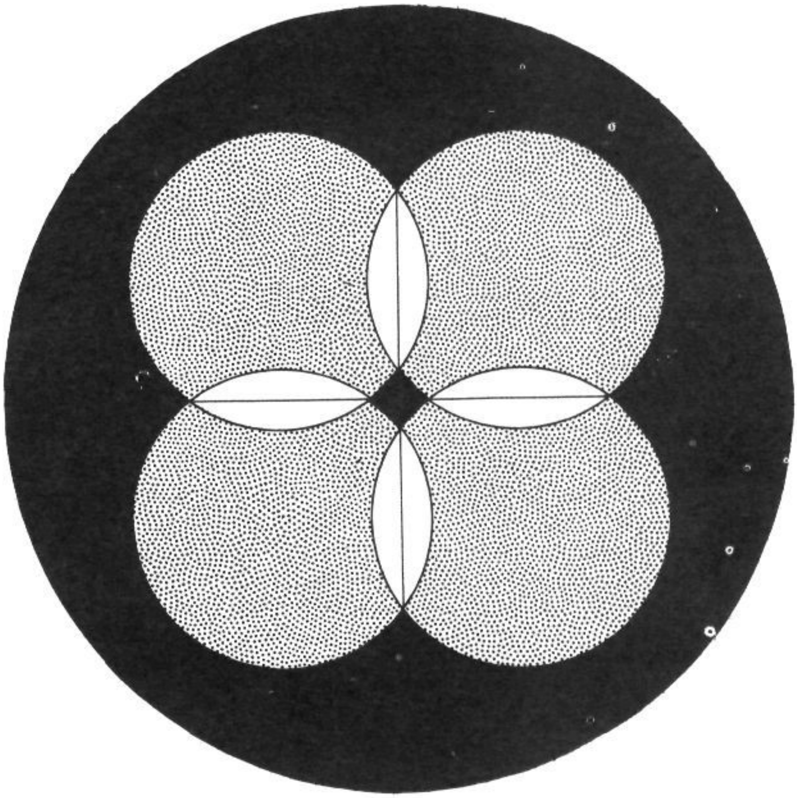


Figure 2. Four overlapping green images produce a bright green cross with dark diamond in the center. Crosshairs are aligned to bisect the central wing tips of the cross, an operation visually easy to accomplish.

| OPERATOR | AZIMUTH DETERMINED |
|---|---|
| S | 297° 06′ 24″ |
| S | 297° 06′ 20″ |
| S | 297° 06′ 23″ |
| $UNSK_1$ | 297° 06′ 26″ |
| $UNSK_1$ | *297° 01′ 08″ |

*Gross error probably caused by misreading instrument scales.

**Small errors apparently from scale reading, instrument handling, or crosshair alignment.

| OPERATOR | AZIMUTH DETERMINED | |
|---|---|---|
| UNSK$_1$ | 297° 06′ 25″ | Obvious variations from the mean discarded, mean of five good observations with spread of 06″ is 297° 06′ 23.6″. |
| UNSK$_2$ | **297° 06′ 03″ | |
| UNSK$_2$ | *297° 01′ 21″ | |
| UNSK$_2$ | **297° 07′ 19″ | Variation from Geodetic Azimuth: 06.58″. |

EFFECTIVE ACCURACY: An angle of 06.58″ subtends 10.25 meters at a distance of 200 miles.

A similar test involving only three sets of readings with a 20-inch transit equipped with solar prism produced a spread of 42″ (readily minimized when additional readings are taken). The mean result varies from the geodetic azimuth by 13.18″, which angle subtends 20.54 meters at a distance of 200 miles.

Under favorable conditions, the time required for a trained operator-recorder team to accomplish 9 to 10 sets of readings using the solar prism (as with the T2 theodolite test results shown above) will be from 20 to 30 minutes. A 3-computer team can reduce 9 to 10 observations to a mean result in an hour's working time.

The solar prism attachment can extend the artilleryman's ability to establish highly accurate direction for the orientation of missiles when the situation suggests sun observation methods.

## AIRPHIBIOUS ARTILLERY EXPERIMENTAL PROGRAM

**LIEUTENANT COLONEL WM. H. CROSSON, JR.**

**DEPARTMENT OF TACTICS AND COMBINED ARMS**

Is the artillery sufficiently mobile to meet the demands of today's battle--or tomorrow's? We don't really know, but we do know that every effort to increase our mobility, both on and off the battlefield, must be made. The search for means to develop greater mobility covers a great many areas of interest, among them the use of helicopters as a means of transport for artillery units.

It is obvious that air movement of weapons overcomes the obstacles to movement which are created by terrain characteristics. Rivers, mountains, swamps, and distance can be crossed with ease by an air vehicle. Unfortunately, it is often necessary to fight on terrain which, by its nature, prevents the use of fixed wing aircraft requiring runways and landing fields. The greater the load carried, the larger the aircraft must be, and the greater the need for suitable landing fields. These requirements are a headache from the artilleryman's point of view.

On the other hand, the helicopter can take off and land in relatively rough terrain. It can, in large measure, fulfill the role of the fixed wing aircraft in moving over terrain obstacles. Unfortunately, the current helicopter is an expensive vehicle and cannot lift the heavier types of artillery. However, it holds considerable promise as a means of providing mobility, both on and off the battlefield, for light cannon and missile field artillery elements.

To determine the proper place of the helicopter in the artillery scheme the School has embarked on an experimental program using the helicopter as an artillery prime mover. The Department of the Army has provided three units as experimental participants. They are the 4th Field Artillery Battalion (Aeropack) the 54th Transportation Company (Light Cargo Helicopter), and the 154th Transportation Detachment (Helicopter Maintenance). Of these, only the 4th FA Battalion is a special unit. Formerly the 4th FA Battalion (Pack) at Fort Carson, Colorado, it was reorganized at Fort Sill as a single firing battery battalion equipped with the 105-mm howitzer. The two transportation units are standard units. All participating units have completed their unit training programs as Phase I of the experimental program.

In early December 1957, these units were brought together as the 4th Airphibious Field Artillery Battalion (Provisional) for Phase II of the program. This phase consists primarily of training to integrate the artillery and transportation elements into an entirely new type of tactical unit--a helicopter-transported light artillery battalion. The standing operating procedure for the battalion will be developed during this phase.

Phase III, the truly experimental phase, will encompass controlled field exercises wherein the helicopter is used as the primary means of transport for the weapons, equipment, and personnel. From these experiments, the value of the helicopter as a prime mover for artillery will be determined. The experiments will also show whether there is a requirement for a TOE unit of the type indicated above and whether standard artillery units can be given tactical mobility by standard transportation helicopter units.

## AUTOMATIC DATA PROCESSING SYSTEMS (ADPS)

CAPTAIN DONALD C. FOX

DEPARTMENT OF COMBAT DEVELOPMENT

The U. S. Army Artillery and Missile School is in the early stages of preparing systems analysis studies to determine whether automatic data processing systems (ADPS) can be advantageously employed to increase the effectiveness of field artillery functions. The systems analysis study is defined as the detailed study of an operation or set of operations and an evaluation of the advantages resulting from the application of automatic or semiautomatic techniques to that operation.

In a letter to the Deputy Chief of Staff for Military Operations, United States Continental Army Command headquarters in July 1956, USCONARC expressed vital interest in the potential advantages, from an operational point of view, offered in the field of ADPS and stated that the ultimate goal must be the development of systems and equipment for the Army in both Continental United States (CONUS) and overseas, all of which must be compatible with each other and with the Army communication system. In October 1956, USCONARC directed that various agencies provide recommendations on the areas wherein ADPS might be profitably employed. The scope was to include but not be limited to:

a. The organizational level from theater headquarters to field Army units.

b. The extent of utilization within the combat arms organizations.

c. The specific ADPS applications at each echelon to include:

(1) Operations.

(2) Intelligence.

(3) Personnel.

(4) Administrative.

(5) Logistical.

(6) Tactical.

(7) Other.

In reply, the U. S. Army Artillery and Missile School submitted possible areas for ADPS applications to include computation of firing data; target analysis to determine type, volume, and quantity of fire to be placed on a target; post strike analysis; fire planning; survey data processing; intelligence data; target acquisition; and ammunition status.

The recommended areas of application received by USCONARC from all agencies were screened by a committee of USCONARC and Department of Army (DA) representatives. Following the committee's review, the areas of application determined worthy of further consideration were subjected to a more detailed study by a technical analysis group from the signal corps. This group examined some 90 areas of possible ADPS application and arrived at initial conclusions concerning operational and organizational concepts and a general description of materiel requirements. USCONARC stated that the study of the technical analysis group supports USCONARC's conclusions that an ADPS offers the best method heretofore advanced to provide the type automation required in the theater of operations to:

a. Decrease reaction time for the coordination of fire support, logistical support, and staff estimates.

b. Assist in depopulating the battlefield and coordinating tactical operations.

c. Increase the overall battlefield responsiveness.

In June 1957, USCONARC directed that the U. S. Army Artillery and Missile School perform systems analysis studies for the artillery functions of fire control, survey, ammunition status (tactical), artillery capabilities computations, and weapons analysis. The completed studies will include--

a. A detailed presentation of how the function as currently performed can be improved to include flow and functions charts and estimated workload data.

b. Appropriate recommendations for changes in techniques, procedures, and regulations without use of ADPS.

c. Recommendations on items requiring further study.

d. Determination of feasibility and preparation of a detailed outline of a proposed system for performing the same function by the use of ADPS to include schematic charts.

The studies are to be used to provide guidelines to the research and development agency in the refinement of the statement of materiel requirements. In addition the studies will serve to--

a. Establish the feasibility of employing ADPS to the extent envisioned in the basic study of the technical analysis group.

b. Define those ADPS areas or specific functions in areas to which an interim capability can be achieved using available commercial items.

The U. S. Army Artillery and Missile School is presently in the initial stages of conducting these system analysis studies to determine advantages gained as a result of applying ADPS to artillery functions. It is estimated that 6 to 8 months will be required to complete each of the studies.

## PROBLEMS OF PREVENTIVE MAINTENANCE IN CORPORAL MISSILE EQUIPMENT

CAPTAIN JAMES L. HARRISON

DEPARTMENT OF OBSERVATION

"An ounce of prevention is worth a pound of cure" is an axiom long recognized by field artillerymen; it is, without a doubt, one of the major factors in establishing our present day preventive maintenance program.

It often seems that the emphasis in this program is placed upon cost consciousness and supply economy. Of less obvious but more real importance is keeping equipment in a combat ready condition. This readiness has a value which cannot be measured in dollars and cents, nor can it be bought on call for any price, but rather must be paid for in advance with strict enforcement of a well-planned preventive maintenance program.

No intelligent artilleryman would try, except in a most dire situation, to use equipment which he had not inspected previously for proper functioning. For this reason, the program has been designed so that he can perform daily checks as well as periodic maintenance, thus assuring the constant preparedness of his equipment.

With the advent of missiles and their adaptation to the field artillery role, the artilleryman's maintenance problem became decidedly more complex. The added complexity results primarily from the many items of electronic equipment.

Preventive maintenance in a Corporal missile battalion includes virtually all the maintenance problems encountered in a cannon artillery unit plus the additional problems encountered in maintaining the complex electronic equipment. For example, the Corporal Battalion is equipped with over 150 motor vehicles, trailers, and generators requiring vehicular maintenance; 5 vans filled with intricate electronic equipment; and a basic load of missiles requiring extensive electrical maintenance and inspection.

To perform maintenance properly on the electronic equipment, personnel must follow the steps outlined in the operator checkout procedures (COP). The operator checkout procedures are the detailed, chronological operator checks and maintenance procedures which are necessary to test, maintain, and set up the guidance equipment for firing a missile. If the prescribed sequence is followed precisely, errors will be minimized, if not eliminated. Proper sequence must be followed since functioning in one particular phase usually depends upon the proper functioning of a preceding phase. The operator checkout procedures are divided into five sections, each devoted to a separate part of the overall operation, and are found in TM 9-5036-2.

Sections 4 and 5 are the preventive maintenance procedures which contain detailed instructions for accomplishing daily, weekly, monthly, and quarterly maintenance. The maintenance function cannot be restricted to sections 4 and 5 alone however, since completion of sections 1 and 2 is a prerequisite to making the many adjustments required in the maintenance procedures.

The succeeding paragraphs briefly outline the scope of each section in the operator checkout procedures. Section 1 includes energizing procedures and initial operator checks for each station in the guidance platoon. For the radar station alone there are 58 major steps, most of which are divided into substep operations. Section 1 must be completed before proceeding to the next section.

Since guiding the Corporal missile is a combined and concurrent operation of all guidance equipment, the operator checkout procedures furnish a means of checking the inter-van operation in Section 2. Although this is primarily a tactical procedure, maintenance is not complete until compatible operation between the separate stations has been assured. Section 2 of the operator checkout procedures must be completed in a relatively short time and before proceeding to the following section.

Section 3, the actual firing sequence, is performed next. It is a tactical procedure also requiring a short performance time, and normally is not performed as a part of preventive maintenance.

Section 4 provides for daily, weekly, and monthly operator preventive maintenance. This procedure follows the FITCAL principle, i.e., feel, inspect, tighten, clean, adjust, lubricate, and includes many adjustments and alignments.

Section 5 provides for weekly, monthly, and quarterly organizational preventive maintenance and is unlike section 4 only in complexity of operation and operational skill requirement. Section 5 can be performed only by highly trained maintenance personnel.

The time required to perform sections 4 and 5 cannot be accurately predicted since their purpose is to locate equipment malfunctions for repair. Their purpose has not been served until all detected malfunctions have been corrected.

Check sheets which parallel the operator checkout procedures and maintenance procedures are provided for use in checking and recording equipment operating tolerances. The advantages of performing the above procedures are twofold: First, they assure the operational readiness of the equipment to fire within the required time, and second, if they are performed daily as prescribed by the operator checkout procedures, invaluable training of operator and maintenance personnel will be accomplished.

The guidance platoon table of organization authorizes 11 personnel, 9 of whom should be school trained for 32 weeks in the proper maintenance of the electronic equipment. These persons can insure operational readiness if sufficient time is allowed to complete the above procedures. To the surface to surface missile artilleryman this is the "ounce of prevention." If he is not allowed sufficient time to complete the checkout procedures, "a pound (or more) of cure" will inevitably be required.

# REVISION OF FIELD MANUAL 6-20. ARTILLERY TACTICS AND TECHNIQUE

LIEUTENANT COLONEL KENNETH B. STARK

DEPARTMENT OF TACTICS AND COMBINED ARMS

If there is a single field manual which can be looked upon as the basic guide for artillery commanders and their staffs, it is FM 6-20, Artillery Tactics and Technique. The edition of this manual currently in use is dated October 1953, yet a major portion of this manual is as current today as it was then. This speaks well for those who had a part in its preparation, for it is not an easy task to prepare a field manual which will remain current for a considerable length of time in this period of rapid change and evolution in artillery doctrine. However, the time for revision of FM 6-20 has finally arrived, as it must for all manuals--if they are to be of continuing value to those who use them.

One of the most noticeable changes required in FM 6-20 has been brought about by a major increase in the number of separate field artillery batteries; e. g., the mortar batteries of the battle groups in the infantry division, the separate batteries of the airborne division artillery, the corps artillery aviation battery, and the new infantry division artillery structure which will not only require employment of certain batteries directly under division artillery control but also will require interchange of batteries between the two organic artillery battalions when organizing for combat. The emphasis in revised FM 6-20 will continue to be on the battalion, but it will not be nearly as pronounced as in the 1953 edition.

The inclusion of artillery mortar batteries as an organic part of battle groups and the introduction of the atomic capability at division artillery level introduce new dimensions into field artillery tactics and technique. Battle group artillery and atomic division artillery will receive considerable coverage in revised FM 6-20. Less emphasis will be placed on weapons which are no longer in the troop list and which appear to have outlived their usefulness.

One of the more noticeable changes in FM 6-20 will be in the discussion of ranges of field artillery. It will no longer suffice to speak of 15 or 20 miles as being long range. Field artillery now has weapons with minimum ranges far exceeding these figures and with maximum ranges extending hundreds of miles. Revised FM 6-20 gears thinking to these new weapons and distances and to the effect which they have on the employment of artillery in combat.

Other concepts in the revised manual are designed to provide the flexibility needed by the artillery on the atomic battlefield if it is to furnish optimum firepower for the supported force--be it a company or field army. The manual will point out that greater flexibility in missions and the assignment of mission type orders is necessary to insure that the artillery can accomplish its mission.

With the increase in ranges comes the requirement for extending the artillery command structure to the field army level, since certain field artillery and air defense artillery units will be retained at that level. The problems involved in target acquisition for our longer range weapons and the use of these weapons in countermissile roles further emphasize the need for a suitable artillery structure at the field army level. The revised manual gives full coverage to the methods employed by the army artillery commander in fulfilling his responsibilities.

Many other changes are being incorporated into the revised FM 6-20 to reflect new developments in artillery tactics and technique. A balanced approach in the use of cannon and missile artillery; more complete treatment of the employment of atomic artillery; employment of cannon and missile artillery in the offense and defense; use of the corps artillery aviation battery; new concepts in organization for combat; atomic and nonatomic target analysis; countermortar and counterbattery operations under atomic and nonatomic conditions; changes in procedures and techniques for handling target information; new procedures in fire direction, fire planning, and fire support coordination; all receive full treatment in the revision.

Revised FM 6-20 is presently being circulated to other service schools for comment. It is due in USCONARC in February 1958. Under the present time schedule, the manual should be published in mid-1958.

# CENTER-OF-IMPACT OR HIGH-BURST REGISTRATION BY SOUND AND FLASH RANGING TECHNIQUES

MAJOR GEORGE R. SARGIS, JR

DEPARTMENT OF OBSERVATION

As stated in TOE 6-577C, 26 January 1956, part of the mission of the field artillery observation battery is ". . . to adjust fire of friendly artillery by means of flash ranging, sound ranging. . .". Precision, center-of-impact, and high-burst registrations are included within the scope of that mission since a registration is "an adjustment of fire on a selected point in the target area to determine data for use in subsequent firing".

The personnel who man the twenty or more sound and flash observation posts of a field artillery observation battalion are capable of conducting precision registrations employing target grid procedures and techniques. In addition, they are capable of conducting center-of-impact and high-burst registrations. The battalion can furnish the registration coordinates and height of the burst center in a flash adjustment or the coordinates only in a sound adjustment. If field artillery units utilize the sound and flash platoons for center-of-impact and high-burst registrations, establishment of their own observation posts for this purpose becomes unnecessary. This saves time and effort for the unit, since they do not have to install the communications or perform the accurate survey required.

Since horizontal accuracies better than plus or minus 50 meters cannot be achieved by sound ranging, and heights cannot be determined by sound, sound ranging techniques are employed only as a last resort. The flash ranging platoon, however, employing a flash long base of 3 to 5 observation posts, each located to an accuracy of 1:3,000, is capable of conducting center-of-impact and high-burst registrations to ranges of 15,000 meters with accuracies of 0 to 50 meters. These accuracies with flash ranging are due to the extremely accurate locations of the observation posts (1:3,000), the precision instruments employed (azimuths and vertical angles are interpolated to the nearest one-tenth of a mil), and the relatively great length of the flash base (normally 6,000 to 10,000 meters).

The conduct of a center-of-impact and high-burst registration employing a flash ranging platoon is described in the succeeding paragraphs:

1. The fire direction officer furnishes the flash ranging officer, who is located at the flash ranging central, with the following information in sequence:

a. Type of registration desired.

b. Approximate coordinates of registration point.

c. Anticipated height of burst center.

d. Number of rounds desired (This is specified only in the event that it is not a six round registration).

2. Direct communication (wire) is desirable for the control of the registration and the transmission of information between the field artillery unit and the flash ranging central.

3. To insure accuracy, the horizontal location (grid coordinates) of the burst center is determined by two independent procedures:

a. Each usable round of the registration is located graphically on the flash plotting board M5A2 by plotting to a scale of 1:5,000 the azimuths announced from each observation post to the burst. If a point plot does not result, i. e., all rays do not intersect at a common point, the center of the polygon of error is determined and the coordinates of the round read and recorded. The mean of the six usable rounds represents the grid coordinates of the registration burst center.

b. The azimuths of the six usable rounds obtained from each observation post are meaned, and the burst center is located graphically by plotting to a scale of 1:5,000 the mean azimuth from each observation post. If a point plot does not result, the center of the polygon of error is determined and the grid coordinates of the burst center read and recorded.

3. If the grid coordinates obtained in 3a and b above, agree within 20 meters in easting and northing, their mean represents the grid coordinates of the burst center; if they do not, all plotting and computations are checked to determine the source of the error.

4. Height is determined from two observation posts and includes a correction for curvature and refraction when the distance from the observation posts to the burst center is greater than 2,500 meters (yards). If the heights determined from the two observation posts agree within one meter (yard), their mean

represents the height of the registration burst center; if they do not, the height is determined from a third observation post and so on, until any two observation posts agree to within one meter. If no two heights agree within one meter, heights considered erratic are discarded and the mean of the heights of usable rounds represents the height of the registration burst center.

5. The adjusted data is verified when the ammunition supply and the tactical situation allow.

6. DA Form 6-3a (fig 5) is a convenient form for recording data obtained by flash ranging. An example of a high-burst registration is shown.

## RADAR-DOPPLER CHRONOGRAPH

LT GEORGE E. BARR

DEPARTMENT OF GUNNERY

Instruments for measuring the velocity of projectiles at the muzzle have been in existence for some time. These instruments, regardless of principle of operation, are called chronographs. Solenoid chronographs are used at ordnance proving grounds to compute data for firing tables and to test ammunition for firing programs. Ordnance ballistic and technical service teams use skyscreen chronographs to calibrate cannon artillery. The solenoid chronograph consists of two magnetic coils placed a prescribed distance apart in front of the muzzle. Similarly, the skyscreen chronograph consists of two photoelectric cells placed an exact distance apart in front of the muzzle. In both methods, the time required for a projectile to pass from one instrument to the other (i. e., the time required to travel a known distance) is converted into an average velocity over a known base. The average velocity reflects the velocity of the projectile at a point midway between the ends of the known base. Muzzle velocity in feet per second is derived by applying certain exterior ballistic effects (i. e., drag and gravity) as a function of the distance and vertical angle from the muzzle to the midpoint.

Although an accurate muzzle velocity is determined by either method described above both have the following inherent disadvantages:

1. Accurate survey is required.

2. Considerable time is required to set up the equipment.

FLASH-RANGING RECORD
(FM 6-120)

| FILE NUMBER | CONC. NUMBER | DATE |
|---|---|---|
| | | 5 DEC 57 |

| TIME OBSERVED | TIME REPORTED | NATURE OF TARGET | NUMBER OF PLOTS | ACCURACY METERS | CALIBER | AREA SHELLED |
|---|---|---|---|---|---|---|
| | | HIGH BURST REGISTRATION | | | | |

| ROUND NUMBER | OP 1 AZIMUTH | OP 1 VERT ∢ | OP 2 AZIMUTH | OP 2 VERT ∢ | OP 3 AZIMUTH | OP 3 VERT ∢ | OP 4 AZIMUTH | OP 4 VERT ∢ | OP 5 AZIMUTH | OP 5 VERT ∢ | OP 6 AZIMUTH | OP 6 VERT ∢ | GRID REFERENCE E | GRID REFERENCE N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5833 | A+5 | 6286 | A+4 | 338 | A+5 | 559 | A+2 | CLAMPING | | ROUND | | NOT USED | |
| 2 | 5830 | A+9 | 6285 | A+6 | 341 | A+7 | 562 | A+5 | | | | | 39300 | 16240 |
| 3 | 5839 | B+8 | 6288 | A+3 | 337 | A+6 | 555 | A+3 | | | | | 39200 | 16330 |
| 4 | 5827 | B+8 | 6277 | B+6 | 335 | A+8 | 558 | A+4 | | | | | 39250 | 16250 |
| 5 | 5849 | B+17 | 6312 | B+16 | 348 | B+18 | 568 | B+19 | | | | | ERRATIC | |
| 6 | 5842 | A+7 | 6295 | A+7 | 345 | A+8 | 563 | B+3 | | | | | 39340 | 16310 |
| 7 | 5832 | A+8 | 6281 | A+6 | 334 | A+6 | 555 | A+5 | | | | | 39270 | 16300 |
| 8 | 5837 | A+7 | 6292 | A+6 | 344 | A+7 | 564 | B+4 | | | | | 39330 | 16260 |
| 9 | | | | | | | | | | | | SUM | 235690 | 97690 |
| 10 | | | | | | | | | | | | MEAN | 39282 | 16282 |
| SUM | 35007 | +47 | 37718 | +34 | 2034 | +42 | 3357 | +24 | | | | | 39285 | 16270 |
| MEAN | 58345 | +8 | 6286 | +5.7 | 339 | +7 | 559.5 | +6 | | | | SUM | 78567 | 32552 |
| OT DISTANCE | 7100 | | 5900 | | | | | | | | | | 39284 | 16276 |
| HEIGHT OF OP | 402.0 | | 425.0 | | | | | | | | | | | |
| TARGET HEIGHT ABOVE/BELOW OP | ⊕ − 55.8 | | ⊕ − 35.0 | | ± | | ± | | ± | | ± | | | |
| ALGEBRAIC SUM | 457.8 | | 458.0 | | | | | | | | | | | |
| CURV. AND REFR. CORR + | + 3.1 | | + 2.2 | | + | | + | | + | | + | | SUM H | MEAN H |
| HEIGHT | 460.9 | | 460.2 | | | | | | | | | | 921.1 | 460.5 |
| | | | | | | | | | | | | HEIGHT: | YARDS 461 | METERS |

DA FORM 1 JUN 55 6-3a PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

Figure 3. High Burst Registration.

3. Weapons to be calibrated must fire a certain deflection and elevation.

4. Ammunition must be expended solely for calibration purposes.

5. Calibrations are limited to daytime operation.

To overcome these disadvantages, ordnance authorized the development and manufacture of a chronograph which operates on the radar-doppler principle. Under this principle, a continuous-wave radio frequency radiates from an antenna. A projectile passing outward through the wave, or beam, reflects a portion of the frequency from the base of the projectile back to the antenna, but at a changed (lower) frequency due to the doppler effect. The amount of this change, or doppler frequency, is proportionate to the velocity of the projectile. The radar-doppler chronograph is similar to the solenoid and skyscreen chronographs in that it establishes a known base. This is accomplished by means of electronic gates which start and stop the count of the reflected doppler frequency. The indicated velocity determined by using the chronograph, therefore, is an average velocity over this known electronic base. Corrections for exterior ballistic effects (i. e., drag and gravity) must be applied as a function of the distance and vertical angle from the muzzle to the midpoint of the electronic base to obtain muzzle velocity in feet per second.

The radar-doppler chronograph is operated on a jeep or tripod from 10 to 30 feet to the rear of the weapon firing. Only an estimate of this distance is required. The equipment can be operated by two personnel and only 5 to 7 minutes are required for emplacement and preparation for operation. The velocity of a weapon-ammunition combination can be measured while the weapon is firing any deflection or elevation, which makes it ideally suited for calibrating weapons during tactical situations. In addition, the equipment may be operated day or night. These are only a few of the advantages of the radar-doppler chronograph over other types of chronographs.

Pilot models of the T33 radar-doppler chronograph were service tested in 1952 for field artillery use. The T33 failed the service test because of lack of ruggedness. Therefore, pilot models of a new and improved radar-doppler chronograph were developed. These pilot models, called T7 chronographs, completed engineering tests at Aberdeen Proving Ground in June 1957 and are presently undergoing user tests by the U. S. Army Artillery Board and the U. S. Army Air Defense Board. If tests prove satisfactory, the T7 chronograph will be produced for issue to troop units. The date that troops can expect to receive a production model of the radar-doppler chronograph cannot be determined at the present time. Tentative position of the U. S. Army Artillery and Missile School is that the basis of issue should be 2 chronographs per Corps Artillery and 1 chronograph per division artillery with artillery personnel responsible for chronograph operation. The allocation and operational responsibility of the radar-doppler chronograph are presently undergoing study. However, until the radar-doppler chronograph is issued to troops, reliance must still be placed on the skyscreen chronograph for velocity calibration of cannon artillery.

## MOBILITY WITH SIMPLICITY

CAPTAIN EUGENE B. HUMRIGHOUSE

DEPARTMENT OF MOTORS

Have you ever spent hours by the roadside while your motor sergeant or mechanic or driver or all three tried to trouble shoot the ignition system? Did your driver have to shift into low gear and continue up a very slight hill, with a noise similar to that of a threshing machine, because you knew that it would take too long to find and replace defective spark plugs, points, etc.? Then look at figure 4 and see the ignition system components of the new 1/4-ton, 4x4, M151-E1 which is scheduled to replace or supplement the M38 and M38A1. The ignition system complete with standard automotive coil, distributor, spark plugs, and high-tension wiring is contained under one cover, completely waterproofed and suppressed for radio interference.

An aluminum cast engine ignition system lower cover (exploded view, fig 5), which serves as the mounting base for the ignition system component parts, is attached to the right side of the cylinder head. It is secured by screws and sealed by an embossed metal gasket.

The base of this cover carries the coil, distributor, and wiring and contains openings on the cylinder-head-attaching side to clear the spark plugs. The end of the coil with the distributor connections extends into the cover with the remaining coil surface exposed.

The engine ignition system upper cover is also cast from aluminum. It is retained by five acorn-type nuts and sealed by a rubber 0-ring-type seal. The enclosure is ventilated at all times by clean air from the air cleaner.

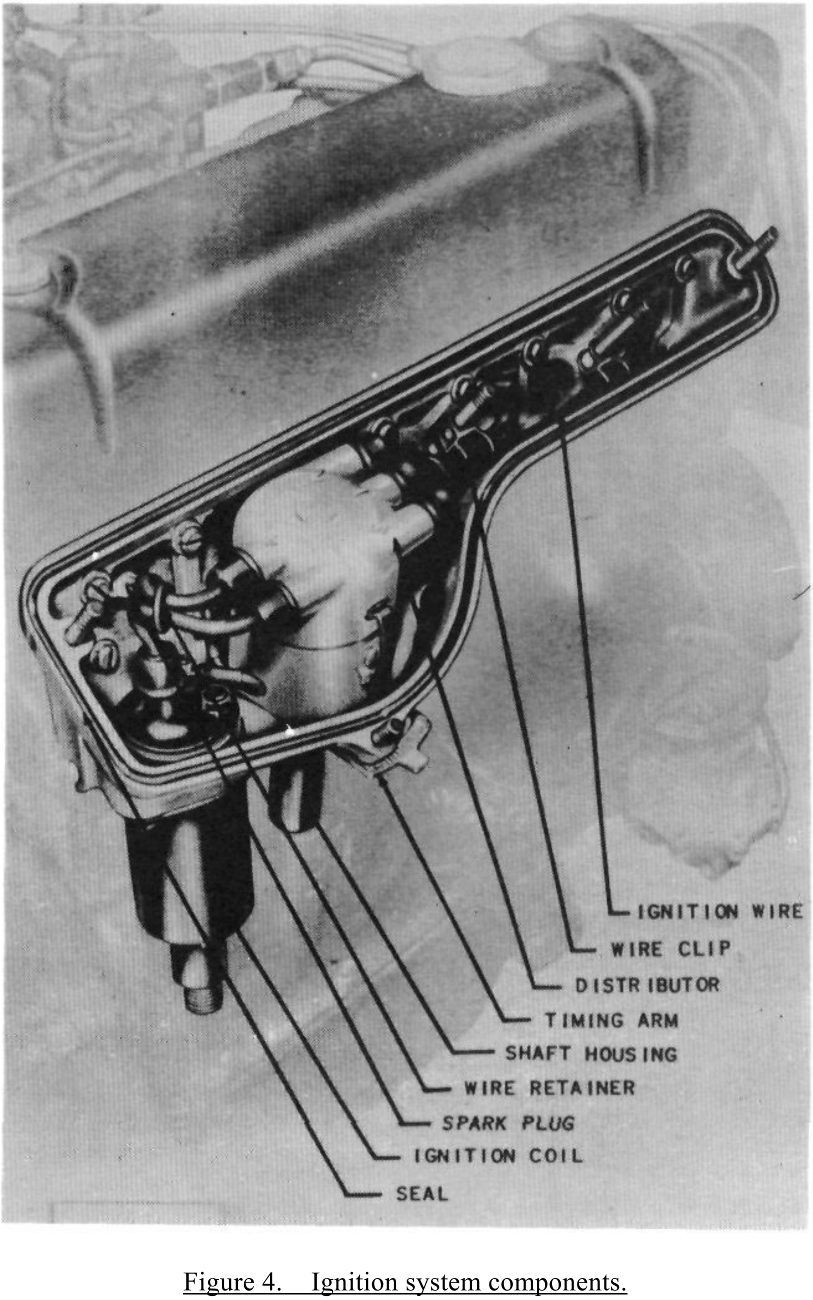



Figure 4. Ignition system components.

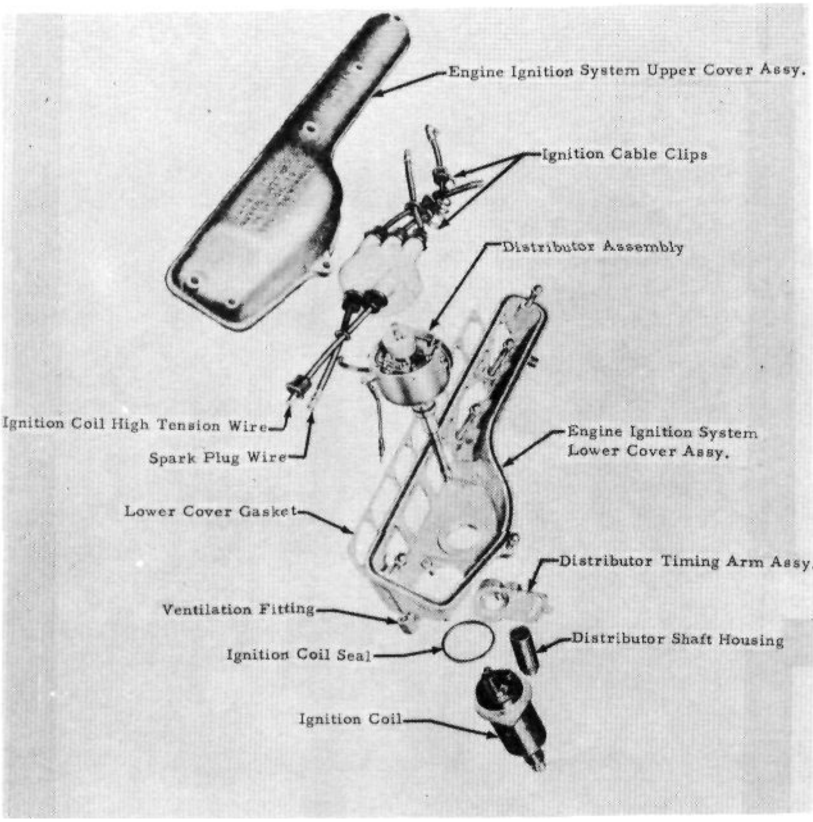



Figure 5. Ignition system components--exploded view.

Initial spark advance can be changed without removing the upper cover. The distributor is retained by a combination clamp-and-timing-arm assembly, creating a wedging action between a groove in the base of the distributor and the external bottom surface of the lower cover.

This change and improvement of the ignition system clearly indicates the possibility for improvement of other portions of our engines and vehicles. If we can achieve overall simplicity in design and construction, we will reduce time and effort required for maintenance tasks, eliminate those countless hours wasted by the roadside, build up the morale of all concerned, and increase mobility with simplicity.

## AIDS FOR THE SAFETY OFFICER

CAPTAIN DAVID L. CRISWELL

DEPARTMENT OF GUNNERY

The Gunnery Department is always happy to receive comments and recommendations from the field. Some suggestions are not practical for use throughout artillery, but some are especially pertinent and worthy of passing on to others. Such is this suggestion submitted by 1st Lt Richard L. Barber, 2d Division Artillery.

Lt Barber has submitted a method for recording and referring to safety data that will decrease the possibility of errors by the safety officer and reduce the amount of "safety time" taken by the safety officer. This safety data record is a tabular arrangement of firing data taken from the safety diagram. It is simple, compact, and especially useful when numerous "doglegs" are prescribed on the safety diagram.

The safety data record is a card of any convenient size, usually 3x5 inches or 5x8 inches, for each charge to be fired. Safety data are transcribed directly from the safety diagram to the card. Additional cards may be prepared for high-angle fires or different types of shells. Registration corrections are applied to the safety data, as they become available.

Figure 6 is the safety diagram for a position for the 105-mm howitzer, having several "doglegs". Figure 7 is the corresponding safety data record. It is interesting to note that the gun position is in use at Fort Lewis, Washington, and is not a figment of imagination.

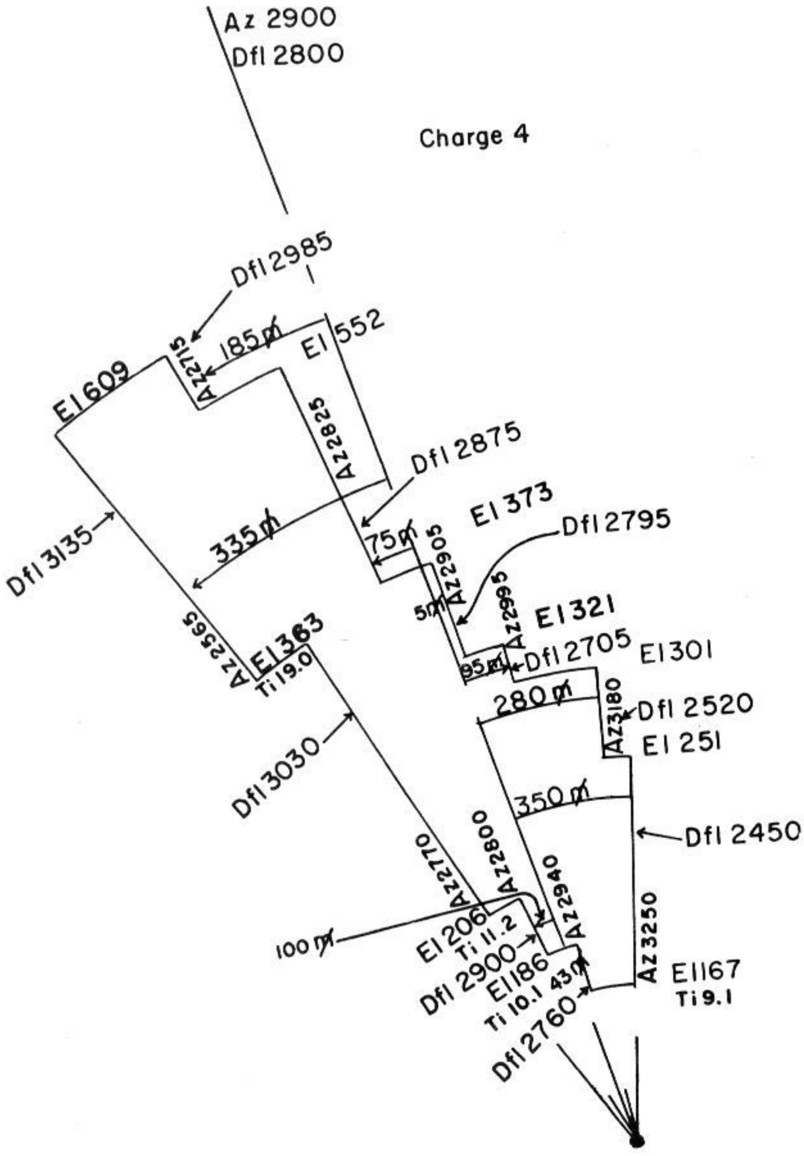



Figure 6. Safety diagram for 105-mm howitzer.

Let's follow a fire mission, as it is received by the battery executive, and the actions of two safety officers--one using the safety diagram and the other using the safety data record. The numbers in parentheses below refer to corresponding number circled on the safety data record, (fig 6):

| Fire commands | Action by safety officer: Using safety data record | Action by safety officer: Using safety diagram |
|---|---|---|
| BATTERY ADJUST | None. | None. |
| SHELL HE | None. | None. |
| CHARGE 4 | (1) Selects proper safety data record. | None. |
| FUZE TIME | None. | None. |
| CENTER 1 ROUND | None. | None. |
| DEFLECTION 2780 | (2) Establishes a deflection bracket on safety data record. | Checks against lateral limits of safety diagram. Waits until time and elevation are announced for a final check. |
| SITE 304 | None. | None. |
| TIME 11.3 | (3) Checks time with minimum time listed beneath deflection bracket. | Checks time with minimum time on safety diagram by referring to deflection and charge. |
| ELEVATION 190 | (4) Checks quadrant elevation with minimum and maximum elevations listed beneath deflection bracket. | Checks quadrant elevation with minimum and maximum elevations listed on safety diagram by referring to deflection and charge. |

The actions of the safety officer using the safety data record follow the fire commands as they are announced. Further, each element of safety data is referred to only once.

**Safety Data Record**

(1) Charge 4

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Df | 3135 | 3030 | 2985 | 2900 | 2875 | 2795 | (2) 2760 | 2705 | 2520 | 2450 |
| Min ti | 19.0 | 11.2 | 11.2 | 10.1 | 10.1 | 10.1 (3) | 9.1 | 9.1 | 9.1 | |
| Min el | 363 | 206 | 206 | 186 | 186 | 186 (4) | 167 | 167 | 167 | |
| Max el | 609 | 609 | 552 | 552 | 373 | 321 | 321 | 301 | 251 | |

Note. Two additional charges may be listed on reverse side, and one additional charge on this side (form inverted).

Figure 7. A typical safety data record.

Preparation of the safety data record is an additional operation for the safety officer. It does not replace the safety diagram but is only an orderly method of recording the safety data. The safety diagram must be prepared to give a graphical presentation of the impact area and provide the data entered on the safety data record.

The safety data record has been used for more than 6 months by the 546th Field Artillery Battalion and the 12th Field Artillery Battalion at Fort Lewis, Washington. It is a definite aid to the safety officer. Its use is now being taught at the U. S. Army Artillery and Missile School. It is highly recommended to you.

## FIELD ARTILLERY GUN DATA COMPUTERS

LIEUTENANT ROBERT E. CAMALANE

DEPARTMENT OF GUNNERY

In the June 1957 issue of Trends, an article appeared indicating the need of electronic computers in the field artillery. Here is the current status of gun data computers and their application in the field artillery.

At the present time, two types of gun data computers for cannon artillery are under development.

The first is the T29E1 gun data computer. This computer for the 105-mm howitzer successfully passed the service test conducted by the U. S. Army Artillery Board and was recommended for limited production and issue. Therefore, some units can expect to be equipped with the T29 in the near future. Since your unit may receive the T29 computer, it would be advantageous to see what it is, what it will do, and how it works.

The T29E1 is an electro-mechanical analog gun data computer. With this type of computer, the parameters involved in a problem (range, azimuth, and altitude) are converted into mechanical or electrical equivalents (the rotation of a shaft, the amplitude of a voltage). Computed results are obtained by the interaction of moving parts or electrical signals which solve an equation or perform a given set of arithmetical or mathematical operations. An analogy is set up in the computer whereby one unit is represented by another. In the case of the T29E1, the analogy is one volt equals one thousand yards.

The T29E1 is compact, rugged, transportable, and easily set up for operation. It is approximately 6 cubic feet in size and weighs 250 pounds. The T29E1 can be operated from the back of a 3/4-ton truck or can be quickly set up in a tent. The computer consists of subassemblies that can be easily removed and replaced in the event of a malfunction.

The T29E1 solves both the geometric and ballistic portions of the gunnery problem for all present delivery techniques (adjustments, K-transfer, meteorological corrections, velocity errors, and predicted fire). As input data, the computer accepts velocity data for each charge, a 10-line meteorological message, propellant temperature, projectile weight, charge, trajectory, and target and battery locations. Deflection, quadrant elevation, and fuze setting, corrected for variations from standard, are computed instantaneously and displayed on the face of the computer for ready reference.

The principal advantage of the computer, in addition to the obvious one of its speed, is its accuracy in comparison to a solution computed by hand. The computer will, for example, automatically interpolate between line numbers as a function of the quadrant elevation to be fired. It also considers and compensates for some interaction effects, i. e., the effect of one nonstandard condition on another. Therefore, while the computer produces primarily a firing table solution, it is in some respects more accurate than a tabular firing table hand solution. The computer has the capability of producing more accurate K-transfer data than the present hand and graphical solution. In conventional computation techniques, the total corrections to range and time are applied in proportion to chart range regardless of the elements necessitating the correction. The computer, however, can correct for each known or estimated condition in its proper element. The computer will treat a velocity error as a velocity error and compute each element correction for the specific trajectory in question. In the computer solution, only the residual effect of unknown existing conditions is treated as a K. Data for replot is considered in the same way. Ballistic conditions are stripped from the computer and true ground coordinates are extracted for replot and passed to other batteries with the same accuracy and speed with which the firing data is determined.

An analog-type computer is usually designed to accomplish one specific job. In the case of the T29E1, firing data are determined for the 105-mm howitzer M2A1 and M4 when using dualgran propellant, and a high-explosive, chemical, or smoke shell. The U. S. Army Artillery Board is presently conducting an evaluation test on the T29E2. This computer has the capability of determining firing data for the 105-mm and 155-mm howitzer; however, certain components will depend on the caliber and will have to be removed and replaced when changing from one caliber to another.

In addition to the T29E1, the T29 computer system includes a gunnery officer's console. The fire direction officer utilizes the gunnery officer's console to automatically transmit elements of his order to the computers (there may be several computers netted in a battalion). Also, and most important, the gunnery officer's console provides a rapid means for massing more than one battery on the target of the adjusting battery.

The U. S. Army Artillery and Missile School has recommended POI's for two computer courses. One course is designed to train computer operators and the other to train maintenance personnel.

Great progress in the field of computers has been made since 1949 when two artillery officers gave the initial impetus to the gun data computer program. Progress in computer development has resulted in the development of the Frankford Arsenal Digital Artillery Computer (FADAC).

The FADAC is an electronic digital computer. A digital computer is one which performs mathematical operations with numbers expressed in the form of digits which can assume only discrete values. The results yielded by a digital computer are expressed in digits. In the case of the FADAC, the complex gunnery problem is broken down into the simplest arithmetic functions of addition and subtraction.

A design study conducted by the engineering research associates of the Sperry Rand Corporation indicated that a digital computer, such as FADAC, would be superior to an analog type and would provide even greater accuracy, greater flexibility, and ease of manufacture and maintenance than can be hoped for from an analog computer. It is anticipated that a contract for a pilot model will be awarded in the next few months. It will require approximately one year to build.

The ballistic solution provided by FADAC is based on the equation of motion. This method of computation, practical only with a digital computer, considers all forces acting on a projectile at given points along the trajectory and numerically integrates them, thus all interaction effects are considered and compensated for. Since the T29 considers and compensates for only a portion of the total interaction effects, its accuracy decreases under conditions of large variations from standard. The accuracy of the FADAC, however, is not affected by the magnitude of the variations. In addition, FADAC will utilize raw meteorological data, thereby eliminating the errors due to meteorological weighting factors.

Because of the relatively small amount of ballistic information that must be entered into the computer, the FADAC will be capable of determining firing data for any projectile for a given weapon. Only a few minutes would be required for ordnance personnel to convert a computer for use with another weapon.

Maintenance in the field would be relatively simple and could conceivably be performed by the operator. The extensive checking features built into the machine will give a continuous check on all major units and a trouble indicator will pin-point malfunctions. The defective component can be removed and a spare inserted to clear the fault. A sample problem, for which the answers are known, can be inserted periodically as a check on proper functioning.

The FADAC should be easier to manufacture. Recent manufacturing developments, such as transistors, miniaturization, printed circuits, and automatic assembly may be utilized. Most parts can be produced without a high degree of manufacturing precision.

In the next issue of Trends, the organization of a fire direction center utilizing the T29E1 will be discussed.

## HIGHER PERFORMANCE ARMY OBSERVATION AIRCRAFT

**LIEUTENANT COLONEL B. A. JOHNSON**

**DEPARTMENT OF TACTICS AND COMBINED ARMS**

Testing of the high performance army observation aircraft T-37 was completed at Fort Sill, Oklahoma in November 1957. The aircraft is a two-place, twin jet engine aircraft capable of speeds up to 470 miles per hour and a cruising speed of 240 miles per hour. The interim aircraft used may not be the T-37 (on loan from the U. S. Air Force) but a turbo prop jet, the Grumman Mohawk OF-1 which will reduce the take-off distance over a 50 foot obstacle from approximately 1, 500 feet to 655 feet.

Tests indicate that the T-37 is a suitable observation plane for artillery surveillance, target acquisition, adjustment of fire, and assessment of target damage of medium and long range artillery. The speed of the aircraft did not prevent a detailed search of a ground area of interest, nor did the speed preclude the gathering of accurate data on ground targets. Most personnel taking part in this test were impressed with their own ability to observe when traveling at low altitudes (50 to 200 feet) and high speeds. Extensive formal aerial observer training is not necessary to produce competent aerial observers. However, it pays to have aerial observers trained in jet aircraft and then assigned to an appropriate TOE position. The T-37 and the L-19 complement each other--neither is a substitute for the other--and continued development and testing of tactics, techniques, and employment of high performance observation aircraft are necessary.

## ROCID ARTILLERY FDC

CAPTAIN WILLIAM A. NAUGHER

DEPARTMENT OF GUNNERY

The U. S. Army Artillery and Missile School concept is that the Reorganization of Current Infantry Division (ROCID) division artillery will normally be employed as two composite battalions. This concept of employment and the area over which the units are expected to be deployed necessitates decentralization of fire control to the batteries. The decentralization will require modifications of present fire direction center (FDC) procedures as outlined in FM 6-40 and of current ROCID tables of organization and equipment (TOE). The modifications are peculiar to ROCID artillery and do not apply to units organized under the Corps or Army artillery (i. e., with three batteries of the same caliber in a battalion). The ROCID artillery battalion fire direction center will exercise tactical fire control and will function in much the same manner as the division artillery and group artillery fire direction center did previously. The battery FDC personnel will exercise technical fire control; they have assumed the duties of fire direction previously performed by the battalion FDC personnel. The principle in FM 6-40 that firing data is normally produced at battery level has not changed; however, on occasions when a unit is operating with 2 platoon fire direction centers (battery (-) and 1 platoon), the data may be produced in the platoon fire direction center. Normally, the primary and check charts will be maintained by the battery FDC personnel; however, when a battery is deployed in firing platoons, a primary and check chart should be maintained by either battery or platoon FDC personnel for each platoon.

The fire direction problems are further complicated since the battalions will consist of mixed caliber weapons. By shifting equipment and personnel within battalions or between battalions, the majority of ROCID artillery units can be organized to provide personnel and equipment to perform the duties required by the ROCID concept. However, the 8-inch howitzer battery personnel cannot accomplish these duties efficiently even with an exchange of personnel and equipment with the other units of division artillery. In view of the above, a study at the U. S. Army Artillery and Missile School has been conducted to determine a suitable solution to the ROCID fire direction problem. The tentative recommendations of this study are reflected in the following paragraphs.

The 155-mm howitzer battery and the 4.2-inch mortar battery have sufficient personnel and equipment to perform all required fire direction functions, except that the 155-mm howitzer battery is not capable of operating independently of battalion unless 1 of the 4 authorized chart operators is designated as a control chart operator. The 105-mm and 8-inch howitzer batteries, however, lack certain fire direction equipment and personnel that would seriously affect continuous operations if these batteries displace or deploy by platoon. In the 105-mm howitzer battery, there are sufficient personnel to operate only for a limited time as a battery (-) and one platoon FDC. The TOE authorizes only 1 fire direction officer (FDO); but during displacement by echelon or deployment by platoon (battery (-) and 1 platoon FDC), the battery executive can perform duties of the platoon fire direction officer while the platoon commander performs all duties normally performed by the battery executive when all weapons are under battery control. If a control chart is required at both battery (-) and the platoon fire direction center, the acting platoon fire direction officer or one of the chart operators in the battery fire direction center (4 authorized and only 2 required) can perform the duties of a control chart operator. The following equipment is short for the platoon fire direction center, but can be furnished by the battalion fire direction center.

| | |
|---|---|
| 2 - 105-mm howitzer graphical firing table (GFT) fans | 12 authorized battalion FDC and only 1 required |
| 1 - 105-mm howitzer graphical site table (GST) | 2 authorized battalion FDC and only 1 required |
| 1 - Command post (CP) light set, set nr 2 | 2 authorized battalion FDC and only 1 required |
| 1 - Plotting board, M10 | 5 authorized battalion FDC and none required |

The most critical item of shortage is the fire direction set artillery, set nr 5, four of which are required for each battery operating under platoon concept. Each battalion FDC has 1 extra fire direction set artillery, set nr 5, but 10 additional sets are required if all 105-mm howitzer batteries are to be deployed or capable of deploying by platoon. A suitable substitute, pending revision of current tables of organization, would be folding tables with improvised map board tops. (The fire direction set artillery, set nr 5, consists mainly of the drawing board for mounting grid sheet or map and a trestle for supporting the drawing board. Other items, such as protractor, range-deflection (aluminum), target grids, and grid sheets are included in the set.)

The 8-inch howitzer battery TOE does not authorize sufficient personnel or equipment for split deployment (battery(-) and one platoon). Personnel for 2 suitable fire direction teams, except for the fire direction officer, could be organized by splitting the battery FDC and by adding 2 wire section personnel as radiotelephone operators. However, the detached platoon would also be short a platoon commander in addition to the fire direction officer. If these shortages in officer personnel can be filled from the battalion headquarters or other division artillery battalions, then the 8-inch howitzer has an emergency capability of platoon deployment. Since only enough fire direction equipment is authorized for 1 fire direction center, the following equipment must be furnished by battalion: Two 8-inch howitzer GFT's; one 8-inch howitzer GST; 1 command post light set, set nr 2; and 1 plotting board M10. That leaves two fire direction sets artillery, set nr 3 as the major items of equipment still short; folding tables and improvised map boards could be substituted for these, pending revision of current tables of organization and equipment.

In addition to the foregoing problems, certain fire direction procedures, as outlined in FM 6-40, will require modification. For instance, in a composite battalion when a battalion FDO order is issued, the order must be modified from FM 6-40 procedure by deleting "charge" and "lot number" since various type calibers are involved. The battery fire direction officer must determine and announce these elements as fire commands. A unit standing operating procedure (SOP) will have to be established for firing a range spread; i.e., a composite battalion of 5 batteries would fire as follows: Adjusting battery at center range, 2 batteries 1/2 C (one C equals the change in elevation for a 100-yard change in range) apart (1 short and 1 over), and 2 batteries 1 C apart (1 short and 1 over). The procedure outlined in FM 6-40 for determining data for replot must be modified because the data for replot is determined by successive approximation at the adjusting battery or platoon fire direction center using the fire direction officer or other designated person as the control chart operator. When data for replot has been determined, it is transmitted to the next higher FDC (battery or battalion) for dissemination to all concerned. Another proposed change is that site for any type unit is best computed by the battery fire direction computer instead of the primary chart operator. Because of this change, the primary chart operator must announce range and 100/R as first elements of data. Range is necessary for site computation, and the 100/R should be announced for use by the computer for site changes caused by the observer corrections.

Because of the different calibers within a battalion, the battery fire direction officer, instead of the battalion fire direction officer, is responsible for adjustment of charts. It is not necessary to adjust to or with other batteries since the batteries do not have the same graphical equipment, and therefore, calibration of equipment is not possible. In the event more than 1 battery is to fire for effect after adjustment by 1 battery, adjusted coordinates and altitude will be furnished by the adjusting battery to the nonadjusting battery(s) through battalion FDC, provided common survey control has been established for all batteries. The altitude announced will be the FDO order altitude as changed by the observer's corrections of up or down. The coordinates announced are the fire for effect pin location. The lack of time prohibits use of successive approximations, and accuracy loss is small, particularly if the observer has made indicated site changes during his adjustment. If common survey control has not been established and batteries are to mass on a target adjusted on by one battery, the final target location must be announced by polar plot from a common known point plotted on all firing charts, i. e., registration point. The battalion FDO will be unable to do specific tasks as listed in FM 6-40; e. g., compute velocity error (VE), conduct registrations, etc., but he must require the batteries to keep corrections current. For the same reason, the chief computer at battalion should not compute the meteorological and velocity error corrections, but the corrections are computed in each battery fire direction center.

Some of the problems arising from the new division concept have been discussed in this article and methods of overcoming them have been offered. It is realized that many more problems are being encountered in the units being reorganized, and that solutions are being determined. Therefore, ideas and comments on the new divisions that pertain to gunnery are solicited from the units in the field. Send your problems and/or solutions to Director, Department of Gunnery, Fort Sill, Oklahoma.

## EXTENSION COURSE COMPLETIONS

The following officers and enlisted men were issued certificates of completion for artillery extension courses during September, October, November, December 1957, and January 1958.

ACTIVE ARMY

| Name | Rank | Component | Course Completed |
|---|---|---|---|
| Boehnke, Roger H. | 1st Lt | USAR-EAD | Army Aviation |
| Cassidy, James J. | Maj | USAR-EAD | FA Gunnery |
| Culpepper, Grady A. | 1st Lt | NG-EAD | AAA Battery |
| Fawcett, John R. | Maj | USAR-EAD | FA Gunnery |
| Gilmore, Edward A. | CWO | USAR-EAD | Army Aviation |
| Leonard, Jesse W. | CWO | USAR-EAD | Army Aviation |
| Loren, William H. | Maj | NG-EAD | FA Gunnery |
| Michaud, Wilson A. | MSgt | RA | AAA Battery |
| Miersen, Charles D. | Pvt | NG-EAD | Communication |
| Rutledge, John M. | Maj | USAR-EAD | AAA Advanced |
| Scott, Wendell A. | WO | RA | FA Battery |
| White, William R. | MSgt | RA | FA Gunnery |

NATIONAL GUARD

| Name | Rank | State | Course Completed |
|---|---|---|---|
| Anderson, Jackson W. | 2d Lt | N. D. | FA Battery |
| Barton, Bernard H. | MSgt | N. H. | FA Gunnery |
| Baughman, H. G. | Maj | Cal. | AAA Advanced |
| Bear, Marvin B. | 2d Lt | Va. | FA Battery |

| Name | Rank | State | Course Completed |
|---|---|---|---|
| Bilbrey, Robert E. | 1st Lt | Tenn. | FA Battery |
| Braever, David N. | Capt | N. J. | Motors |
| Brower, Paul J. | 1st Lt | Tex. | FA Battery |
| Delcore, John P. | 1st Lt | Mass. | AAA Battery |
| Denis, George L. | Maj | N. H. | FA Gunnery |
| Donges, Richard F. | 1st Lt | Wash. | AAA Battery |
| Eastman, R. W. | 1st Lt | Ver. | AAA Battery |
| Fallgren, J. R. | Capt | Cal. | AAA Battery |
| Farndon, Thomas W. | 1st Lt | Md. | FA Battery |
| Gill, Frank E. | MSgt | R. I. | FA Gunnery |
| Gipson, David C. | 1st Lt | Tex. | FA Battery |
| Golej, Paul | Capt | N. H. | FA Gunnery |
| Helm, John B. | 2d Lt | Ky. | Motors |
| Higgins, Kendall F. | 1st Lt | Mass. | AAA Battery |
| Hoots, Dorrance L. | Capt | Ore. | FA Battery |
| Hunte, Rudolph J. | 1st Lt | N. Y. | FA Gunnery |
| Hutson, James H. | Capt | Okla. | FA Advanced |
| Ibson, James W. | 2d Lt | Conn. | FA Battery |
| Johnson, Arthur J. | Capt | N. J. | FA Battery |
| Johnson, Leland E. | 1st Lt | N. Y. | FA Battery |
| Kaardal, Elmer A. | 1st Lt | Minn. | FA Gunnery |
| Kennealy, James E. | 1st Lt | N. J. | FA Gunnery |
| Kolivas, Nicholas | Maj | N. H. | FA Gunnery |

| Name | Rank | State | Course Completed |
|---|---|---|---|
| Kretzler, F. J. | Capt | O. | AAA Advanced |
| Laughney, Edward | Maj | Cal. | AAA Battery |
| Liebold, Henry C. | 1st Lt | Penn. | Army Aviation |
| Lloyd, Jules B. | 1st Lt | N. Y. | FA Gunnery |
| Mathieu, J. J. | 2d Lt | Mich. | AAA Gunnery |
| Mathson, John R. | Sp 2 | Wy. | Motors |
| McGrath, Melvin F. | Capt | Wy. | Survey |
| Minick, William M. | 1st Lt | S. C. | AAA Battery |
| Miskelly, William W. | 1st Lt | S. C. | AAA Battery |
| Mitchell, Joe F. | 1st Lt | N. C. | FA Battery |
| Myers, Samuel M. | Capt | Tenn. | MOS 1174 |
| Nadeau, Alexander D. | Capt | Ala. | AAA Battery |
| Nichols, Hobert C. | 1st Lt | Cal. | FA Battery |
| Nielson, Bill W. | Capt | U. | Army Aviation |
| Perry, James D. | CWO | S. C. | AAA Battery |
| Rubinovitz, J. I. | 1st Lt | Mass. | AAA Battery |
| Sillin, Percy P. K. | 1st Lt | Kan. | FA Battery |
| Simerly, Enoch B. | 1st Lt | Tenn. | Communication |
| Simms, Arthur W. | WO | N. J. | FA Supply |
| Stefanick, Frank | Maj | Penn. | AAA Advanced |
| Stinnett, William C. | 1st Lt | Cal. | AAA Battery |
| Swan, Quentin J. | CWO | Col. | FA Supply |
| Taylor, Lon W. | 1st Lt | N. C. | FA Battery |

| Name | Rank | State | Course Completed |
|---|---|---|---|
| Templeton, Willard F. | 1st Lt | Tenn. | FA Battery |
| Thomasson, Russell L. | 1st Lt | Tex. | FA Battery |
| Thompson, Billy H. | 1st Lt | Tex. | FA Battery |
| Thompson, Paul L. | Capt | O. | AAA Battery |
| Todd, Donald G. | SFC | Wy. | Supply |
| Vath, Alvin R. | 1st Lt | La. | AAA Battery |
| Ward, Philip P. | 2d Lt | N. Y. | FA Battery |

USAR

| Name | Rank | State | Course Completed |
|---|---|---|---|
| Ailstock, James W. | Capt | Va. | Motors |
| Blanton, John A. | MSgt | Mich. | Motors |
| Brown, Harry E., Jr. | Maj | Okla. | Army Aviation |
| Burbank, R. W., Jr. | MSgt | Mass. | Communication |
| Cootsona, A. N. | Maj | Wash. | FA Gunnery |
| Erdmann, Leonard C. | 1st Lt | Wis. | FA Battery |
| Ettinger, George M. | Capt | Cal. | 40 FA |
| Fewins, Kenneth D. | Capt | Wash. | Army Aviation |
| Frohman, Irving G. | Lt Col | N. Y. | Army Aviation |
| Glozer, Norman L. | Capt | S. C. | AAA Advanced |
| Harwick, Richard | Lt Col | Tex. | AAA Gunnery |
| Hoch, Robert H. | Lt Col | Minn. | MOS 1172 |
| Hoke, Russell L. | 1st Lt | Cal. | AAA Battery |
| Louis, Henry W. | 1st Lt | Ia. | Army Aviation |

| Name | Rank | State | Course Completed |
|---|---|---|---|
| Mitchell, Edwin T. | Maj | Kan. | Communication |
| O'Connell, Paul | Maj | Mass. | Communication |
| Oser, Daniel H. | 1st Lt | O. | AAA Battery |
| Peters, Everett J. | Maj | Ill. | Observation |
| Porzio, Americo J. | 1st Lt | N. Y. | FA Battery |
| Romjue, K. L. | Maj | Wash. | AAA Gunnery |
| Symon, William M., Jr. | Capt | Mo. | FA Gunnery |

OTHERS

| Name | Rank | Service | Course Completed |
|---|---|---|---|
| Little, Richard G. | 1st Lt | USMC | FA Gunnery |



**287 ARMY-FORT SILL, OKLA.**

## 1/2 STABLE

| GT RANGE IN YARDS | ANGLE T IN MILS | | | | |
|---|---|---|---|---|---|
| | 0 - 99 | 100 - 499 | 500 - 799 | 800 - 1399 | 1400 - 1600 |
| 2000 | 2 | 4 | 8 | 16 | 16 |
| 3000 | 2 | 4 | 8 | 8 | 16 |
| 4000 | 2 | 4 | 4 | 8 | 8 |
| 5000 | 2 | 4 | 4 | 8 | 8 |
| 6000 | 2 | 2 | 4 | 4 | 8 |
| 7000 | 2 | 2 | 4 | 4 | 8 |
| 8000 | 2 | 2 | 4 | 4 | 4 |
| 9000 | 2 | 2 | 2 | 4 | 4 |
| 10000 | 2 | 2 | 2 | 4 | 4 |
| 11000 | 2 | 2 | 2 | 4 | 4 |
| 12000 | 2 | 2 | 2 | 2 | 4 |
| 13000 | 2 | 2 | 2 | 2 | 4 |
| 14000 | 2 | 2 | 2 | 2 | 4 |
| 15000 | 2 | 2 | 2 | 2 | 2 |

## FDC SENSING TABLE

| GUNS LEFT | Observer Sensing | 1 -99 | 100 -499 | 500 -799 | 800 -1399 | 1400 -1600 | 1601 -1799 | 1800 -2399 | 2400 -2699 | 2700 -3099 | 3100 -3200 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | ? R | ? R | + R | + ? | + ? | + ? | + ? | + ? | + ? | + L | ? L |
| | ? L | ? L | - L | - ? | - ? | - ? | - ? | - ? | - ? | - R | ? R |
| | + LN | + L | + L | + L | + L | + L | - L | - L | - L | - L | - L |
| | + R | + R | + ? | + ? | + ? | + L | + L | ? L | - L | - L | - L |
| | + L | + L | + L | + L | ? L | - L | - L | - ? | - ? | - ? | - R |
| | - LN | - R | - R | - R | - R | - R | + R | + R | + R | + R | + R |
| | - R | - R | - R | - R | ? R | + R | + R | + ? | + ? | + ? | + L |
| G O | - L | - L | - ? | - ? | - ? | - R | - R | ? R | + R | + R | + R |

| GUNS RIGHT | Observer Sensing | 1 -99 | 100 -499 | 500 -799 | 800 -1399 | 1400 -1600 | 1601 -1799 | 1800 -2399 | 2400 -2699 | 2700 -3099 | 3100 -3200 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | ? R | ? R | - R | - ? | - ? | - ? | - ? | - ? | - ? | - L | ? L |
| | ? L | ? L | + L | + ? | + ? | + ? | + ? | + ? | + ? | + R | ? R |
| | + LN | + R | + R | + R | + R | + R | - R | - R | - R | - R | - R |
| | + R | + R | + R | + R | ? R | - R | - R | - ? | - ? | - ? | - L |
| | + L | + L | + ? | + ? | + ? | + R | + R | ? R | - R | - R | - R |
| | - LN | - L | - L | - L | - L | - L | + L | + L | + L | + L | + L |
| | - R | - R | - ? | - ? | - ? | - L | - L | ? L | + L | + L | + L |
| O G | - L | - L | - L | - L | ? L | + L | + L | + ? | + ? | + ? | + R |