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**THE
FIELD ARTILLERY
JOURNAL**

EDITED BY

ARTHUR F. CASSELS

LIEUTENANT-COLONEL (FIELD ARTILLERY), UNITED STATES ARMY, RETIRED

**THE UNITED STATES FIELD ARTILLERY ASSOCIATION
WASHINGTON, D. C.**

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THE FIELD ARTILLERY JOURNAL

**Volume IX
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MAJOR GENERAL CHARLES T. MENOHER, UNITED STATES ARMY
DIRECTOR OF AIR SERVICE

Colonel Commanding 5th U. S. Field Artillery, American Expeditionary Forces, France, July to September, 1917.
Brigadier General U.S.A. Established and Commanded School of Instruction for Field Artillery Officers, Saumur, France,
September to December, 1917.
Major General U. S. A. Commanding "Rainbow Division" from December 19, 1917, until the day before the Armistice
was signed. Commanding Sixth Corps A. E. F., France, until December 17, 1918.

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NO. 1

Notes on the Visibility Problem From an Observation Post and the Determination of the Dead Space of a Battery.

BY CAPTAIN CHRISTIAN PIERRET, 7TH FRENCH FIELD ARTILLERY, OFFICE OF
THE FRENCH MILITARY ATTACHE.

AMONG the interesting problems that the Field Artillery officer has to solve as soon as there is time to perfect the hasty organization of a war of movement, are the ones that deal with the possibilities of an observing station or a battery position.

Even during a continuous war of movement, a careful study on the map of the likely places where the batteries moving forward and the observers will take up their positions, very much reduces hesitation during a reconnaissance and avoids the disappointment of finding many more unsuitable than suitable emplacements and observation stations.

The ordinary methods of finding dead spaces or hidden areas by the study of vertical sections and tangent trajectories or straight lines has the disadvantage of a graphic construction with square and ruler, and of the necessity of multiplying the differences of level in the sections so as to obtain a certain degree of accuracy. That is a source of error and the difficulty of drawing a series of perpendiculars under adverse circumstances is another cause of mistakes.

The following methods do not pretend to be simpler than the ordinary ones, but they do away with the above disadvantages.

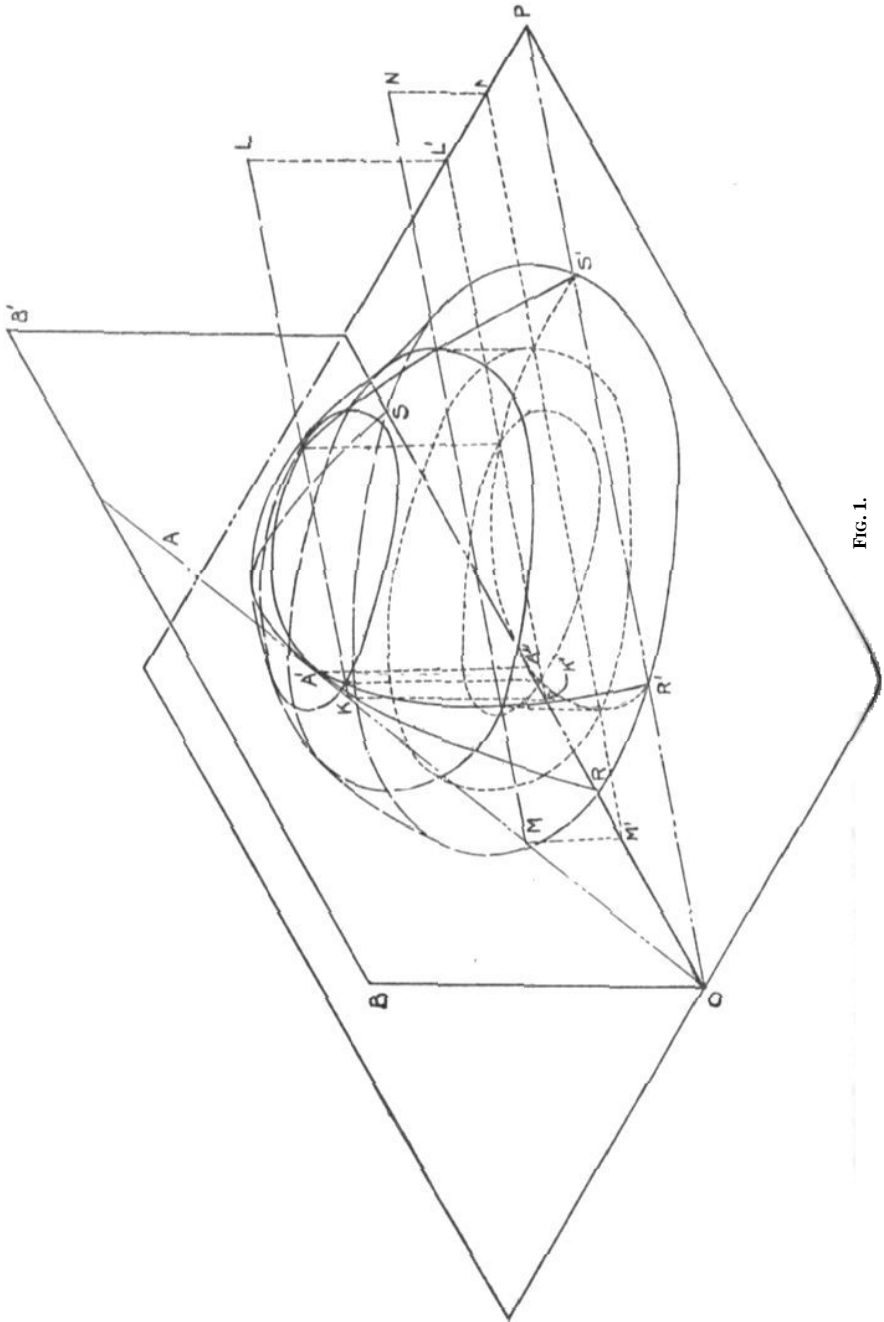


FIG. 1.

NOTES ON THE VISIBILITY PROBLEM

VISIBILITY FROM AN OBSERVATION POST

If we consider a portion of the terrain and an observer at O , Fig. 1, the ordinary method consists in drawing tangents to a series of sections cut by vertical planes passing through O , such as OA' tangent to the section $RA'S$ which is cut by the vertical plane OB' . The line OA is tangent to the terrain at A' . But if instead of using a series of vertical auxiliary planes turning around the axis OB , we use a series of inclined planes such as the plane AOP all passing through O , and keeping the same inclination, a series of sections will be obtained, but with the advantage that their projections on the horizontal plane are not just straight lines, as is the case when vertical planes are used.

An inclined plane cuts the horizontal planes of the contours in horizontal lines MN and KL which project on the horizontal plane through O as lines $M'N'$ and $K'L'$ parallel to the line of intersection, OP , of the inclined plane and the horizontal plane through O . Other positions of the inclined plane will give sets of parallel lines similar to the parallels just described.

The horizontal projection of an oblique section of the terrain cut by the inclined plane AOP is shown in the figure as $R'A''S'$.

Since any section of the terrain cut as above is a plane curve lying in the same plane as O ; a tangent from O to the curve will be horizontally projected as a tangent to the horizontal projection of the section of the terrain; *i.e.*, the line OA which is tangent to the section $R'A'S'$ at A ; will be projected as the line $OA''S'$, tangent to the curve $R'A''S'$, which is the horizontal projection of the section; at the point A'' which is the horizontal projection of A' .

To determine the invisible portion of the terrain as seen from the point O , Fig. 2, draw through O the line OA which is the intersection of some inclined plane with the horizontal plane through O . Parallel to OA draw the lines BC and DE equally spaced. These lines are the horizontal projections of the intersections

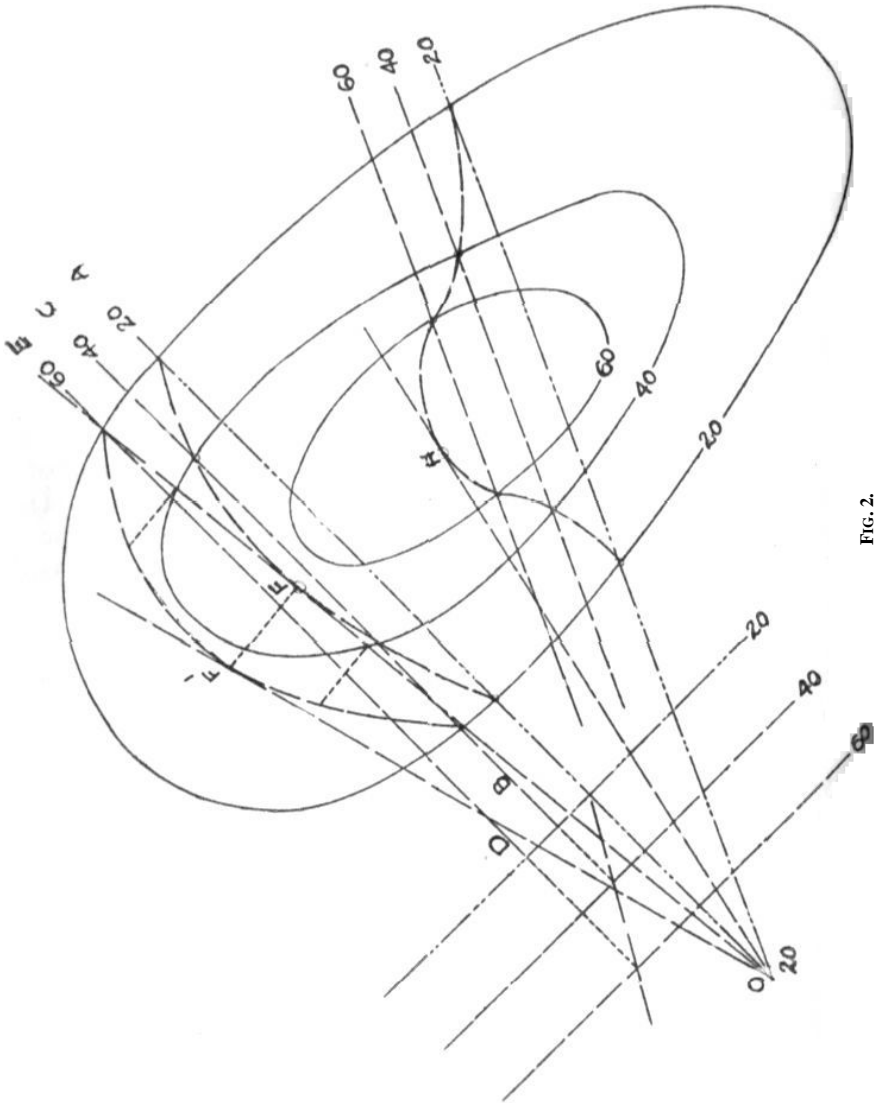


FIG. 2.

NOTES ON THE VISIBILITY PROBLEM

of the above-mentioned plane with the horizontal planes of contours. Number the parallel lines with the heights of their corresponding contour planes. The intersections of similarly numbered contours and parallel lines will be points on the horizontal projection of the curve of intersection of the terrain and the inclined plane used. Through the points thus determined draw a smooth curve; and a line from O tangent to this curve.

This tangent is the horizontal projection of the actual tangent to the real curve of intersection of the inclined plane with the terrain, and the point F is the horizontal projection of the real point of tangency and therefore a point on the line separating the visible from the invisible as seen from O .

Other points, such as H , are obtained in like manner. A line joining these points will separate the visible area from the invisible.

Fig. 2 also shows the determination of point F by means of the rotation of a vertical plane, and the determination of the parallel lines of a grid for any particular inclined plane.

The solution of a general problem in which one crest is obscured by a crest in front is shown in Fig. 3.

A practical solution would consist of a piece of celluloid or cardboard with a rectangular window across which are stretched threads corresponding to the parallel lines of the grid. The points of intersection of the grid lines with the terrain contours can then easily be marked on the map without having to draw the various horizontal lines. Another method would consist of a transparent sheet of celluloid through which are cut equally spaced parallel lines corresponding to the threads of the above construction. The lines are wide enough to allow the point of a pencil to reach through the celluloid sheet to the map.

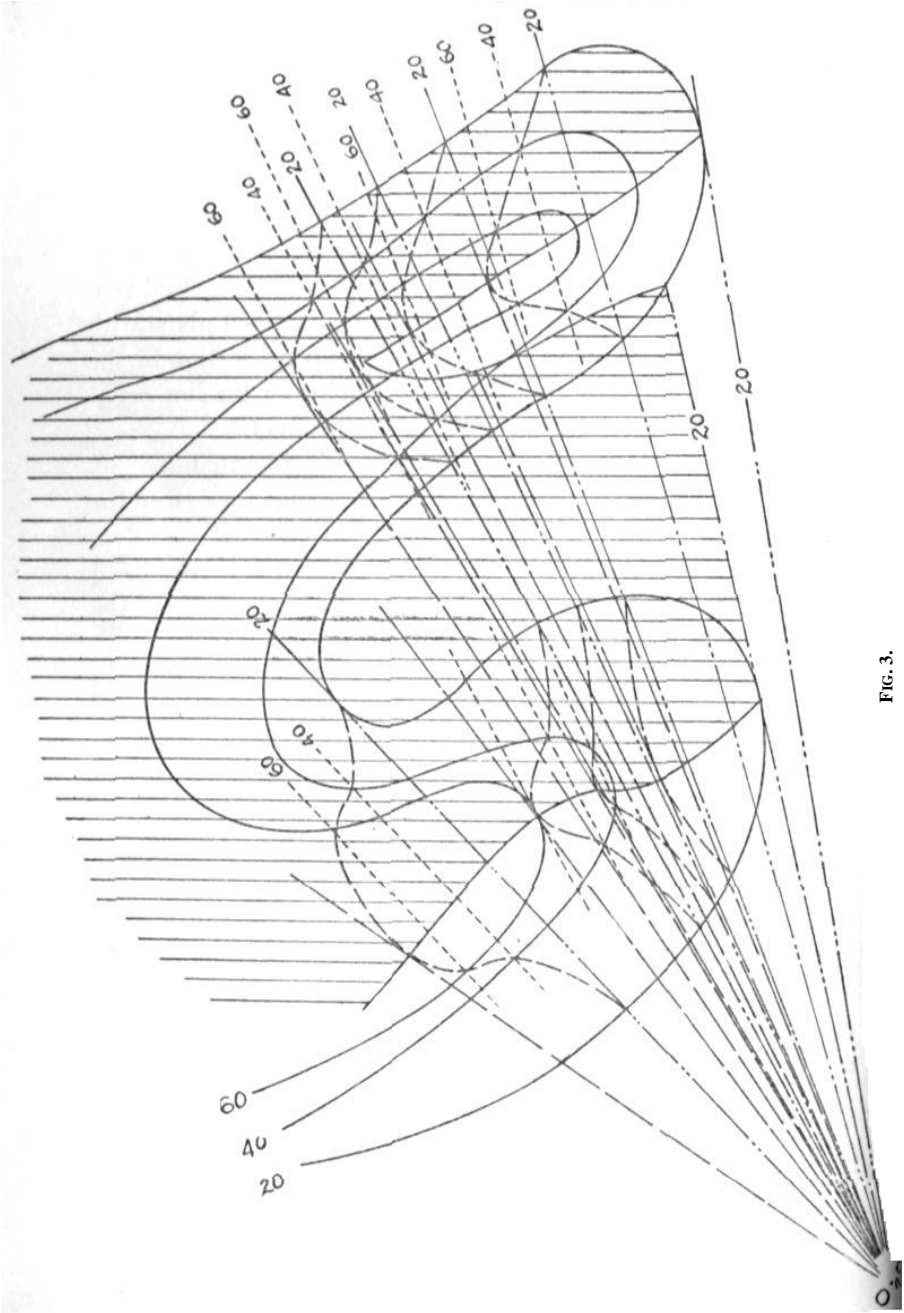


FIG. 3.

The Apache Gate Sector*

BY MAJOR HARRISON FULLER, FIELD ARTILLERY

AT any center for the training of field artillery officers the greatest problem of instruction is not the presentation of theory but the opportunity for practice. This is true because of the difficulty of obtaining sufficient space for firing, with sufficiently varied terrain to make that firing valuable and interesting. Officers who have had to do with the small and unsatisfactory ranges which were the best that could be provided at many divisional camps will testify to this fact. Moreover, having available plenty of ground suitable for artillery firing, the task of laying out firing points and targets in such a manner as best to take advantage of the opportunities provided by nature is no easy one.

The disadvantages of the silhouette target, unrelated to its neighboring targets by any tactical bond, having been recognized long since, efforts at the School of Fire for Field Artillery at Fort Sill have been directed toward providing for the student officer a range presenting conditions of real warfare as plausibly as possible, thus affording opportunity for problems of every kind and at the same time giving the student the tactical background which must be an important part of his training.

These efforts have reached their consummation at Fort Sill in the so-called Apache Gate area. Because of its varied topography, including wood and plain, streams, ravines and hills large and small, this area was found an ideal terrain for the laying out of an enemy sector. Extraordinary opportunities for observation exist, as will be described. In this area, approximately two and one-half kilometres wide and three and one-half kilometres deep, has been developed a complete enemy

* Prepared in the Department of Gunnery, School of Fire for Field Artillery, Fort Sill, Oklahoma.

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sector, including within its limits targets of every description, each one in proper relation to the whole and the whole presenting to the student battery commander an excellent picture of what he may expect to find when his period of training is over and he is called upon to solve real problems of adjustment across a real No Man's Land.

The following notes on the sector are presented with dual purpose in mind. First, it is desired to give the Field Artillery at large an idea of the progress of the school in instruction in firing. Second, it is hoped that those who will have charge of the service practice of the new field artillery regiments may gain suggestions here for the development of similar sectors on their own ranges. These officers may be assured that a little time and thought directed toward the preparation of complete target sectors, representing actual conditions as nearly as possible, will be amply repaid in the interest created among the officers firing and in the variety of problems which may be arranged. This is true no matter how restricted the area available for firing.

ORGANIZATION OF THE SECTOR

The accompanying panoramic photograph shows the sector as seen from the Chrystie Hill observation station, looking west.

Skirting the foot of Chrystie Hill, the American front line trench runs generally north and south. Portions of it may be seen in the background on the right of the picture, disappearing over the crest of Ketch Hill, Chrystie Hill and Rumbough Hill, the latter at the extreme left of the picture, are important observation posts and will be discussed more in detail later. In the southern portion of the sector, opposite Chrystie Hill, No Man's Land includes Medicine Creek and Apache Wood. To the north, No Man's Land is open and flat, varying in width from 60 to 325 metres.

Two distinct areas have been developed within the enemy's lines thus far, and others are being added. One of these lies just to the west of Chrystie Hill and includes Apache

THE APACHE GATE SECTOR

Wood. Here is a close network of trenches, highly organized, with observation posts, posts of command and front line, support and communication trenches. At the bend of the creek is the farthest outposts of the enemy, a sniper's post in the edge of the woods, commanding a view of our front line and giving an opportunity for enfilade fire along a portion of our trenches. The other and more open area lies to the north and contains a more extensive and less closely knit trench system. Here long communication trenches are necessary. Five hundred metres behind La Marne trench, the enemy front line, is Barbed Wire Hill, a strongly fortified hummock of ground containing observation posts for enemy artillery. Just behind the hill is a casemated battery at irregular intervals, barely visible from our most favorable O.P.'s. Behind this hill, parallel to La Marne trench, is Creek trench, the enemy's second line, from 300 to 600 metres behind the front line. Six main communication trenches join the two. Eleven lookout and listening posts have been thrown forward from La Marne trench, some of them being as close as 80 metres to our own front line. They consist of camouflaged dugouts heavily protected by sandbags and presenting targets of low relief, or of organized shell holes, guarded by "hedgehogs" of barbed wire.

THE CHRYSTIE HILL O.P.

Unusual facilities for forward observation of the enemy sector are offered by the rocky ridge of Chrystie Hill. Those familiar with the topography of Fort Sill will remember Chrystie Hill as the rugged knob, hitherto nameless, 700 metres northeast of Rumbough Hill on the opposite bank of Medicine Creek. It now bears the name of the late Captain Phineas P. Chrystie, 312th Field Artillery. Captain Chrystie, a member of the Fourth Class at the School of Fire, was killed February 6, 1918, in the explosion of a 155-mm. howitzer at Chato Ridge, not far from the hill named in his honor.

The elevation of Chrystie Hill is about 372 metres. One hundred metres westward and fifteen metres below is the creek

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bed, its west bank fringed by a thicket of scrubby trees and undergrowth known as Apache Wood. This is the beginning of the enemy's fortified area, his trenches extending well into the thicket from the open ground beyond. From the hill one sees beyond the creek and its border of woods the successive reaches of wooded and open country into which the area is divided. On the left, or south, Rumbough Hill and Heyl's Hill form a natural boundary for the sector. On the north a broad rolling plain extends to the limits of the reservation and to the hills beyond. Across this plain winds the plow furrow which marks our first line trenches. To the west, Monument Hill, Mount Scott and Rabbit Hill dominate a rugged and picturesque skyline.

The design of the shelter constructed on Chrystie Hill was dictated by the necessity for providing protection for an entire section—twenty-five or thirty students—at a time. The result is a dugout 92 feet long with a roof proof against 3-inch and 75-mm. projectiles. Further protection is afforded by the crest of the hill, the slope being 1 on 6. The slope of fall of the 3-inch gun trajectory at 2000 yards is 1 on 14. The excavation for the dugout, blasted in the solid rock of the hill, is 8 feet deep on the side near the crest, 6 feet deep on the lower side, and approximately 7 feet wide. The native rock, partly supplemented by concrete, forms the rear wall and the rear support for the proof. The front wall is composed of 8×8 timbers, faced with 2-inch plank. The space between this wall and the rock of the hill is filled with material from the excavation, topped by a double layer of sandbags as protection against shell splinters. The shell-proof roof rests upon a series of 8×10 beams, placed transversely 8 feet apart. Above these and spiked to them are 8×8 timbers, 8 inches apart, running longitudinally. Next comes a layer of heavy corrugated iron. Above this is a layer of rock from the excavation, 8 inches to one foot in thickness, covered by a similar layer of concrete reenforced by steel mesh. Two layers of sandbags and four inches of rock have been superimposed as additional protection.

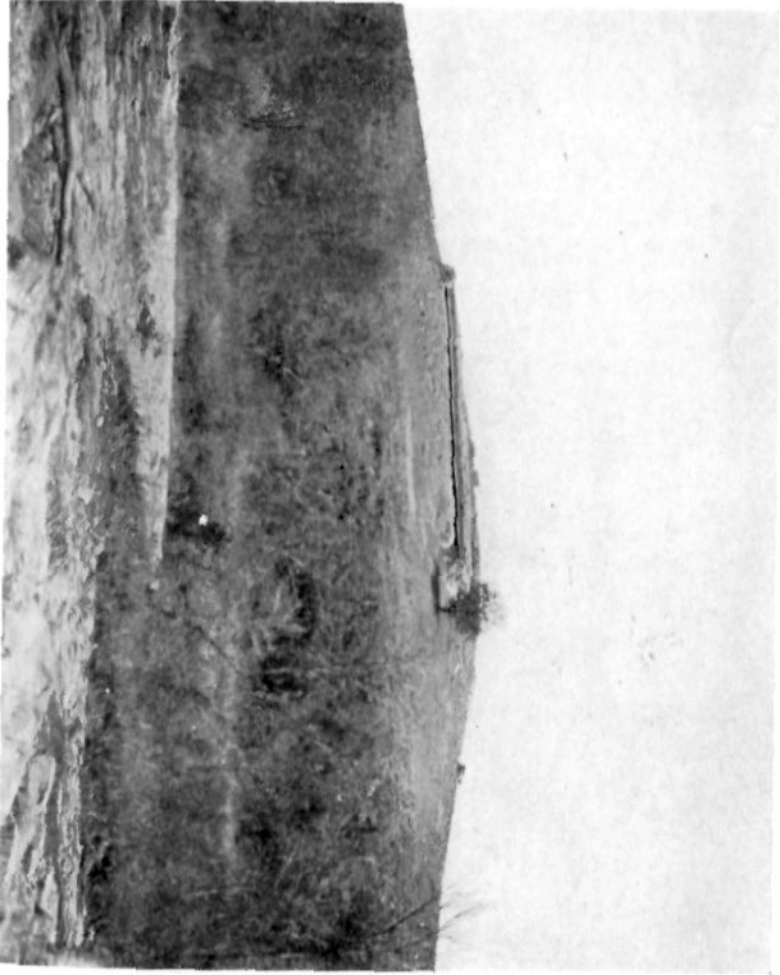


FIG. 1.—CHRISTIE HILL AND THE O. P. AS VIEWED FROM THE BED OF MEDICINE CREEK

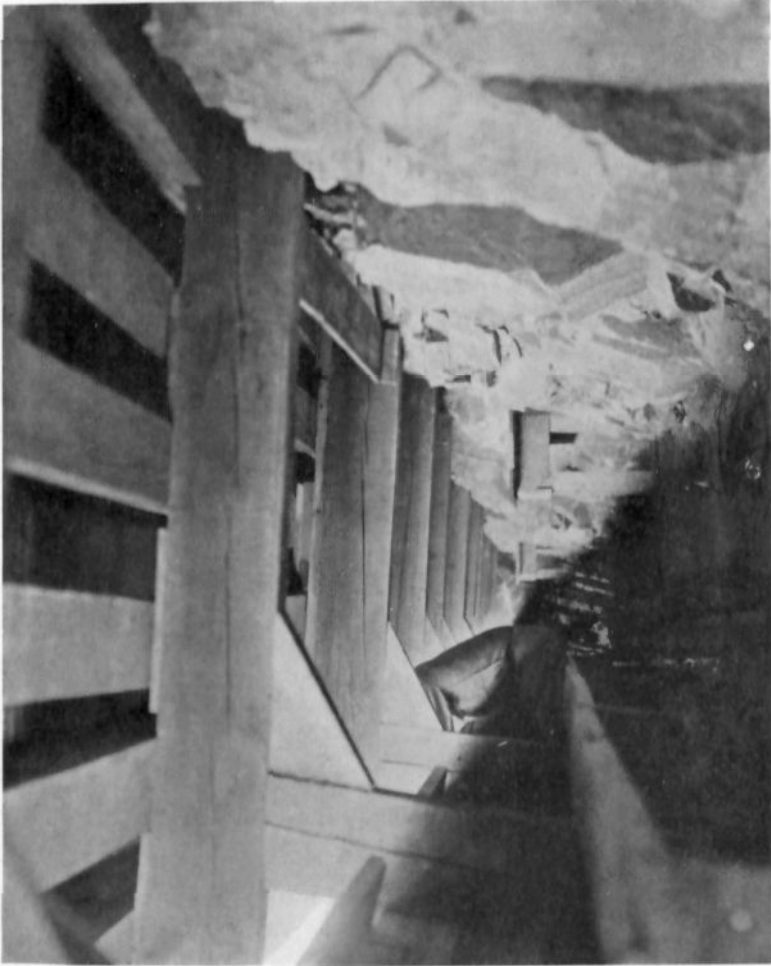


FIG. 2. — THE INTERIOR OF CHRYSTIE HILL O. P. SHOWING THE OBSERVATION APERTURE AT THE LEFT

THE APACHE GATE SECTOR

This structure is designed to resist even a direct hit from a 75-mm. projectile with delayed action fuze.

While the space within the shelter, from floor to ceiling, is but 4 feet, arrangements have been made for the comfortable accommodation of a large group of students. The floor is of concrete. Against the rear wall are tables for the use of students, while near the front wall, is a bench extending the length of the dugout. Seated here students are comfortably placed for observation through the 8-inch aperture provided. A 2 × 8 inch plank, mounted at an angle above the opening, provides protection from the afternoon sun and augments the protection afforded against splinters. The dugout is entered from the front, a door of heavy plank closing the passage. As a final precaution against injury to students, the firing of shell in the area immediately in front of the dugout is prohibited. The targets here may be attacked with shrapnel, either time or percussion. It is possible to bring air bursts sufficiently close to the dugout for a study of shrapnel action.

RUMBOUGH HILL AND HEYL'S HILL

Rumbough Hill has an elevation of about 393 metres. The elevation of Heyl's Hill is 416 metres. From these lofty points one looks almost down upon the enemy sector to the north and northwest. No protection against projectiles is necessary at either of these observation posts. Heyl's Hill, the most advanced post, is used by students firing the 155-mm. howitzers against targets well to the rear of the sector. Rumbough Hill is used principally in the conduct of fire of the light batteries. From it, flank observation may be had against some of the targets in the sector, while the use of almost any observing angle in lateral observation may be illustrated by the selection of targets at longer ranges. Upon this hill have been erected four sheds as protection for students against the elements. One of these, on the crest of the hill, is practically an open air class room, where preliminary instruction may be given in the principles of lateral observation, illustrated by the problems conducted

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by more advanced classes in the other sheds. The students here have the advantage of being able to see exactly what is accomplished by the application of lateral observation methods. On the other hand, the three shelters for classes engaged in firing are well down the slope, at elevations below 385 metres, thus maintaining in some measure the normal difficulties of terrestrial observation.

TARGETS

As has been pointed out, the German sector presents a great number of targets and an opportunity for firing problems the variety and nature of which are limited only by the imagination and ingenuity of the instructor.

Most of the targets are not plainly visible from either Rumbough or Heyl's Hill. Except for a few silhouette targets here and there, the country looks as peaceful and as innocent of enemy occupation as your own back yard. A study of the sector, however, reveals many things. One by one the lines of trenches emerge from obscurity as dark streaks on the ground here and there and reveal themselves as a well organized network of defense. Tufts of grass are turned by a study through the glasses into carefully camouflaged observation posts or batteries in position. Here are two tanks, advancing to the assault in support of a line of infantrymen, presenting a definite tactical situation as the basis of a problem. Just beyond a strip of woods may be seen an airplane which has fallen to the ground or which has been forced to a landing and which must be reached by effective fire almost instantaneously if the occupants are to be kept from escaping into the woods or raising the ship into the air again.

A careful search with the glasses will enable one to pick up the sniper's post just across the creek, hidden in the woods at the foot of two large trees. From certain positions there can be seen a foot bridge erected by the enemy across Medicine Creek to connect two parts of his trench system. Farther away the positions of enemy batteries may be determined from a



FIG. 3.—CAMOUFLAGED CASEMATE FOR ENEMY GUN



FIG. 4.—A CLOSE INSPECTION OF THIS PICTURE WILL REVEAL THE SNIPER'S POST AT THE BASE OF THE TWO LARGE TREES

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Careful inspection of certain localities, such as the edges of woods. Heavily casemated batteries are to be found practically in the open but camouflaged so successfully as to be almost invisible. The enemy's barbed wire may also be located with a little patience. The "hedgehogs" used in the protection of listening posts are more plainly visible and mark their localities as targets. A fatigue party at the edge of Boche woods offers opportunity for speedy adjustment or a problem lost. Mine throwers, one pounder shelters and machine gun nests are to be identified in abundance and offer targets of varying demands and difficulties. Two kilometres beyond the enemy front lines is a German village which will be enlarged from time to time until it is complete in every detail, including church spire and windmills. From the firing points the small houses at the edge of the woods present a very realistic appearance. Infantry figures in the vicinity add to the illusion.

The targets are simply constructed and are easily replaced when destroyed. The most elaborate ones not of a permanent nature are the airplane and the tanks. All these have been constructed out of discarded lumber and old panels formerly used for representing the shields of artillery in position. A few touches here and there, such as real wings for the airplane and fence posts representing guns for the tanks, produce excellent likenesses as seen from a distance. Casemates and camouflage used on the battery targets are real, and real barbed wire has been used in quantity in simulating defense systems.

FIRING POINTS

Of the many battery positions in the broken country to the east of the enemy sector, ten are regularly used as firing points. Here are placed batteries of 4.7-inch guns, 155-mm. howitzers, British, French and American 75's and 3-inch guns. Targets for the 4.7's lie far beyond the organized portion of the enemy territory. The 155's are employed against targets in the rear of the sector in an area now being developed in the same manner.

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Naturally, it is the light guns which find their best targets in the German trenches. Most of the new targets at present are at ranges from 1800 to 3500 metres, although the extension of the sector is providing targets at ranges for the light guns up to 4500 metres.

Any method of observation may be arranged in the instruction of students. From several of the firing points, targets in the sector may be seen, thus providing an opportunity for axial observation. Chrystie Hill lies directly between the firing points and the south half of the sector. Its principal use is in combined observation, the observer in the O.P. adjusting the fire for direction, while the adjustment in range is made from Heyl's Hill or Rumbough Hill. Both these latter hills may be used as stations for lateral or flank observers, while Ketch Hill on the northern boundary of the reservation is used in bilateral observation.

CO-OPERATION WITH AIRCRAFT

Both balloons and airplanes are used in the adjustment of fire against targets in the sector. The development of a better understanding between the School of Fire and the School for Aerial Observers, coupled with more thorough and systematic preparatory training for student officers in both schools has resulted in a much higher degree of efficiency in this work. Aviation headquarters may be reached from any of the firing points for communication with captive balloons, while at any firing point a radio receiving set may be quickly set up for use with airplanes. It is hoped to develop many special features in connection with this work. For instance, there are not a few targets tucked away in the woods and behind hills which are not visible from any of the terrestrial stations. These the airplanes may be expected to locate, notifying the batteries by the use of coördinates and asking for fire. By means of dropped aerial photographs the progress of destructive shoots and other information may be conveyed. Thus with the attainment of a higher



FIG. 5.—A MACHINE GUN SHELTER CAMOUFLAGED

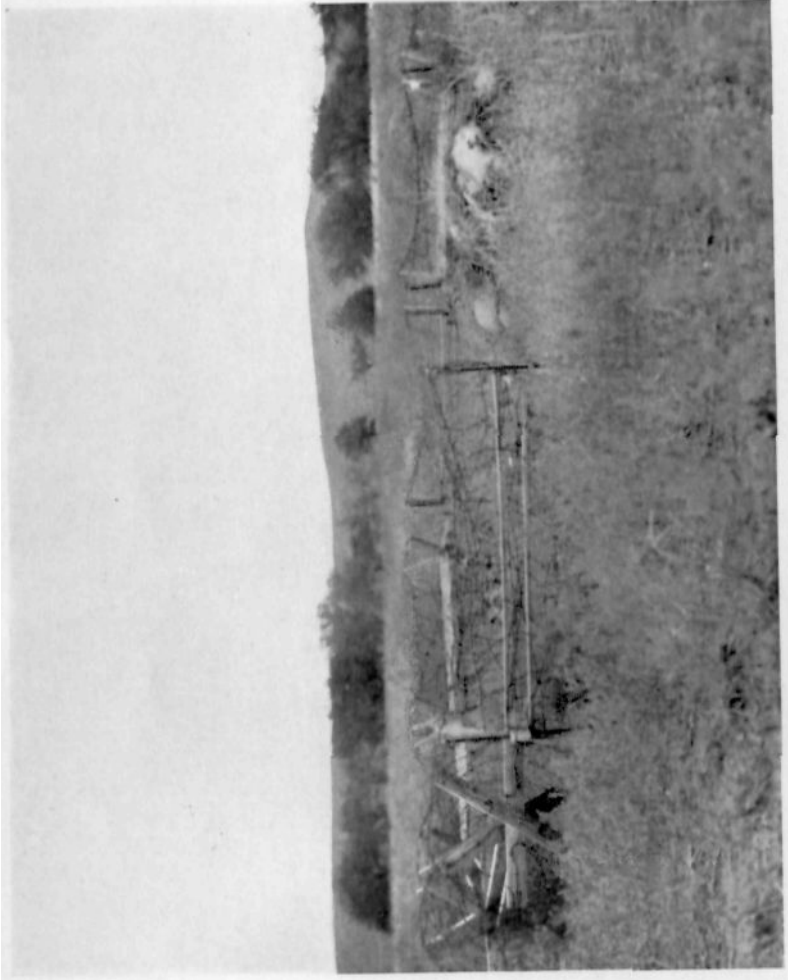


FIG. 6.—A LOOKOUT POST PROTECTED BY ENTANGLEMENTS

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degree of proficiency on the part of student battery commanders and student observers, the conditions of real warfare may be more closely approximated than in the past where shoots have been of necessity more or less cut and dried.

COMMUNICATIONS

The communications system is sufficiently elaborate to meet the needs of all the firing points and observation posts. Heyl's Hill, Rumbough Hill and Chrystie Hill are connected with each other and with all the firing points. The focal points of the system are two twelve-line switchboards at Rumbough Hill, forming the main central, two switchboards of the same type at Firing Point 23, where are centred the lines from all the firing points, and two four-line switchboards at Firing Point 25, near Apache Gate. Each sheaf of wires contains enough circuits to make possible almost any combinations of battery, observation posts and targets necessary in the instruction of students. Nine circuits enter the Chrystie Hill dugout. Thus observers from many different batteries may occupy the O.P. simultaneously, communicating directly with their battery commanders without interference with each other. From the central at Firing Point 23 there are three circuits to the School of Fire switchboard, from which in turn all range lines on the reservation and the commercial telephone system may be reached. One of the most important connections obtained in this way is that with the School for Balloon Observers, used in the conduct of fire with balloon observation. From the switchboard at Firing Point 25 a line extends to Ketch Hill, used in bilateral observation, completing the network of communication lines "at the front."

CONCLUSION

As might be expected, many targets representing important enemy positions in the sectors have remained undiscovered

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by even the most assiduous students. No class as yet has had the time or the patience to exploit the sector to the utmost. Its possibilities are practically without limit and there is hardly a situation of position or open warfare which may not be simulated. Each day of firing discovers new problems of adjustment. Following a careful precision adjustment upon a trench intersection or an enemy O.P. the announcement of the appearance of a working party, a machine gun in action or an airplane on the ground calls for quick decision and immediate action on the part of the battery commander, who now has his opportunity to make effective use of the information he has been obtaining by deliberate shooting against inanimate targets. In this manner the students are brought to realize that even heavy guns are not made simply for pounding away at objectives which cannot escape but are capable of being turned with great speed upon other targets. A link is formed between the methods of precision adjustment and the hasty methods demanded by open warfare conditions.

Since each target represents an actual enemy defense or weapon and occupies a logical position in the larger scheme, the imagination of the student is stimulated and he is compelled to use his judgement in the solution of problems of the most practical nature, precisely as if he were conducting the fire of a battery at the front. He has before him not merely a target, to be attacked by conventional methods for the approval of an instructor, but an actual sector, occupied by an enemy whose every movement must be watched. He learns the control of a sector by fire capable of being transferred rapidly and accurately from one target to another.

The student soon comes to a keen appreciation of the demands made upon artillery both in the defense and in the attack and of the initiative and resourcefulness which must be the qualities of the battery commander who is to fulfil the mission of the artillery by meeting these demands promptly and efficiently. And he understands, as never before, the power and flexibility of the weapon at his command.

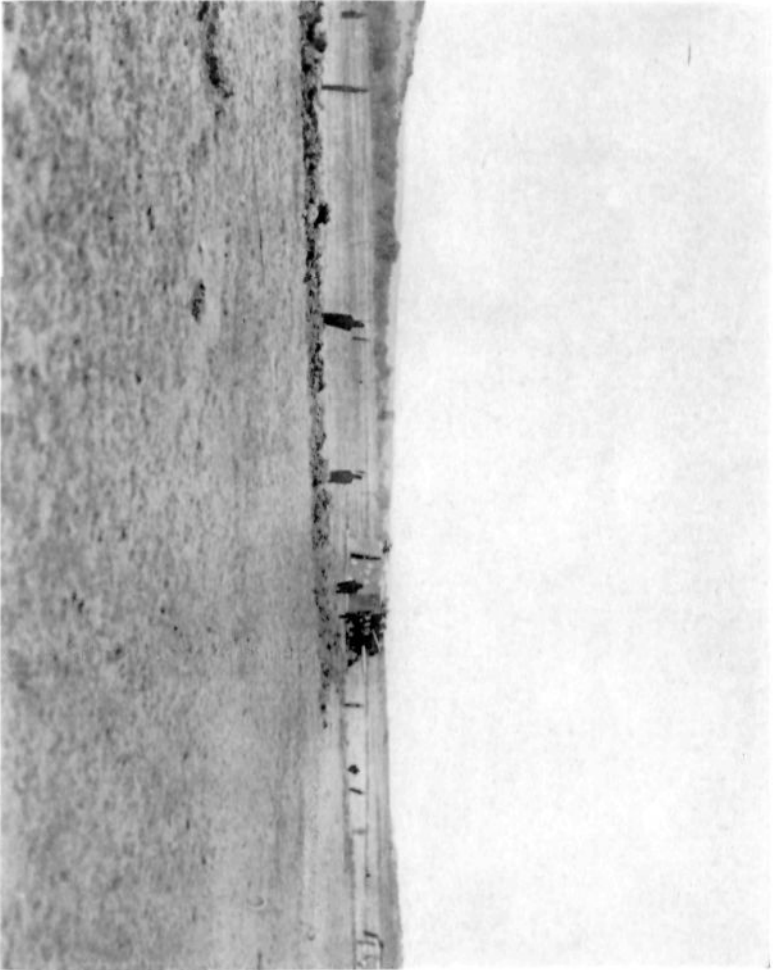


FIG. 7.—INFANTRY ADVANCING TO THE ATTACK, SUPPORTED BY TANKS

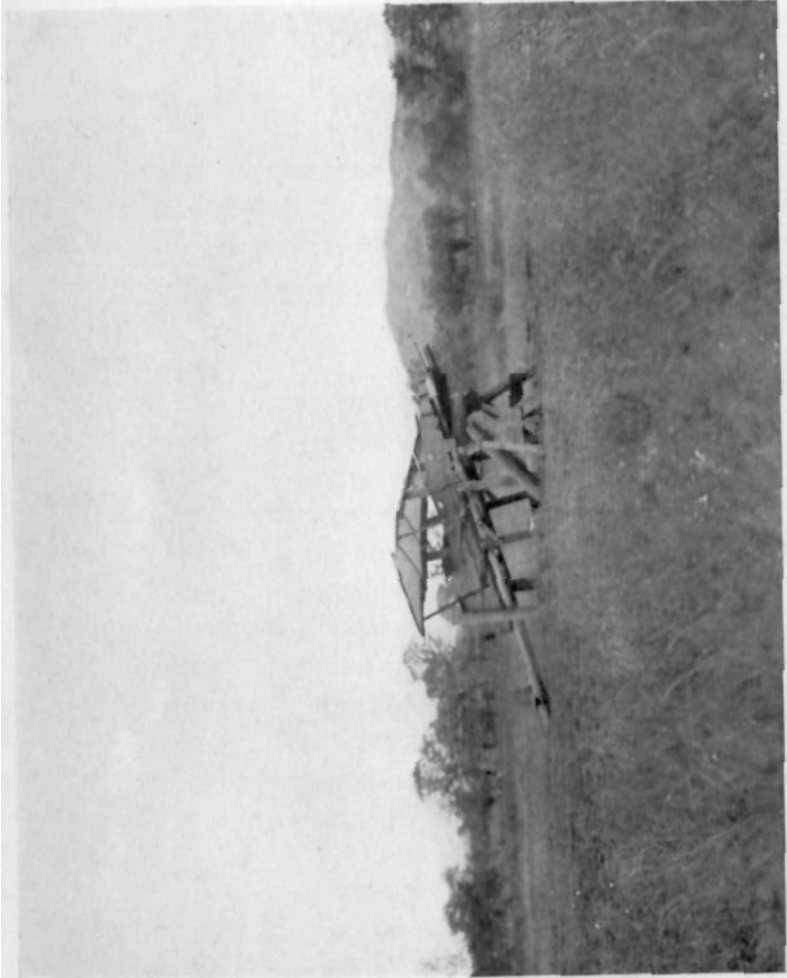


FIG 8.—A FALLEN AIRPLANE

Field Artillery Units of the Reserve Officers' Training Corps

PREPARED BY COLONEL WALDO C. POTTER, FIELD ARTILLERY U.S. ARMY TRAINING
SECTION, OFFICE OF THE CHIEF OF FIELD ARTILLERY, U. S. ARMY

THE Reserve Officers' Training Corps is organized under authority of the Act of Congress of June 3, 1916, providing that it shall consist of the units of the various branches of the service established by the President in those universities, colleges, and schools which shall have applied for admission of such units to membership in the corps, and shall have agreed to the regulations prescribed by the Secretary of War for the government and training of said units.

Units of the senior division may be organized at civil educational institutions which are duly authorized to grant academic degrees, including state universities and those state institutions that are required to provide instruction in military tactics under the provisions of the Act of Congress approved July 2, 1862, donating lands for the establishment of the colleges where the leading object shall be practical instruction in agriculture and the mechanic arts, including military tactics, and at essentially military schools not conferring academic degrees but especially designated by the Secretary of War.

The regulations and instructions governing the establishment, administration, and maintenance of the Reserve Officers' Training Corps are set forth in G. O. 49, W. D., 1916, under which the corps was operated before the war. These have not proven satisfactory, however, and are now in process of revision on liberal lines after several conferences with the Presidents or representatives of the colleges of the country, and its provisions will soon be published. In addition, Congress has been asked for modification of the Act of June 3, 1916, so as to allow this work of training officers to be performed in a much more efficient manner and on a larger scale. These amendments include provision for a greater number of officers and non-commissioned

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officers for detail at colleges, and for pay for students during summer camps.

The R.O.T.C. is directed and administered by the Committee on Education and Special Training. This Committee functions as a section of the Training and Instruction Branch, War Plans Division of the General Staff, and is authorized to represent the War Department in its relations with the educational institutions of the country. For purposes of administration and control of the R.O.T.C., the United States has been divided into twelve districts with respect to the geographical location of educational institutions. A district headquarters is established in each district under an officer of the army called the District Inspector, who is allowed commissioned assistant inspectors in the ratio of one to every five R.O.T.C. units in the district. It is intended that the district headquarters be employed as the channel of communication between the committee and the professors of Military Science and Tactics. In addition, an officer of each of the various corps has been designated to assist the committee in Washington in the work of the units of his corps. In this connection a field artillery officer in the Training Section of the Office of the Chief of Field Artillery is now devoting his entire attention to the work of field artillery units of the R.O.T.C., which is considered of the greatest importance.

The R.O.T.C. exists for the purpose of enlisting the coöperation of the educational institutions of the country in the national defense, and its primary object is to promote military training at schools and colleges, and to enable specially qualified students to earn commissions as reserve officers. It is intended to obtain this result with the least waste of time by providing military training at the same time that men are pursuing their general or professional studies, and by employing methods designed to fit men for pursuits of peace as well as for pursuits of war. There are certain qualities, such as physical fitness, alertness, power of coördination, discipline, loyalty, character, leadership, organization and manual dexterity, which condition

FIELD ARTILLERY UNITS

success in any occupation, whether civilian or military; and it will be the aim of the Reserve Officers' Training Corps especially to emphasize and promote such qualities. While it is not expected that every member of the Reserve Officers' Training Corps will demonstrate his fitness for a commission, experience has shown that the great bulk of the leaders in times of great national emergency must be drawn from the colleges and higher secondary institutions.

This war has taught the imperative need for a large number of trained officers who must be provided in time of peace and not after the outbreak of war. While this applies to every branch of the service, it applies in particular to the officers of the field artillery, who cannot be adequately trained in the technic of their arm in a few months, if at the same time they must receive their basic military education. Moreover, the experience of the war has taught that military power involves a high degree of technical and specialized training, and that in the future even more than in the past the nation must depend upon its educated men. The circumstances of another war may not provide the opportunity to take time to train the necessary officers.

It should be the aim of every educational institution to maintain one or more Units of the R.O.T.C. in order that in time of national emergency there may be instantly available a large number of educated men, physically efficient and thoroughly trained in military science and tactics, to officer and lead intelligently the units of the armies upon which the safety of the country will depend. Moreover, it is believed that the R.O.T.C. will enrich the academic and professional curricula of schools and colleges, bringing to the institution a large amount of scientific and technical equipment. This will not only vitalize the course of study, but give to the student a training which will be as valuable to him in his industrial or professional career as it would should the Nation call upon him to act as a leader in its defensive forces. Physical training will also form an essential part of the military instruction of the R.O.T.C., in view of the fact that a military establishment is dependent for efficiency

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upon the physical fitness of the individuals of which it is composed. The attainment of robust health and organic vigor, together with self-reliance and confidence, will be the aim of the training. These qualities are not essential to a successful military career alone, but apply equally in achievement in any profession and along any line of human endeavor.

The Secretary of War has recently declared that in his opinion the R.O.T.C. should be developed regardless of the permanent military policy of the United States, and regardless of the outcome of the present peace negotiations. The recent war has established the fact that no sharp line can be drawn between military and civilian agencies; and it is inconceivable that in the future the War Department should not desire the active and loyal support of agencies for education and research throughout the country. The contribution of the colleges in time of war is so fresh in the minds of all that it needs no further emphasis. The under-graduates and younger graduates of the colleges must be relied on largely to supply the active junior officers of an army that may need to be raised in time of national emergency. The scientific, technical and industrial aspects of war which have been so enormously developed require trained experts, such as the civilian educational institutions alone can produce.

The bond of connection between the individual colleges and the nation will be preserved by the conception that the activities of the R.O.T.C. are of an educational as well as a military nature, thus offsetting the inevitable decrease of enthusiasm for military life. The war has shown that in reality military activities are co-extensive with civilian activities, and, therefore, that the training required for a military officer in every field of activity depends as much, if not more, on what seems to be his civilian studies as on his strictly military work. This intimate interrelation between the academic and the military sides of the program must be fully recognized. This country was unprepared for war because it was unprepared for peace, and the same elements are required for national strength in either case. The R.O.T.C.

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should be the common inspiring agency for fostering in time of peace the same enthusiastic spirit of devotion to public service that has characterized the Nation at war. The manner in which men of all ages sought service in some capacity with the Government further demonstrated the eagerness and desire of our best manhood to be active workers in a national cause which effected the welfare of mankind. There is no other work so satisfying to the man of character and worth as unselfish service in a cause which has for its purpose the protection of his fellowman. "Public Service" is the form of duty which all men respect most, and which they reward with the highest marks of public respect and esteem.

It is not intended to urge the militarization of the school curriculum in any way. The main purpose is to perpetuate those valuable elements that result from a military training such as better physique, courtesy, respect for authority, high sense of patriotism, etc., by supplementing the training and knowledge that has been the result of school work with the fundamentals of a military education without making it necessary to eliminate any essential part of their former program. In addition, the student will be instructed in the military application of his training.

The great value of continuing to utilize the colleges and universities for this purpose and of broadening the scope of the work is thus apparent. There has been a national slackening of interest in military training, but we should fail in our duty to the country, did we fail to develop this military agency which will prove of such tremendous benefit to the country, the college, and the student. Whatever the future military policy of the United States may be, a continuous supply must be maintained of educated young men who have had the fundamentals of military training, and of technically trained men who have been well instructed in the military applications of the several sciences.

By means of training afforded at the field artillery R.O.T.C. unit successfully operated at Yale University prior to the

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entrance of this country into the war, a large number of very valuable officers was obtained by the field artillery. This unit made an enviable record and abundantly confirmed the wisdom of the plan.

It is now proposed by the field artillery to establish other field artillery units in various colleges to be determined upon by the Committee on Education and Special Training, and the independent coöperation of everyone is requested in creating and promoting interest in the establishment and maintenance of field artillery units among the faculty, fraternities, college publications, alumni and undergraduates of the various institutions.

The field artillery units of the R.O.T.C. will first be established preferably at our larger colleges and universities on account of the limited number of officers available as instructors. Also, on account of the value of the material and equipment involved, this equipment can be used to the best advantage at the larger institutions. However, any institution which can furnish 100 or more students for field artillery training, and which requests such a unit, will not be refused provided equipment and instructors are available. The committee has decided that both field artillery and coast artillery units will not be established in any one college and will be governed by the preference which it expresses. The following is a list of the colleges at which field artillery units have been, or are now in the process of being, established. It is planned to establish a total of about twenty units:

- Yale University, New Haven, Conn.
- Princeton University, Princeton, N. J.
- Cornell University, Ithaca, N. Y.
- Harvard University, Cambridge, Mass.
- Leland Stanford University, Palo Alto, Calif.
- University of Nebraska, Lincoln, Nebraska.
- Purdue University, Lafayette, Indiana.
- Texas Agricultural & Mechanical College, College Station, Texas.
- Alabama Polytechnical Institute, Auburn, Ala.

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University of Wisconsin, Madison, Wis.
Carnegie Institute of Technology, Pittsburgh, Pa.

The size of one instruction organization or battery will be considered approximately the same as the present authorized enlisted strength of one battery of "Light Field Artillery. Tables of Organization and Equipment, United States Army." No field artillery unit will be established unless there are at least 100 students for the unit. Organizations will be formed approximately on the following basis:

- 100 to 199 students, 1 battery;
- 200 to 399 students, 2 batteries;
- 400 to 599 students, 3 batteries, etc.

Batteries in any institution will be lettered and designated accordingly. For instance, "Battery A (college), F.A., R.O.T.C." Three batteries will be designated as a battalion, and six batteries, as a regiment.

The following lists of matériel, equipment, animals, detachments and instructors will be used as a basis for the supply of units. The supply of equipment and animals will be controlled by the facilities for their use and care which the college can provide from time to time.

(a) Battery Matériel and Equipment.

That prescribed for a battery in the "Handbook of 3-inch gun matériel," Ord. Publ. 1659, with changes as noted. (Guns should preferably be of the 3-inch type. Model 1902, 4 or 5; failing these, any type of 75 available.)

(b) Additional Equipment.

1. Range finding, fire control, radio, signal, telephone and engineer equipment as prescribed for one battalion Light Field Artillery.

2. One gun and one caisson with limbers, sights, fuse-setters and accessories of each of the following types:

- 155 mm. gun (G.P.F.)
- 155 mm. Howitzer.

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75 mm. Field Gun, Model 1916, American.

75 mm. Field Gun, Model 1917, British.

75 mm. Field Gun, Model 1897, French.

4.7" gun.

(c) *Miscellaneous Equipment.*

1 2½-ton tractor.

1 5-ton tractor.

1 set sectionalized projectiles.

1 set sectionalized fuses.

4 dummy powder bags, 155 mm. and containers.

4 heavy Browning Machine guns.

4 Browning automatic rifles.

1 flash battery outfit (smoke bomb).

1 set subcaliber tubes.

2 wagons, escort, Q.M.C.

harness, Q.M.C. for wagons.

2 sets lead.

2 sets wheel.

2 trucks, cargo, Q.M.C.

30 Officers' field saddles.

Full individual equipment for each student
taking the R.O.T.C. course.

(d) *Animals.*

4 mules.

62 horses, draft (for 5 sections).

28 horses, riding.

(e) *Detachment.*

Without animals, approximately the following detachment will be necessary to care for equipment and matériel and to act as assistant instructors in matériel.

1 supply sergeant.

1 sergeant (mechanic).

2 sergeants (instructors).

6 privates (to care for equipment and matériel).

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If animals are provided, the following detachment will be necessary:

- 1 first sergeant.
- 1 supply sergeant.
- 1 stable sergeant.
- 2 cooks.
- 2 horseshoers.
- 1 sergeant (mechanic).
- 4 sergeants (instructors).
- 1 saddler.
- 1 corporal.
- 15 privates, first class { For each
30 horses provided.

(f) *Instructors.*

It is highly essential to have on duty with each unit a really sufficient number of qualified officers as instructors. Every effort will be made to secure more officers for this important duty. The course must be made thoroughly attractive and valuable, or students will lose interest and seek to drop it, or will not elect it at all.

For adequate instruction and satisfactory work it is absolutely necessary that officer-instructors be furnished in the proportion of five field artillery officers for the first field artillery battery formed at any institution.

It is deemed much better to have field artillery units at a few representative institutions where the work is well and thoroughly conducted and is successful, than to have units at a greater number of institutions where the work is not of the highest standard and will therefore fail. From these the work can be expanded to other institutions as officers become available.

In any field artillery unit the following would be used as a basis for their assignment to duties:

- 1 Officer (Senior) Commandant (or senior artillery instructor) supervises all instruction, prepares schedules, keeps all records, has general administrative control.

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- 1 Officer Quartermaster, supply officer, disbursing officer, in charge of Matériel. Specializing in gunner's instruction and examination.
- 1 Officer In charge of and commands detachment, in charge of horses, stables. Instructor in equitation, horsemanship, driving and draft.
- 1 Officer In charge of all physical training and drills. Assistant instructor in Matériel. Specialist on work of the special details.
- 1 Officer Instructor in motors and military science.

All officers would be available as classroom instructors in the various subjects in military science.

COURSE OF INSTRUCTION AND TRAINING FOR FIELD ARTILLERY UNITS OF THE SENIOR DIVISION, RESERVE OFFICERS' TRAINING CORPS

1. This course is planned to cover a period of four years. With the approval of the Faculty, however, it may be covered and completed in three years. It has for its object the qualifying of college men to become officers of Field Artillery in the Army of the United States. Any student electing this course is expected to do so with the idea that he will, unless prevented by unforeseen necessity or circumstance, complete it, and that upon its satisfactory completion, and upon being awarded a degree by the educational institution, he will accept from the President of the United States a commission as Second Lieutenant, Field Artillery Reserve Corps.

2. The following are the salient features of the courses:

(a) A few academic subjects, together with the course in "Military Science," are prescribed as prerequisites to obtaining a commission. These academic subjects, with the exception of the one in "Advanced Study," are those which are ordinarily considered the basis of a general college education. The prerequisite subjects must be taken and completed prior to or during the college course.

(b) A minimum number of field artillery and military subjects,

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collectively termed "Military Science," are prescribed. These subjects are selected as being those of the highest educational and technical value. They will ordinarily be taught by army officers detailed for the purpose. Academic credit toward a degree in these subjects will be fixed by the President and Faculty, and should be assigned in the same manner and under the same rules as apply to other courses of like nature in the institution.

(c) Only those subjects which are deemed strictly essential are prescribed as prerequisites. This is done with the idea that the student will thus be enabled to fit this limited number of subjects into almost any course he desires to pursue in college, it being appreciated that a good education is the primary requisite.

(d) The course in Military Science as prescribed may be rearranged by the Faculty and the Professor of Military Science and Tactics, when by so doing it will better fit the local conditions and curriculum, provided the general scope and order of the course is preserved.

(e) As a part of the Military Science course physical training throughout the academic period, and three summer camps each of six weeks duration, are required.

Physical training is accentuated because sound physical development and good health are prime requisites of an officer. During the Freshman year the course in physical training will include American, British and French army methods of calisthenics and physical training, gymnastics, fencing, athletics, games, qualification in swimming, etc. During the remaining years the physical training will include a thorough course in equitation and horsemanship, if the facilities therefor are available. Under such rules as may be adopted by the faculty, a student engaged in college athletics may be excused from the regular classes in physical training during the season he is actually engaged in such athletics.

It is planned that the camps be attended at the end of the Freshman, Sophomore and Junior years. For good and sufficient

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reasons, however, one may be attended the summer before entering the Freshman class, and one at the termination of the Senior year. Every possible effort will be put forth to make each summer camp the most interesting, instructive and invigorating kind of intensive military training.

(f) Other than that which may be necessary in connection with the physical training, no drills or military formations will be required during the academic year. Such practical work during the college year as the Faculty may deem desirable, however, may be added.

(g) Except on special recommendation of the Faculty and the Professor of Military Science and Tactics, a commission will be issued only in case a student earns and is awarded his degree from the institution.

3. Prerequisites for a Commission:

I. *Mathematics.*

Advanced algebra, including permutations, combinations, probabilities, and the law of errors; plane and solid geometry; plane and spherical trigonometry; use of logarithms; the slide rule.

(NOTE.—This course must be completed prior to entering upon the course of Field Artillery Gunnery prescribed in Military Science for the Junior year.)

II. *English Literature and Composition.*

Grammar, composition and rhetoric, to include the practical essentials of those subjects. Such general knowledge of American and English literature and their history as is covered in Standard works on these subjects.

III. *General Physics.*

The general subject covering the mechanics of solids, liquids and gases; heat, sound, light, magnetism and electricity.

IV. *A Modern Language.*

To include grammar, reading, translation, pronunciation, and conversation; or,

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General History.

So much of the history of ancient Greece and Rome as is contained in good high school text-books on these subjects; the important facts in general ancient history and in the history of mediæval Europe to the end of the fifteenth century; also so much of the political, social, and economic history from the end of the Middle Ages to the present day, and the fundamental principles of civil government historically considered as is contained in any standard text, such as "Outline of the World's History" (Swinton). Or,

American Constitution and Government.

A general knowledge of the rise and growth of the American government as determined by its constitution and political usages.

V. Advanced Study.

This will be an advanced or specialized course of study in any subject approved by the Professor of Military Science and Tactics. Under this head the following subjects are suggested for the reason that it is desirable to have among Field Artillery officers specialists in these subjects.

1. Advanced mathematics, including analytical geometry, differential and integral calculus, and the method of least squares.
2. Civil Engineering to qualify for the C. E. degree, or covering thoroughly one of the following:
 - (a) Plane surveying.
 - (b) Topographical surveying, geodesy.
 - (c) Geological surveying.
 - (d) Bridge construction and design.
 - (e) Road construction and maintenance.
3. Mechanical Engineering to qualify for the M. E. degree, or one of the following:
 - (a) Thermo dynamics.
 - (b) Gas engines and automobile engineering.
 - (c) Engineering design.

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4. Mechanical Engineering to qualify for the M. E. degree, or one of the following:
 - (a) Electro dynamics.
 - (b) Electrical communication.
5. Advanced physics, including heat, light, sound, optics, and spectroscopy.
6. Advanced chemistry, including the chemistry of explosives and toxic gases.
7. A modern language, to attain fluency in reading and speaking.
8. Architectural engineering, to qualify for the degree in this subject, or the following:
 - (a) Strength of materials and structural design.
9. Economics.
10. Principles of teaching and educational psychology.
11. Advanced English, composition, argumentation and logic.
12. Psychology.
13. Agriculture to qualify for the degree of Bachelor of Science in Agriculture, or one of the following:
 - (a) Animal Husbandry. Judging, breeding, feeding and management of horses and mules.
 - (b) Farm motors, trucks, tractors, etc.
14. Veterinary Medicine to qualify for the degree of Bachelor of Veterinary Medicine.

VI. *Military Science.*

Freshman Year

1. Field Artillery Ordnance and Gunnery. Three hours per week. First Term.
 - (a) Ordnance: Guns, types, construction, mechanical principles and design; ammunition, shell, shrapnel, powders, fuses, etc.; sights, quadrants, fuse setters, care, operation, adjustments, etc.; fire control instruments, care, operation, principles of design, adjustments, etc.; signal equipment, telephones, projectors, radio, etc.; disassembling and assembling various parts

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gun matériel; tools, accessories, equipment, etc.; and methods of carrying same.

(b) Gunnery: Simple definitions; elements of the trajectory and calculation thereof; trajectory problems; determination of firing data and use thereof by cannoneers; firing data problems; duties of various cannoneers in the gun squad and firing battery; gunner's instruction; gunner's examinations.

(NOTE.—Opportunity will be afforded Freshmen to qualify as Field Artillery Gunners during this year.)

2. Administration. Three hours per week. Second Term.

(a) Military Hygiene: Elements of military hygiene; personal hygiene; condition and exercise; clothing, food and dietetics; camps and camp sanitation; principles of first aid.

(b) Battery Organization and Administration: Organization and administration of a battery as set forth in Field Artillery Drill Regulations; mess management; records, returns, etc.; lectures on discipline, courtesies, and the psychology of handling men.

3. Physical Training. Five periods per week of three-quarter hours each. Both terms.

Calisthenics and Physical training, American, British and French army methods; gymnastics, fencing, games, athletics, swimming, etc.

*First Camp—Six Weeks**

The soldier dismounted, the squad, the battery dismounted, dismounted ceremonies. Practical and theoretical.

Calisthenics and physical training. Practical and theoretical.

Military discipline, customs and courtesies. Practical and theoretical.

Guard duty. Practical and theoretical.

Manual of the pistol, position and aiming drill, pistol practice. Practical and theoretical.

Military hygiene, including personal hygiene, camps and

* NOTE: During the first camp students will be specialized as cannoneers of the firing battery.

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camp sanitation, condition and exercise, foods and dietetics.
Practical and theoretical.

Commands and signals. Practical and theoretical.

Duties of cannoneers and gunners in connection with the following:

Preliminary exercises of the gun squad.

The cannoneers.

The firing battery and duties of its gun squads.

(Including barrage tables.)

Occupation of positions.

Camouflage.

Construction of battery emplacements.

Sub-calibre firing.

Service firing.

Marches and march discipline.

Camping and shelter.

Personal equipment and field kits.

Entraining and detraining matériel.

Care of matériel and equipment.

Gunners' instruction and examination.

Sophomore Year

1. Field Artillery horses and tractors. Three hours per week.
First term.

(a) Hippology, anatomy and physiology of the horse; care and conditioning of horses; forage, animal nutrition; types of artillery horses, breeds and blood lines; lectures on shoeing, grooming, stable management and exercise; study of equitation and horsemanship; training of artillery horses, care and management in the field; Field Service Regulations, including marches and supply.

(NOTE.—Institutions having facilities therefor will be furnished horses, and a thorough course in riding and equitation will constitute the physical training required of Sophomores and Juniors.)

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(b) Artillery trucks, tractors, gas engines, etc. Theory, mechanical design, operation, care, maintenance, etc.

2. Military Law. Three hours per week. Second Term.

A study of military law, rules of evidence, procedure of courts-martial, rules of land warfare, Hague Conventions, and Peace Conventions.

3. Physical Training. Five hours per week. Both Terms.

(a) Same as Freshman year.

(b) Practical equitation and horsemanship.

*Second Camp—Six Weeks**

Equitation, horsemanship and hippology, care and conditioning and training of horses, stable management. Practical and theoretical.

The soldier mounted. Practical and theoretical.

The driver mounted. Practical and theoretical.

Gas engines, trucks and tractors—operation, care, road discipline, manœuvres. Practical and theoretical.

Guard duty. Practical.

Pistol practice. Practical.

Duties of drivers in connection with the following (practical and theoretical):

Care of horses in the field.

Driving and draft.

The battery mounted.

Mounted ceremonies.

Care and maintenance of equipment.

Advance to and occupation of positions.

Marches and march discipline.

Camping shelter and bivouac.

Personal equipment and field kits.

Entraining and detraining animals.

Junior Year

1. Field Artillery Topography and Orientation. Three hours per week. First Term.

Military maps and mapping; scales, construction and use;

* NOTE: During the second camp students will be specialized as drivers, for both horse and motor drawn carriages.

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traverse, intersection and resection; contouring, visibility, etc.; road sketches; position and place sketches; French coördinate system; hidden and visible areas; computation of dead areas; area sketches; orientation, methods of determining the exact location of the directing piece; field work; field artillery positions; reconnaissance of positions; determination of firing data, etc.

2. Field Artillery Gunnery and Conduct of Fire. Three hours per week. Second Term.

Field Artillery gunnery as taught at the School of Fire; accuracy of fire; dispersion; probable error; law of errors and theory of probabilities as used in the deduction of the principles of fire; ballistics, exterior and interior; use of range tables; atmospheric effects on the trajectory; principles governing conduct of fire in open warfare and in stabilized or trench warfare; relative importance of the two; functions of the various calibers of field artillery, and principles involved in determining the types used.

(NOTE.—Opportunity will be afforded Juniors to qualify as battery special details during this year.)

3. Physical Training. Five hours per week. Both terms.

(a) Same as Freshman year.

(b) Practical equitation and horsemanship.

Third Camp—Six Weeks

Use and practical handling of all fire control instruments for field artillery. Practical and theoretical.

Field gunnery, computation of firing data, corrections of the moment. Practical and theoretical.

Scouting, reconnaissance, functioning of B. C. detail and duties of its members. Practical and theoretical.

Signalling, use of buzzer, telephone and radio, communications, and liaison. Practical and theoretical.

Military topography, maps and mapping; battle maps and charts, orientation, road sketches and reports, position sketches, panoramic sketches. Practical and theoretical.

* NOTE: During the third and last camp, students will be specialized as officers, non-commissioned officers, and details of a firing battery.

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Duties of Officers and non-commissioned officers with particular attention to the following (practical and theoretical):

Battery organization and administration.

Command, care and handling of men.

Commands and signals.

Schedules, training and instruction of Field Artillery.

Firing instruction, the firing battery, preparation of fire, principles of artillery, effect of fire, use of ammunition, conduct of fire—blackboard, miniature terrain, sub-calibre practice, smoke bomb, service practice, aerial and terrestrial observation, artillery in the field, tactical employment, field problems, and manœuvres of field artillery, field orders, security and information, the battery mounted, reconnaissance, selection, advance to and occupation of positions, marches, march discipline, camping, bivouac.

Senior Year

1. Minor Tactics and Map Manœuvres. Three hours per week. First Term.

Organization; tactics of the various arms, with special relations to the use of field artillery; divisional, corps, and army artillery, tactics of each; scouting; carrying information; messages and reports; communications; liaison; field orders; map problems involving practical use of field artillery; minor tactics and map manœuvres based on the courses as given in the Army School of the Line.

2. Military History and Policy of the U. S., and Principles of Military Strategy. Three hours per week. Second Term.

(a) A critical military survey of the most important campaigns and battles of the United States (including the late war), and a study of our military policy.

(b) Military Strategy based on the campaigns of Cæsar, Augustus, Hannibal, Frederick, etc.; Napoleon's Maxims; strategy of the World War.

3. Physical Training. Five hours per week. Both Terms.

(a) Same as Freshman year.

(b) Practical equitation and horsemanship.

The Dead Space Graph

DESCRIPTION OF A TRANSPARENCY DEvised FOR RAPID DETERMINATION OF DEAD AREA

PREPARED IN THE DEPARTMENT OF RECONNAISSANCE, SCHOOL OF FIRE FOR
FIELD ARTILLERY, BY MAJOR H. C. JACKSON, F.A.

WHILE there are many methods now in use for determining dead space (areas which cannot be reached by gunfire), the majority of these require a great deal of time and are quite laborious; whereas, it is possible with the graphs described herein, to determine at a glance whether a point on the map can or cannot be reached by fire.

The method employed simply is that of a rapid projection of a given trajectory to the surface of the ground as represented by the map. And since the method is one of projection, all that is needed is a series of trajectories drawn to the same horizontal scale as the map and with any convenient vertical exaggeration.

Since the method of projection is to be used in handling the graph it is necessary, first, that a series of parallel lines be drawn representing ground elevations above and below the gun position. A 10-meter interval and a total difference of 100 meters above and 100 meters below the guns is sufficient for most terrain. (See graph.)

With a zero plane of site construct a series of trajectories on the determined scale of vertical exaggeration. (*Note.*—It will be necessary to construct each curve separately as an attempt to draw in trajectories of lesser range, by revolving one of greater range, which has been exaggerated vertically, will result in a diagonal exaggeration of the trajectories of the lesser ranges.)

USE OF GRAPH

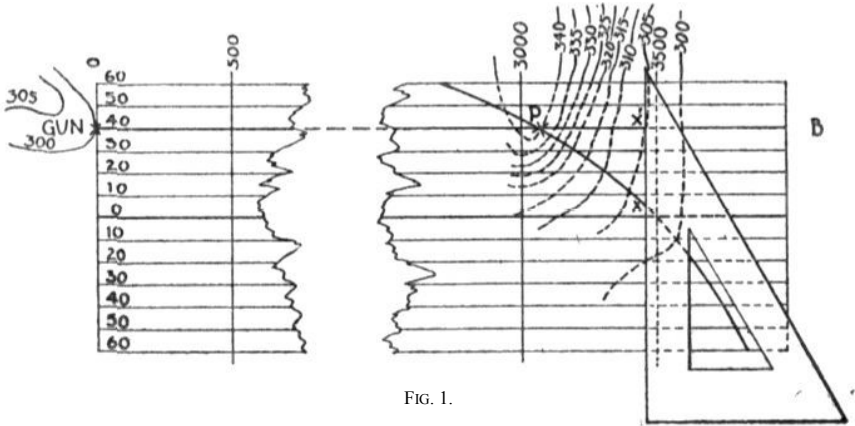
To use the graph draw a ray through the gun position and the area being considered. From an inspection of the map determine the point most likely to mark the near limit of the

THE DEAD SPACE GRAPH

dead space and note the difference in elevation of this point compared to the elevation of the gun position. (The difference in meters above or below the gun.)

Place the graph on the map so that the horizontal line corresponding to the difference in elevation just noted lies along the ray GPB drawn from the gun (see Fig. 1), and so that the perpendicular line with zero range passes through the gun position.

To determine if P is the grazing point, take the trajectory passing through P as a basis for comparison with the slope of the



ground along GPB. (It may be necessary to draw in a trajectory through P by interpolation.) This comparison may be made either by noting whether in a drop of a certain distance on the trajectory, say 10 meters, the ground has dropped a like distance, or by noting the amount of drop in the trajectory for one or more contour intervals.

Adopting the last method, first lay a ruler at right angles to the parallel lines and crossing GPB where the line is crossed by contour 335, five meters below P. Drop down on the rule to a point 5 meters below GPB and note if such point is above or below the trajectory. If above, the ground has not fallen so fast as the trajectory and hence can be reached by fire. If below, the ground has fallen away faster and lies in the dead

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area. In this case it will be noted that a point projected down from contour 335 to a point 5 meters below, lies below the trajectory and hence is in dead area. P may, therefore, be considered the grazing point. If the slope of the ground corresponded exactly to that of the trajectory, P would still be considered the grazing point.

If there were another contour showing above P, a point would be taken on that contour and would be examined for a possible grazing point.

Having determined the near edge of the dead space or the grazing point of the trajectory, the next step is to determine the far limits of the dead area. This can be done merely by moving the ruler to the right along the trajectory, keeping it perpendicular to the parallel lines, and noting the point where the ground elevations, *read from the contours along the ray GPB*, correspond to the elevation on the horizontal lines, where the trajectory considered crosses them. (Elevations considered are, of course, all computed with respect to the gun position.)

Thus if contour 310, which is 30 meters below the grazing point, is examined and this point on the ray GPB is projected downward 30 meters, a point will be reached on the 10-meter line, which is below the trajectory, showing that the ground at contour 310 still lies in dead area.

If contour 300 is examined in a like manner and a projection made downward by means of the ruler to a point 40 meters below P, the point reached will lie on the 0 line and will be above the trajectory, showing that the ground at the 300 level lies in beaten area.

Moving the rule back to x' on contour 305, which is 35 meters below the grazing point, a projection is made by means of the rule, and it is found that this crosses the trajectory at x which also is 35 meters below the grazing point. Therefore x' may be considered as the far limit of the dead space.

It will be noted that each of the horizontal lines of the graph is divided into a number of short intervals by short vertical marks or ticks. The spaces between these ticks represent the

THE DEAD SPACE GRAPH

horizontal distance which a projectile, at the given range and elevation, will travel in dropping 10 meters. Thus each parallel line becomes a measuring device for the comparison of the quadrant angle of fall with the ground slope. This permits an even more rapid determination of the grazing point or the near limit of dead space than does the use of the curves, but of course cannot be used for the determination of the far limits of the area. Figure 2 illustrates the method of use. Assume that the ray GPB

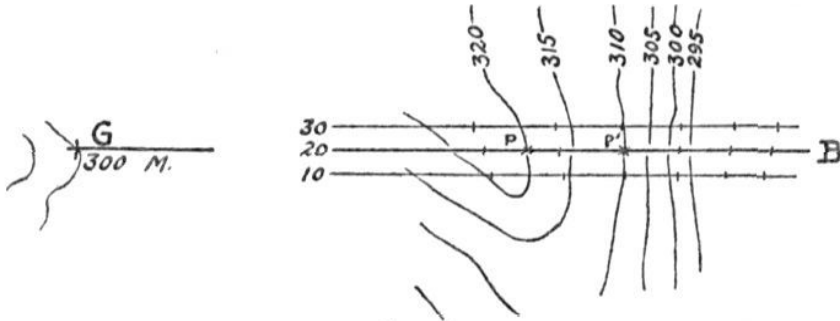


FIG. 2.

is being examined and P is selected as a possible grazing point. From a comparison of contours it is seen that the point P is 20 meters above the gun. Therefore the graph is laid over the ray GPB so that the line 20 meters above the level coincides with the ray in the manner described above.

By a comparison of intervals with the contours crossed it is seen that, in the interval representing a drop of 10 meters on the trajectory, the ground falls away but 7 meters. Evidently P is not the grazing point. It remains then to try a second point. Let the second point considered be P' on contour 310 which is 10 meters above the gun-level. The graph should be moved vertically upward until the line numbered 10 and corresponding to the ground level considered lies along the ray GPB.

When this is done it will be seen that the two contour intervals corresponding to a 10-meter drop lie within the interval used. Or, the ground drops nearly 12 meters while the projectile

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is falling 10. Therefore the area is dead and P' may be considered the grazing point.

In using this method of determining the grazing point it may be necessary to move the transparency to the right or left slightly until the limits of one of the intervals coincide with a contour line. Care must be exercised in doing this because this changes the range on the graph and a change of range changes the interval for the 10-meter fall. It is safer and even more rapid to set off on a pair of dividers the ten-meter interval taken from the map and apply this interval to the graph for the same range and elevation.

COMPARISON OF METHODS FOR TIME AND ACCURACY

To determine the accuracy which may be expected in the solution of dead space by use of the graph as compared to other methods: to make a comparison also of the time required by the various methods, a sector showing two rather large irregular areas of dead space was selected and charts were prepared by each method. Eight rays were drawn through the area and the ground examined along these areas by three methods, the same rays being used so that there would be no difference of time due to a variation of ground forms, as might be the case if different rays were selected.

By Use of the Graph

With the graph the solution was completed in 30 minutes.

By Graphic Method

With the graphic method an hour and 15 minutes was required to plot the profiles along the rays; 25 minutes was necessary to plot the slopes of fall (using the tangents of the angles of fall exaggerated to the same scale as the profiles, and 10 minutes was required to complete the solution. In fairness, however, the time required for the plotting of the slopes of fall should be disregarded, since, any artilleryman who makes use of this method would, undoubtedly, preserve a series of transparencies

THE DEAD SPACE GRAPH

giving the various slopes of fall at all ranges for all projectiles and so would not have to stop to construct them. These transparencies would take up the same amount of room as the graphs herein described.

The total time then, by the graphic or profile method, may be considered as but 1 hour and 25 minutes or nearly three times that by the use of the graph.

In point of accuracy the graph has an advantage over the graphic method. Slopes of fall plotted from tangents are not accurate for points above and below the level of the gun, since such slopes take no account of the change in the angle of fall due to the change in the angle of site. Further, the slopes of fall are inaccurate for dead areas of more than 150 meters in range since this change in range causes an appreciable change in the slope of fall.

A comparison of charts made by the use of the graph and by use of the graphic method showed, as was to be expected, that the near and far limits of the dead areas did not agree. With the graphic method the near limits above the gun level did not extend as far back as they should, while the far limits below the gun level extended too far.

BY COMPUTATION

By computation it was found that 2 hours and 30 minutes were required for the determination of the dead areas in the sector considered. This is perhaps excessive for some of the computations might have been eliminated by inspection, while the use of a slide rule would have cut down the time on others. With all short cuts, however, it is doubtful if the time could have been reduced below an hour and a half.

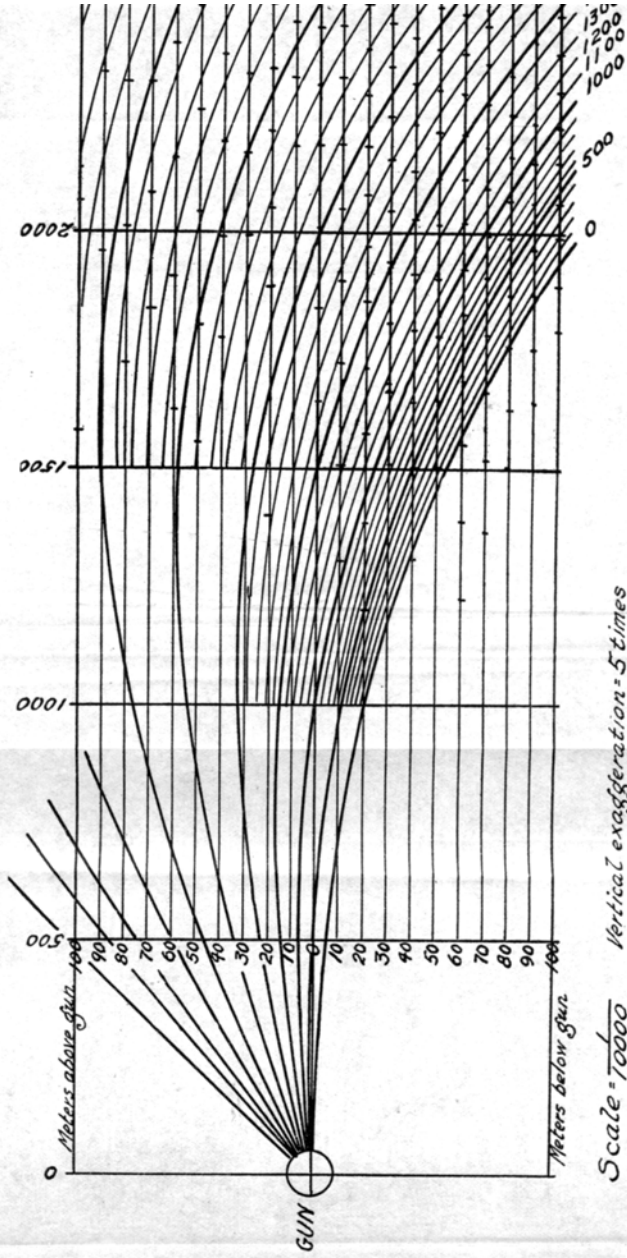
The computation method is the most accurate of those used. A comparison of the dead area so determined with that obtained by the use of the graph indicates that in most instances the limits will agree within the probable error of the gun; the variations greater than this being due either to carelessness in the use of the graph or to the variation expected among different individuals

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in the matter of interpolation between contours where the interval is as great as 5 meters.

The graph described in this article can be constructed by any artilleryman at his leisure. The battery reconnaissance officer or the battalion orienting officer might provide these but it would be more logical for corps or army headquarters to provide a set for each battery. These could be printed on light celluloid, one graph for each projectile, and could be carried with the plotting board of the battery where they would take up no appreciable amount of room. If the 1/20,000 map were being used, naturally they would be furnished in that scale.

DEAD-SPACE
F_c
 FRENCH
 Normal Charge - H.

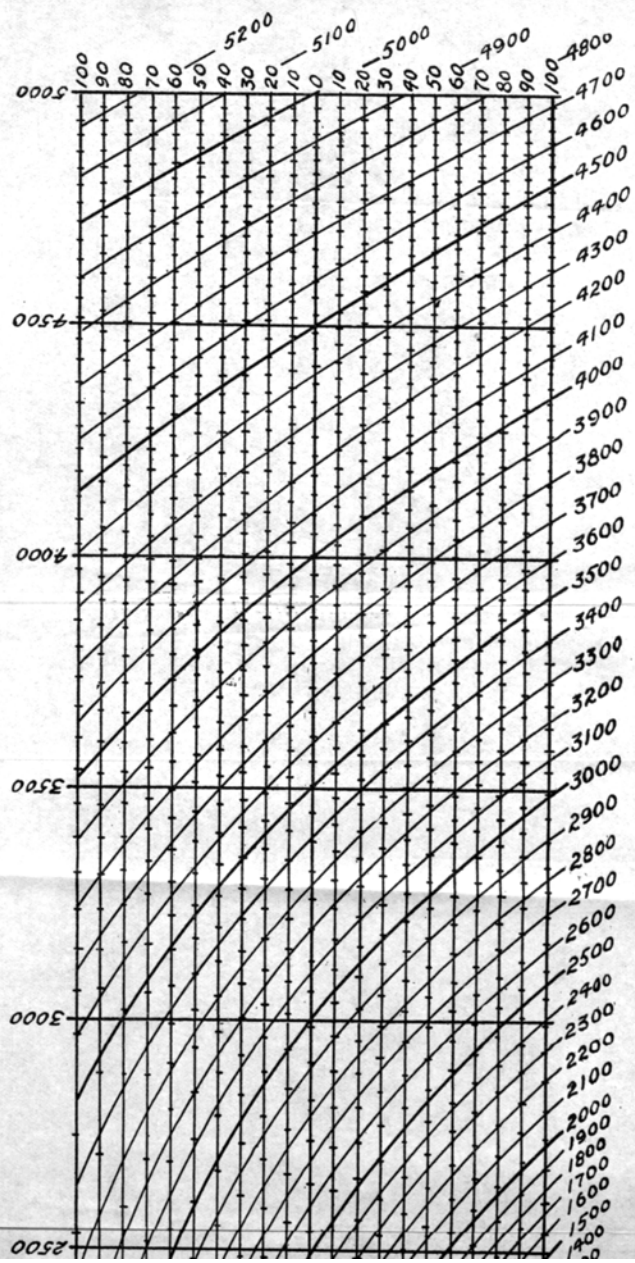


Scale = 10000
 Vertical exaggeration = 5 times

CE "GRAPH"

75 M.M.

F. Shell - Short Fuze



The Principles of Lateral Observation

BY COLONEL EDMUND L. GRUBER, FIELD ARTILLERY, U. S. ARMY

THE following notes on this subject were made for the benefit of officers who with their brigades took the course at the Field Artillery Brigade Firing Center, Fort Sill, Okla., in order to give them a simple and rapid means of correcting observations in the conduct of fire on the miniature range, the reduced terrain and in the field when no maps would be available, and with all kinds of observation. Many officers are prone to sneer at the application of mathematical principles to artillery fire and call it "highbrow." But these officers forget that it is only by such studies that the easy and simple so-called "rules" are deduced which may then be applied even by an intelligent non-commissioned officer. To such officers it can only be said that the mere application of a "rule" is not knowledge. An efficient officer must possess not only mere knowledge but also the mental power to appreciate the principles involved in the technic of his profession. If he possesses this mental power, the application of the "rules" will produce satisfactory results because they will then be applied with intelligence and judgment.

Whenever the observation of fire is conducted from a point other than that of the position of the battery, the observed deviation from the target of a group of shots must be corrected before the proper firing data can be applied to the piece. After a study of the chapter on "Unilateral Observation" contained in "Artillery Firing," the impression has been gained by many officers that the factors, by which the observed deviation from the target of a group of shots is translated into the proper firing data for the guns, can be determined only by the *graphical* operations described in the footnotes of paragraphs 433 and 435, "Artillery Firing." This is not true. It must be remembered

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In Fig. 1, let P be the position of the piece, B the position of the target, O the position of the observer, and S the mean point of burst of the first group of shots fired.

Then $PB = R =$ the correct range.

$OB = r =$ observing distance.

$SY = F =$ range change that is necessary to bring the mean point of burst S to the line OB.

$SX =$ lateral *distance* necessary to bring the mean point of burst S on the line OB.

$\omega =$ observed deviation in mils.

$\phi =$ deflection change to be made at the battery either to place or to keep the shot on the line OB.

$i =$ angle of the observer's displacement.

Draw SN perpendicular to OX (observing line) and call it "a."

For practical purposes it will be sufficient to make the following assumptions:

(a) That the fire is approximately correct for direction and range, *i.e.*, within 400 meters in range and 30 mils in deflection. Under these conditions PS may be taken as parallel and equal to $PB = R$.

(b) That the actual distance of the mean point of burst S from O is approximately equal to the observing distance $OB = r$. This assumption follows from the previous one.

(c) That the angles ϕ and ω are small, *i.e.*, within 30 or 40 mils, which is usually the case.

These are practical assumptions, necessary to a discussion of the mathematical principles involved. It would be absurd to attempt to apply any principles whatever to a group of shots which struck, for instance, on Signal Mountain when the target under observation was located on Monument Hill.

In Fig. 1 we have $\tan \omega = \frac{SN}{OB} = \frac{a}{r}$

Now for small angles, the angle in mils may be substituted for the tangent or:

$$\text{Tan } \omega = \frac{\omega}{1000} \therefore \omega = \frac{1000 a}{r} \quad (1)$$

Also,

$$\frac{SN}{SX} = \cos i \therefore SX = \frac{SN}{\cos i} = \frac{a}{\cos i}$$

In Fig. 1, we also have, $\tan \varphi = \frac{SX}{SP} = \frac{SX}{BP} = \frac{a}{R \cos i}$

For small angles, $\tan \varphi = \frac{\varphi}{1000}$.

Substituting for $\tan \varphi$ in the above equation, we have

$$\varphi = \frac{1000 a}{R \cos i} \quad (2)$$

Referring to Fig. 1,

$$\sin i = \frac{SN}{SY} = \frac{a}{F} \therefore F = \frac{a}{\sin i} \quad (3)$$

All the principles of observation, whether axial, flank or lateral are based upon these three equations.

Dividing (2) by (1), we have

$$\frac{\varphi}{\omega} = \frac{r}{R \cos i} \quad (4)$$

which expresses the relation between the observed deviation ω and the deflection change φ to be made at the guns, to bring the next group of shots on the line OB by a deflection change only. This is the same as the graphical result given in the footnote to paragraph 433, "Artillery Firing."

Now for angles of observer's displacement less than 400 mils, $\cos i$ is approximately unity, consequently when the angle of displacement is less than 400 mils no appreciable error is made in taking the factor

$$\frac{\varphi}{\omega} = \frac{r}{R} \quad (5)$$

Dividing (3) by (1), we have

$$\frac{F}{\omega} = \frac{r}{1000 \sin i} \quad (6)$$

which expresses the relation between the observed deviation ω and the range change F to bring the next group of shots on the line OB by a range change only, which will be in meters or yards depending upon the unit taken. This is the same as the graphical result given in the footnote to paragraph 435, "Artillery Firing."

In order to convert this range change F to a corresponding

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elevation change in mils, minutes or 20ths, it will be necessary to divide the factor by the number of meters or yards corresponding to an elevation change of one mil, one minute or one-twentieth at the particular range. This information is given in the range tables. The factor thus determined, when applied to the observed deviation will then give directly the correct elevation change in the proper angular unit.

Now for angles of observer's displacement less than 400 mils, the angle in mils may be substituted for the sine without introducing an appreciable error, and we have from equation 6

$$\frac{F}{\omega} = \frac{r}{1000 \times i/1000} = \frac{r}{i} \quad (7)$$

It will be noted that the factor $\frac{F}{\omega}$ is independent of the range $PB = R$.

Dividing (2) by (3), we have

$$\frac{\phi}{F} = \frac{1000 \sin i}{R \cos i} = \frac{\tan i}{R/1000} \quad (8)$$

which expresses the relation between the change in range F and the corresponding change in the deflection ϕ to keep the next group of shots on the observing line OB by a simultaneous change in both range and deflection. The same result will also be obtained by dividing (4) by (6).

Based upon our studies in "Probabilities," the range change F to be made during adjustment is determined as four field probable errors (six proving ground probable errors). This is called the "fork" and its value is given in the range tables. In maneuver warfare, however, an average value may be taken. Each officer should know the value of the "fork," for the particular type of cannon with which his battery is armed. For example, with the 3-inch or 75-mm. gun we find that 100 yards or meters is the average value of the "fork."

For angles of observer's displacement less than 400 mils, the angle in mils may be substituted for the tangent without introducing an appreciable error, and we have from equation 8

$$\frac{\phi}{F} = \frac{i/1000}{R/1000} = \frac{i}{R} \quad (9)$$

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The numerical value for the factors $\frac{\phi}{\omega}$, $\frac{F}{\omega}$ and $\frac{\phi}{F}$ should, if possible, be calculated in advance. The exact values may be calculated by the equations deduced above, namely:

$$\frac{\phi}{\omega} = \frac{r}{R \cos i} \quad (4)$$

$$\frac{F}{\omega} = \frac{r}{1000 \sin i} \quad (6)$$

$$\frac{\phi}{F} = \frac{1000 \tan i}{R} \quad (8)$$

When the angle of the observer's displacement is less than 400 mils these factors may be calculated almost exactly by the simplified equations,

$$\frac{\phi}{\omega} = \frac{r}{R} \quad (5)$$

$$\frac{F}{\omega} = \frac{r}{i} \quad (7)$$

$$\frac{\phi}{F} = \frac{i}{R} \quad (9)$$

in which R is the range, r is the observing distance and i is the observer's displacement in mils.

As a matter of fact the factors determined by these simplified equations (5), (7) and (9) give values which for field purposes are sufficiently exact for an observer's displacement even up to 800 mils. They therefore provide a rapid means of determining these factors in maneuver warfare.

Example: Range 4000; observer's distance 1000; observer's displacement 600 mils.

By equation (5) we have, $\frac{\phi}{\omega} = \frac{1000}{4000} = \frac{1}{4}$ or .25

Exact value calculated by equation (4) is .3

By equation (7) we have, $\frac{F}{\omega} = \frac{1000}{600} = \frac{5}{3} = 1.67$

Exact value calculated by equation (6) is 1.8

By equation (9) we have, $\frac{\phi}{F} = \frac{600}{4000} = \frac{3}{20} = .15$

Exact value calculated by equation (8) is .167

It will be noted that the factor $\frac{\phi}{F}$ is independent of the observing distance $OB = r$. The equation therefore gives a simple means of tracing out with shrapnel or shell at a range R, a line inclined at an angle i to the direction of fire.

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This factor can therefore be used to move the fire along a linear target such as a road or a trench which is inclined to the direction of fire.

Example: A trench salient or cross road (Fig. 2) is visible

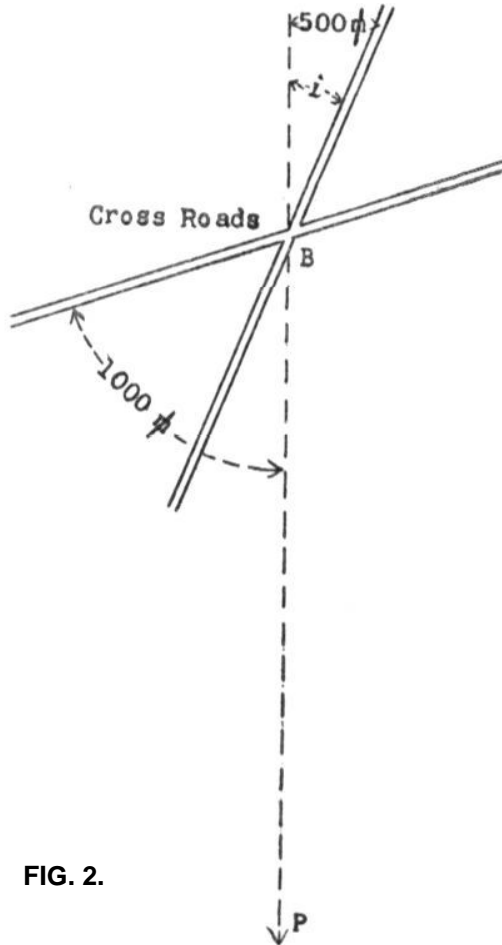


FIG. 2.

and fire has been adjusted upon it at range 4000. It is now desired to proceed along the trench or road by shifting the fire. The angle i made by the trench or road with the direction of fire is measured from the map or simply estimated as 500 mils.

We next determine the factor $\frac{\phi}{F}$ which expresses the relation

between the deflection and the range to keep the fire on the linear target which is inclined at an angle i with the direction of fire.

Since the angle i is not much greater than 400 mils, we may use the simplified equation (9), and

$$\frac{\phi}{F} = \frac{i}{R} = \frac{500}{4000} = \frac{1}{8}$$

If the B. C. now decides to proceed along the road or trench by range changes of 25 meters the corresponding deflection change is $\frac{1}{8} \times 25 = 3$ mils, and his next command will be Right 3, Rn. 4025.

When the angle of the observer's displacement is greater than 1300 mils (flank observation), or when proximity of the target to our own front lines makes it dangerous to bracket the target by changes in range, it is better to bracket the target by deflection changes, making the appropriate changes in range to keep the shots on the observing line. In this case the factor $\frac{F}{\phi}$ is taken,

which is the reciprocal of $\frac{\phi}{F}$, or,

$$\frac{F}{\phi} = \frac{1}{\phi/F} = \frac{R}{1000 \tan i} \quad (10)$$

As in the case of the factor $\frac{\phi}{F}$ previously discussed, the factor $\frac{F}{\phi}$ can also be used to move the fire along a linear target inclined at an angle i to the direction of fire. It will be observed that in using the factor $\frac{\phi}{F}$, we first decided upon the range change to be made and then by multiplying this by the factor we determined the corresponding deflection change. The factor $\frac{\phi}{F}$ is therefore used whenever a particular range change must be used to insure effect.

But in attacking a linear target which is more or less perpendicular to the line of fire, in other words, when the angle i is greater than 800 mils, the deflection change must not exceed a certain amount which is limited by the width of the cone of dispersion of the shrapnel or the radius of effect of the shell. In this case, we must first decide upon the deflection change to

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be made and then by multiplying this by the factor $\frac{F}{\phi}$, which is the reciprocal of $\frac{\phi}{F}$, we determine the corresponding range change.

Example: Let us assume that the trench or road previously considered (Fig. 2) made an angle of 1000 mils instead of 500 mils with the direction of fire. From equation (10) we have

$$\frac{F}{\phi} = \frac{R}{1000 \tan i} = \frac{4000}{1000 \times 1.5} = \frac{8}{3}$$

If the B. C. now decides to sweep along the trench or road by changes of 5 mils in deflection, the corresponding range change is $\frac{8}{3} \times 5 = 15$ meters approximately.

A table of natural sines, cosines and tangents is given in Table A, showing the values for every 100 mils of the observer's displacement. Table B is a very convenient approximation of Table A, which in this form can be easily remembered. These approximations are sufficiently close to give fairly accurate results in practice, and are therefore particularly useful in the field.

It occasionally happens that the change determined by applying the calculated factors are uniformly too large or too small. In this case the error may be due either to a large error in laying the piece for the initial direction or an error in calculating the factor, or to both. It is usually impossible to determine whether the failure to bring the shots on the line is due to one or to the other cause. As a general rule it is advisable to proceed as follows:

When using factor $\frac{\phi}{\omega}$. If the first application of the factor fails to place the group of shots on the observing line, apply the factor again in the appropriate sense. If after two applications of the factor $\frac{\phi}{\omega}$, the center of burst is still not on the observing line, then the factor is very probably in error and must be corrected by firing.

As an example: The calculations for $R = 4500$; $r = 1500$; $i = 280$ mils gives $\frac{\phi}{\omega} = \frac{1}{3}$.

The first two rounds are fired and the center is sensed 30

mils right. $30 \times \frac{1}{3} = 10$, so the next command will be: – Left 10, Range –, Fire. This center is now sensed 15 mils right. The factor failed to bring the shots on the observing line. However, the factor should be used again in order to verify an error in the factor. The next command will therefore be: Left 5, Range –, Fire. This center is sensed 7 mils right. Again the factor failed to respond. There is therefore a reasonable assurance that the factor itself is in error. The question is how much?

The first change of $\varphi = 10$ mils moved the mean point of burst from 30 right to 15 right or $\omega = 15$ mils.

The second change of $\varphi = 5$ mils moved the mean point of burst from 15 right to 7 right or $\omega = 8$ mils.

Therefore, $\frac{\varphi}{\omega} = \frac{10}{15} = \frac{5}{8}$ or $\frac{2}{3}$ approximately, which is the corrected factor $\frac{\varphi}{\omega}$ determined by firing.

When using factor $\frac{F}{\omega}$. If the first application of the factor $\frac{F}{\varphi}$ fails to place the group of shots on the observing line, it is best first to assume that there was an error in laying the gun for initial direction. In this case the deflection should be changed to correct for the discrepancy by applying the factor $\frac{\varphi}{\omega}$ to the observed deviation in order to bring the next group of shots on the observing line.

The existence of an error in the calculations of the factors will then not be disclosed until trial fire is executed by using elevation bounds of one fork. The corresponding deflection to be applied is determined by the factor $\frac{\varphi}{F}$. If the next group of shots fails to remain on the observing line, the observed deviation is corrected for the discrepancy by the factor $\frac{\varphi}{\omega}$ and this correction is applied to the next and subsequent deflections.

Example: Calculations for $R = 4500$; $r = 1500$; $i = 700$ mils (observer to the left) gives $\frac{\varphi}{\omega} = .43$ $\frac{F}{\omega} = 2.4$ $\frac{\varphi}{F} = .18$

The first group of shots is observed 50 mils right. $50 \times 2.4 = 120$, or the next command will be, Range (4620 or) 4625, Fire.

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This center is now observed 12 mils right. The next shots should therefore be brought on the observed line by applying the factor $\frac{\phi}{\omega}$ to the observed deviation or $12 \times .43 = 5$ mils.

The next command is therefore: Left 5. Range 4625 which brings the next shots on the observing line, the shots being sensed as over.

The trial elevation is now determined by making changes of one fork in range and the corresponding change in deflection. At 4500 the fork is approximately 100 m. $100 \times .18 = 18$ mils which is the corresponding change in deflection. The command is therefore: Left 18, Range 4525.

The center of this group is sensed as 5 mils left. There is therefore some error in the factor $\frac{\phi}{F} = .18$

The observed deviation must be corrected by the factor $\frac{\phi}{\omega} = .43$ or $5 \times .43 = 2$ mils. The next command is therefore: Right 2, Range 4525. We have now found that a change of 100 m. in range and a change of $18 - 2 = 16$ mils in deflection will keep the shots on the observing line. The correct value of $\frac{\phi}{F}$ is therefore $\frac{16}{100} = .16$ which had been determined by firing.

Method to be Pursued in Firing with Lateral Observation.

1. Determine $\frac{\phi}{\omega}$, $\frac{F}{\omega}$ and $\frac{\phi}{F}$.
2. *When observer's displacement is less than 300 mils.* Fire two shots and observe the mean deviation in mils. Multiply this observed mean deviation by factor $\frac{\phi}{\omega}$. This will be the deflection change to bring the next shots on the observing line. Having made this correction in deflection, fire two more shots and again observe the mean deviation. If the center is not on the observing line, apply factor $\frac{\phi}{\omega}$ again to the observed mean deviation. If this does not bring the shots on the observing line, then the factor is very probably in error and must be corrected by firing.
3. *When observer's displacement is greater than 300 mils.*

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Fire two shots and observe mean deviation in mils. Multiply this observed mean deviation by factor $\frac{F}{\omega}$. This will give the range necessary to bring the next shots on observing line (the result being either in mils, 20ths, minutes or meters, depending upon the unit in which F was originally taken). Having made this correction in elevation, fire two more shots and observe the deviation. If the center is not on the observing line, apply the factor $\frac{F}{\omega}$ again to the observed mean deviation. If this does not bring the shots on the observing line, then the factor is very probably in error, and must be corrected by firing.

4. *Trial fire.* Observation of fire is possible only by keeping all shots on the line OB. Any change in the range, therefore, also involves a certain proportional change in deflection. *If the displacement angle is less than 1300 mils*, use elevation jumps of 1 or 2 forks. The corresponding deflection change to be applied is obtained by multiplying this range change by the factor $\frac{\phi}{F}$. Two shots are fired at each trial elevation.

If the observer's displacement angle is 1300 mils or greater, use deflection changes of 1 lateral fork, but never greater than 16 mils. The corresponding range change to be applied is obtained by the factor $\frac{E}{\phi}$. Two shots are fired at each trial elevation.

Continue the fire until a verified bracket of 1 fork is obtained.

5. *Improvement fire.* Fire a series of, say, 6 shots, in two groups of 3 shots each, at the mean of both the range and deflection brackets. Groups of 3 are chosen so that if the first 3 are all in the same sense, the elevation and deflection for the next group of 3 may be changed by half a fork, the whole series being taken as having been fired at the mean of the two elevations and deflections, to which the subsequent corrections are referred.

The deflection used in opening improvement fire being, under ordinary conditions, usually the split of about a 4 mil deflection bracket, should be nearly correct. For this reason during improvement fire or during fire for effect, all bursts

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observed to the right or left of the target are taken as short or over if the observer is to the left of the line of fire, and *vice versa* if he is to the right of this line. The accuracy of the deflection is checked by those bursts which fall on the line of observation OB. Since improvement fire was begun at the mean of the deflection brackets the deflection change will seldom exceed 1 or 2 mils, if the fire has been properly conducted up to the point.

TABLE A.

TABLE OF NATURAL SINES, COSINES AND TANGENTS.

Observer's Displacement in Mils.	Sines	Cosines	Tangents
0	.00	1.00	.00
100	.098	.995	.0986
200	.195	.98	.199
300	.29	.956	.3
400	.38	.92	.4
500	.47	.88	.5
600	.556	.83	.669
700	.63	.77	.82
800	.707	.707	1.0
900	.77	.63	1.21
1000	.83	.556	1.49
1100	.88	.47	1.88
1200	.92	.38	2.43
1300	.956	.29	3.29
1400	.98	.195	5.02
1500	.995	.098	10.14
1600	1.0	.00	∞

TABLE B.

CONVENIENT APPROXIMATE TABLE.

Observer's Displacement in Mils.	Sines	Cosines	Tangents
0	.00	1.00	.0
100	.10	.99	.1
200	.20	.98	.2
300	.30	.95	.3
400	.40	.90	.4
500	.50	.85	.5
600	.60	.80	.65
700	.65	.75	.8
800	.70	.70	1.0
900	.75	.65	1.2
1000	.80	.60	1.5
1100	.85	.50	2.0
1200	.90	.40	2.5
1300	.95	.30	3.0
1400	.98	.20	5.0
1500	.99	.10	10.0
1600	1.00	.00	∞

NOTE.—The table of sines jumps by 10 up to .60, then by 5 up to .95. The table of cosines is the inverse of the table of sines.

The Balloon Observer

BY MAJOR T. W. WRENN, (FIELD_ARTILLERY) AIR SERVICE AERONAUTICS

[Editor's Note.—Major Wrenn's interesting article gives the artilleryman a comprehensive idea of the balloon observer's side of the game. Too much emphasis cannot be placed upon the necessity for the closest kind of liaison with this important branch of artillery observation of fire. We have heard far too little in the past from this branch of the service and the JOURNAL welcomes expression of opinions, both from the balloon service and the artilleryman, which will make for better team-work.]

"HERE comes a man with a grandstand seat for the war," remarked a lieutenant of infantry, as an officer with Air Service insignia approached the group.

"Want to go up sometime and spend the day with me?" countered the young man with a single wing over the left breast pocket of his coat.

"No, thank you," said the infantryman. "I'll stick to the ground and the cooties."

The place was a Y. M. C. A. hut that had been placed rather close to the lines on the south side of the St. Mihiel salient, when things were still more or less quiet there, and a balloon observer, the officer about whom the first remark was made, had dropped by in search of chocolate when returning from liaison with some neighboring batteries.

Now we know that many a truth is spoken in jest, also it is to be inferred that the doughboy lieutenant was jesting, or, let us say, trying to "kid" the observer. Nevertheless, he spoke a profound truth.

For when a grandstand seat is mentioned the American naturally thinks of a choice location for viewing a ball game and if the game of war is substituted for baseball, this is just what the man in the balloon basket has. He is so placed that he can see everything that goes on within his range of vision. This

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range of vision is only limited by the atmospheric conditions and distant hills which obscure certain relatively small portions of the terrain behind them. He is fixed and has this terrain continually under surveillance; he needn't miss anything that is going on, and in addition he has the every-ready telephone to transmit instantly whatever he sees to those interested. In comparison with the man in an aeroplane, his field is somewhat limited, but it is that continuity of observation and the ability to communicate instantly, by word of mouth, to all for whom he works (which the aeroplane observer cannot have) that makes him indispensable.

Whenever the weather permitted and it was possible to see the front line from the balloon position, the big sausage-shaped bags could be seen at intervals along the lines floating high overhead, each with its one or two pairs of eyes gazing intently and intelligently into the enemy's territory, eager to pick up and report his slightest movement. If you had happened to have been on hand at the start of an ascension, had seen the observer in his furlined "combination," with his little cushioned seat, his maps, instruments and lunch all neatly arranged in the basket, the thought would have struck you that he ought to have a rather comfortable time of it. But his job, while not the most dangerous perhaps, was by no means an easy one. The extremely long hours, the necessity for continual concentration on the work, the ever-present possibility of an aerial attack or the Boche taking a shot at him with a long-range gun, made for a strain, both physical and nervous, that was very real. One is impressed, when first going up in a balloon, by the quiet. At the front, an almost constant buzz of aeroplane motors took its place, yet the observer could not let them bother him or look to see if they were enemy or not, he was there to keep on observing until he received a warning from the ground, and as for the long-range gun—well, there is no doubt about it, he did feel mighty conspicuous at times.

There are normally five observers to a balloon company, whose work justifies the existence of the company of one hundred

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and seventy enlisted men and a large amount of equipment. How these five officers are kept busy when on the ground will be taken up later; their missions in the air come under three general heads:

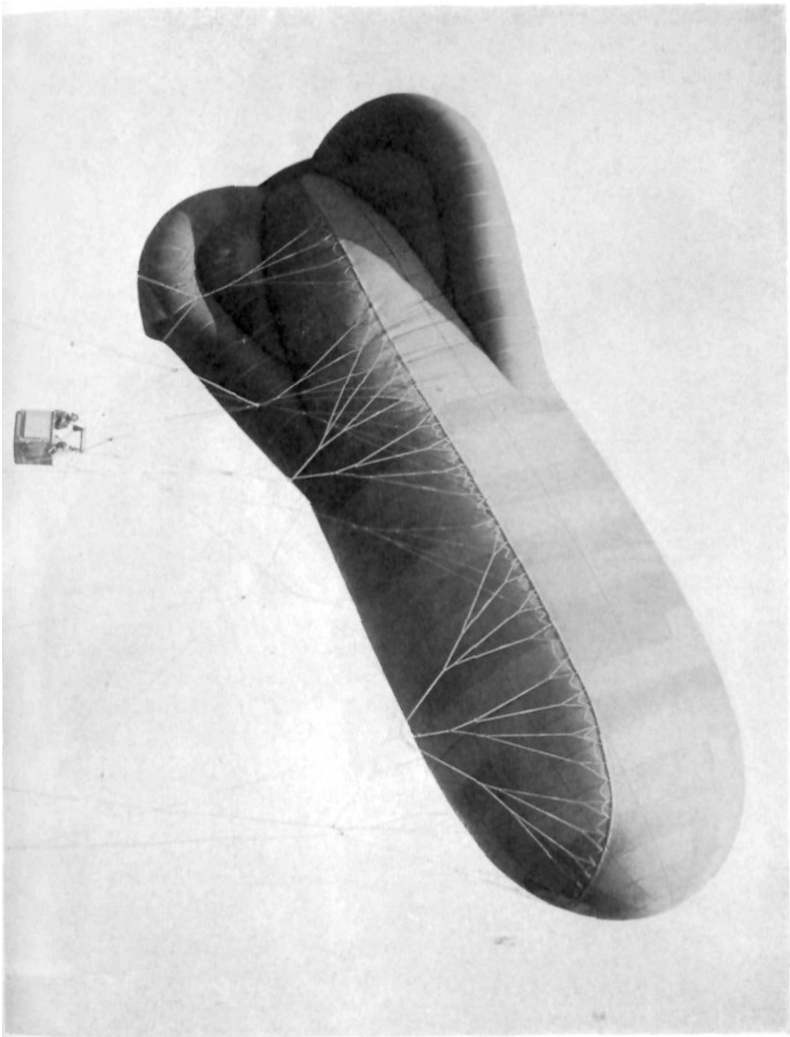
1. The mission of information and general surveillance.
2. Missions for the staffs and liaison with infantry.
3. Missions for the artillery.

One and two will not be considered in detail. It will suffice to note that the observer had to know the characteristics of his sector so well that any change in the enemy's habits would be noticed immediately. It was essential that he study well the organization of the hostile positions and troops, the movements of trains, vulnerable points, ammunition dumps, supply depots, battery emplacements and information on activity of enemy batteries, air service units and their activity, in fact, everything within the enemy's lines, for his field was broad and he had to be able to pick out the new from the old and know, for instance, if the number of trains arriving in a sector was on the increase, heralding an increased activity.

In addition, he had to know, of course, our own order of battle, the disposition of troops of all arms, the plan for their use in offense or defense, the scheme of liaison and particularly and in detail the missions of the artillery with which he worked.

The information gained by the application of the above to aerial observation was of benefit to the artillery in that their targets were accurately located for them, whether it was a company of troops on the road or a new defensive position. This was true particularly in the case of active enemy batteries when the quick, accurate reports from the balloon were of infinite value for effective counter battery work.

In position warfare, when the lines are practically stationary, the balloon observer's work can reach its greatest refinement. There is the time for thorough study of the terrain both in the air and from maps and photographs, the installation and maintenance of telephone lines and that personal liaison so necessary for efficient work with the artillery. Therefore, for



FLOATING HIGH OVERHEAD, WITH ITS TWO PAIRS OF EYES GAZING INTENTLY AND INTELLIGENTLY INTO THE ENEMY'S TERRITORY



THE U. S. ARMY BALLOON SCHOOL, ARCADIA, CAL., SEEN FROM THE SCHOOL OBSERVATION STATION, MT. WILSON

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purposes of illustration, it is best considered from this viewpoint.

Let us take then, as an example, a balloon company moving into a relatively quiet sector of the front, as north of Toul in June, 1918. We will leave the company to establish itself in some little village or shacks in a wood or whatever else is handy, select sights for a balloon bed and points of ascension, establish its telephone central, etc., and interest ourselves in the affairs of the observers.

Possibly it would be several days before the balloon would ascend, before the lucky first man to go up would get his initial look into that enemy sector. But the observers did not spend this time waiting for the others to get ready—quite the contrary.

Their first consideration was the selection of a location for a Chart Room (the French Bureau Technique), usually the best place to be found, where the maps and observation records were kept and where much of the observers' work was done. Then there were the maps and photographs of the sector to be thoroughly studied, as well as the reports of the enemy's activity; charts to be made for the listing of enemy batteries on which their daily activities were to be recorded; a dead space map to be prepared showing the invisible portions of the sector from three altitudes of the balloon, usually 800, 1000 and 1200 meters above the ground; a perspective of the sector as seen from the balloon to be accurately drawn; map for use in the basket to be prepared and mounted; a file of photographs for basket use to be arranged; and last, but not least, liaison to be immediately started by visits to the various headquarters and command posts. The objects of these visits were to make arrangements for telephonic connections, to learn the plan of employment of the artillery, the location of the batteries, names of their officers, in fact, to lay the foundation for the closest possible coöperation between the balloon and those it would serve.

The battery officers were the observer's ultimate aim, theirs were the names that composed his standing visiting list, they were the men that he wanted to know well and that he wanted

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to know him. The inexperienced man will ask, "Why was this continual visiting necessary?" and "Why could not any capable man send down the corrections for the shots to obtain the required adjustments of fire?" But the man of experience will know that, in such a case, mutual understanding and confidence is essential for satisfactory results, and that this personal intercourse is the only means of obtaining it.

There is another slightly different light in which the matter might be considered. Observers were absolutely certain that they could be of great service to the artillery, but all artillerymen didn't have exactly the same views in the early stages of the game. In fact, it was not unusual to hear an observer, just returned from a liaison trip, remark that he had been out "selling business to the artillery." So it became a part of the balloon man's job to prove his worth, and it has been the untiring efforts of these "salesmen" with a splendid article to sell that has made the balloon what it is to-day—the acknowledged best medium of aerial observation.

Some rather amusing incidents occurred.

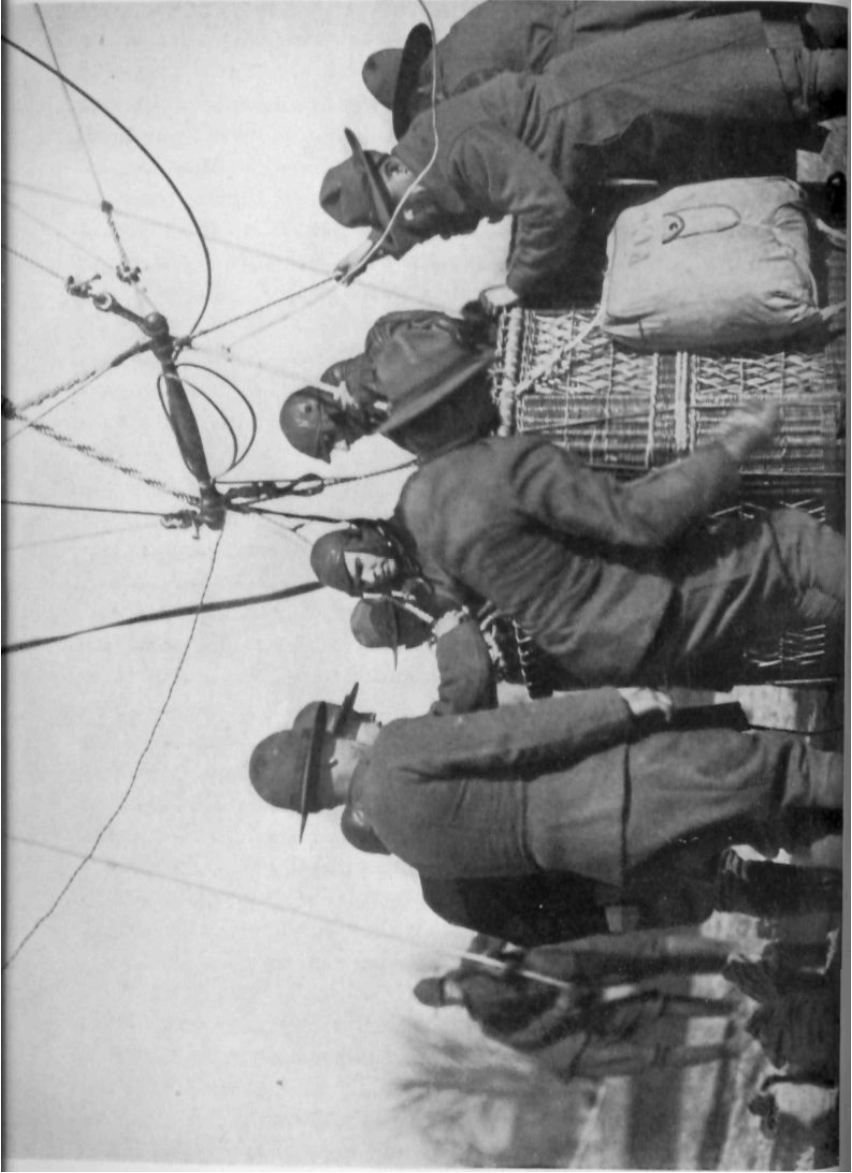
There was the case of one major of artillery, commanding a group at the front, who had little faith in aerial observation, in general, and balloon observation in particular. But finally, after many visits from the balloonists and much artful persuasion, this major consented to visit the balloon encampment, was shown the chart room with its outlay of photographs and maps, the accurate tabulations of enemy activities, and the records of work done, the need and methods of using each thing being thoroughly explained. He was not yet convinced, however, so after having had laid before him a specially prepared luncheon to which he did full justice, he was inveigled into the basket and into the air with one of the observers.

When they had reached an altitude of about seven hundred meters the major remarked, "Yes, it's all very nice, there's L——," naming a village about a kilometer from the balloon position.

"Oh, no!" said the observer, "that is not L—— but M——,"



MAJOR GENERAL W. J. SNOW, CHIEF OF FIELD ARTILLERY, U. S. ARMY, ADJUSTING PARACHUTE HELM'T PRIOR TO ASCENDING AS AN OBSERVER



READY FOR THE ASCENT

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5 kilometers away," and proceeded to substantiate his statement by reference to his map.

After which, the major was witness to a couple of adjustments of fire, quickly and accurately done. He was brought to the ground at dusk, a wiser though not a sadder man, for he was thoroughly enthusiastic on the subject of balloon observation for artillery, thereafter calling the balloon on the slightest provocation, sometimes having the observer check his own observation posts when firing on targets visible from them.

So, wherever there was a battery of artillery, there the balloon observer would surely find his way. He wanted to get the point of view of each battery commander and wanted each battery commander to get his point of view. He made sure that the artilleryman realized the necessity of uninterrupted telephonic communication during an adjustment, explained to him the reason for the observer having to know the kind of shell and fuse, the time of flight, the method of fire, when and why he would call for a round of shrapnel, why the departure of each round had to be announced, discussed the use of auxiliary targets and demonstrated his ability to pick them out, made lists of targets on which the batteries desired adjustments (these for future reference and study of surrounding terrain, on the ground and in the air). He endeavored to impress upon the battery commanders' minds the advantage of going over a shoot beforehand and told them that an observer was ready to come to the battery at any and all times on such an errand and that he would always come afterward to tell them about it. But he had them understand, at the same time, that the observer was in the air to serve them and that if they should want an adjustment on the spur of the moment, why—all they would have to do was just call the balloon.

In a war of movement the general principles outlined above still apply, but necessarily modified to meet conditions. However, the balloon company is a mobile outfit, which, with its latest equipment, can stay right with the artillery.

Consider, then, how great would become the value of this

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observation post when sound-ranging sections are out of commission, the system of terrestrial observation posts is disorganized and the advance has left the aeroplane landing grounds well to the rear, making both personal and telephonic liaison with them next to impossible.

Of course, all liaison becomes difficult at such times and we cannot hope for the same system and coördination that obtained when the lines were stationery. Yet it is possible for the observers to keep in close touch with at least a part of the artillery at a time when the enemy is in the open, when his elaborate scheme of trenches, dug-outs and battery emplacements count for nothing. Fleeting targets, such as supply trains, troops on the march, or enemy concentrations and batteries in action are quickly spotted, objectives which the artillery must take under fire. Certainly nothing could add more to its effectiveness than being in direct communication with the balloon at such times.

That the Germans appreciated this fact is shown by captured documents, from which we have learned that balloons were attached to certain groups, to remain constantly with them and serve them to the exclusion of others. The idea is, obviously, to make sure that the maximum value of this means of observation is taken advantage of by a relatively small number of batteries, rather than to take the chance of its being almost entirely lost by a more haphazard liaison which endeavors to include all the artillery in a sector. Some such scheme seems advisable in our service, and would almost certainly have been in operation on the French front if there had been many more days of war.

Unquestionably the balloon men have done good work. It may have been better, perhaps, but still it was good. The maximum efficiency in their work with artillery can only be obtained, however, by the active coöperation of artillery officers. This the observers should have and all artillerymen should bear in mind that where there is a balloon, there also is an observer anxious to take them up into the air and show them.

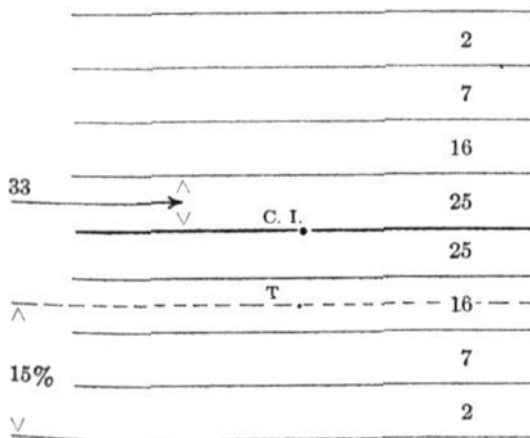
Probabilities As Applied To Artillery Firing

BY PROFESSOR JOSHUA I. TRACEY, ASSISTANT PROFESSOR OF MATHEMATICS,
YALE UNIVERSITY.

[Note by Colonel Walter S. Sturgill, Field Artillery, U. S. Army. The accompanying paper on Probabilities is commended to our readers and to the service as being a very clear exposition of the subject, simple and sufficiently non-technical to be easily understood. The subject of probabilities as applied to artillery firing has been for years a bugbear to most field artillery officers, principally for the reason that no really practical "working" explanation of the subject was available. It is believed that this paper by Professor Tracey will go a long way toward giving our officers a very clear conception of the subject.

With reference to the "Approximate Solution"* mentioned in connection with Example 2, many officers will undoubtedly prefer to solve problems by that method, using rough sketches of the zone of dispersion or dispersion diagram, without reference to the Table of Probabilities.

Example 2 would be solved by this method as follows (see figure): 3 out of twenty shots, or 15 per cent., are short of the target. The range probable error is 33 yards. Therefore the target is $2\frac{1}{16}$ probable errors, or $33 \times 2 + \frac{1}{16} \times 33$, or 78.4 yards, approximately, from the short edge of the 100 per cent.



* Sometimes called "The 25-16-7-2 Rule."

zone. The center of impact, then, is $4 \times 33 - 78.4$, or 53.6 yards beyond the target, as compared with 50.8 yards obtained by using the tables.

Take this example: The range probable error of the point of fall of a shot fired at a certain range is 30 yards. What is the probability that the range error of a single shot will not exceed 40 yards?

If the range error is not to exceed 40 yards then the shot will not be at a greater distance from the center than $1\frac{1}{3}$ probable errors. A zone having this width on each side of the center will contain $25 + 25 + 2 \times \frac{16}{3}$, or $60\frac{2}{3}$ per cent. of all the shots, therefore, the required probability is 0.61, or 61 per cent. approximately. The result obtained by using the tables is 0.63.

Another problem:

The ground surface of a machine-gun nest is 4 meters square. Assume that you are firing on it with a 155-mm. howitzer at such a range and with such a charge that the corresponding range and deflection probable errors are 36 meters and 4 meters, respectively. If your fire is adjusted on the center of the nest, how many shots must you fire in order to secure two direct hits?

To secure a hit for range the shot must fall within a zone 4 meters deep, the center of which is the center of impact. The probability of this is $50 \times 4/(36 \times 2)$, or 2.8 per cent. The probability of securing a hit for deflection is $50 \times 4/(4 \times 2)$, or 25 per cent. Therefore, the probability of securing a hit for both range and deflection is 0.028×0.25 , or 0.007. That is, 7 shots out of every 1000, or 1 shot out of every 143, will hit the target. Therefore, to secure 2 hits you must fire 286 rounds.

By using the tables the problem is solved as follows:

For the first phase $r = \frac{2}{36} = .055$; from which by interpolation, $p = .0297$.

For the second phase $r = \frac{2}{4} = 0.50$; from which $p = 0.264$.

The required probability is then 0.0297×0.264 , or 0.00784, as compared with 0.007 obtained by the approximate rule.]

PROBABILITIES AS APPLIED TO ARTILLERY FIRING

Probabilities.—The theory of probabilities is in general applicable to a future event or group of events the occurrence of which may produce any one of a definite number of outcomes.

The Single Event.—The probability of a particular outcome of an event is the number obtained by taking the ratio of the number of times that particular outcome occurs to the total number of events, as the number of events increases indefinitely. In other words, the probability of a particular outcome of an event is the ratio, in the long run, of the number of favorable cases to the number of all possible cases.

Thus in tossing a coin it will be observed that heads uppermost and tails uppermost will occur with the same average frequency. Hence the probability of each outcome of this event is one-half, or fifty per cent.

In artillery firing, if a number of rounds are fired under given conditions at a target and it is observed that on the average out of every ten, one strikes the target, three fall short, and the others over, then for any round fired the probability of a hit is one-tenth, or ten per cent., the probability of a short thirty per cent., and the probability of an over sixty per cent.

Law.—Since every event is certain to have an outcome, if certainty is expressed by unity then the sum of the probabilities of all possible outcomes of an event is unity, or one hundred per cent.

Sometimes the probability of each outcome is obvious from the nature of the event as in the first illustration. But in the application to artillery firing the probability can be approximately determined only by the observation of a number of events as in the second illustration.

The Compound Event.—This consists of two or more single independent events which may occur simultaneously, the outcome of any event being independent of the outcome of any other event. If p_1 is the probability of a definite outcome of one event and p_2 the probability of a definite outcome from a second event, then in the occurrence of both events the probability of

that particular combination of outcomes is $p_1 \times p_2$. To illustrate, suppose two guns G_1 and G_2 are firing at a target and it has been observed that one-third of the shots from G_1 are short and two-thirds over, and three-fifths of the shots from G_2 are short and two-fifths over, then:

- The probability of a short from G_1 is $\frac{1}{3}$.
- The probability of an over from G_1 is $\frac{2}{3}$.
- The probability of a short from G_2 is $\frac{3}{5}$.
- The probability of an over from G_2 is $\frac{2}{5}$.

If the compound event is a shot from each gun the following are the outcomes with their respective probabilities:

- The probability of two shorts is $\frac{1}{3} \times \frac{3}{5}$, or $\frac{1}{5}$.
- The probability of two overs is $\frac{2}{3} \times \frac{2}{5}$, or $\frac{4}{15}$.
- The probability of a short from g_1 and an over from g_2 is $\frac{1}{3} \times \frac{2}{5}$, or $\frac{2}{15}$.
- The probability of an over from g_1 and a short from g_2 is $\frac{2}{3} \times \frac{3}{5}$, or $\frac{2}{5}$.

Now a short and an over can occur in either of the last two ways, so the probability of a short and an over is the sum of these or $\frac{8}{15}$.

In the compound event, as in the case of the single event, the sum of the probabilities of all possible outcomes is unity. The same principle applies if there are more than two events.

Dispersion.—If a number of rounds are fired from the same gun, it will be observed that no two projectiles burst at exactly the same height, nor will they fall in exactly the same spot even when fired under apparently the same conditions. This phenomenon is known as *dispersion*. For a given elevation of the gun there are two limiting ranges, one a maximum and the other a minimum, such that the range of each projectile will be between these limits. There are similar limits for the height of the point of burst when all the rounds are fired with the same corrector. Now if the outcome considered is the exact

PROBABILITIES AS APPLIED TO ARTILLERY FIRING

range or the exact height of burst it is obvious that the number of possible outcomes is indefinitely large, whereas the theory of probability can only be applied to events which have a definite number of possible outcomes. For this reason it is necessary to divide the interval between the maximum and the minimum limits into a definite number of equal parts, then the probability of an outcome being in any one of these parts can be determined.

The Mean.—The "mean" or average of a group of n numbers is the sum of these numbers divided by n . If a series of measurements are made upon some quantity, each measurement having the same degree of accuracy, then the mean of these values is generally accepted as being the most probable value of the measure of that quantity. Suppose it is desired to measure the range of a gun when fired with a given elevation. A number of shots being fired, the range to the point of fall of each is measured. The mean of these values is called the mean range or range center of the group. The difference between the range of each shot and the mean range is called the error of that particular outcome. If the range for a given trial is greater than the mean, the error of the trial is positive, if less it is negative. Obviously the algebraic sum of any such group of errors is 0. However, if we disregard the sign and take the mean of the numerical values of the errors the result is called the mean error, e_m . To illustrate, suppose eight shots were fired and the following ranges measured:

Range.	Algebraic Error.	Numerical Error.
3260	+65	65
3170	-25	25
3215	+20	20
3240	+45	45
3155	-40	40
3205	+10	10
3125	-70	70
3190	- 5	5
8) <u>25560</u>	0 (check)	8) <u>280</u>
3195 Mean range		35 Mean error

It is important to remember that the mean of a limited number of outcomes is not the true mean and the errors are not the true errors. Thus if we consider only the first two shots the mean range is 3215. Similarly the mean range obtained by observing 50 or 100 shots will more nearly approximate the true mean than the value obtained by eight observations.

The Law of Probabilities Applied to Errors.—In a series of events the probability of an error of a given magnitude is the ratio of the number of outcomes having that error to the total number of outcomes.

Laws of Errors.—In any series of events: (1) The outcome with error O , that is the mean value, has a greater probability than any other outcome. (2) Small errors are more frequent than large ones and hence have greater probability. (3) Positive and negative errors of the same magnitude occur with the same frequency and hence have equal probabilities. (4) There is a definite limit to the magnitude of the errors and no outcome will have an error exceeding that limit.

The Probable Error.—In order to measure and compare the errors obtained from a series of events, a unit error is taken of such magnitude that one-half the number of errors will be greater than this unit and the other half less. This unit error is called the *probable error*, e_v . In other words, the probable error is that error which, in the long run, is exceeded as often as it is not exceeded.

Explanation of Probability Tables.—From the principle of probabilities and the fundamental hypotheses involved in the laws of errors, mathematical equations have been derived from which probability tables are constructed. These tables give the percentage of errors which are less than a given error e . To determine the probability p that a given error will be less than r times the probable error where r is a given factor, enter the probability tables for the given value of r and the corresponding probability p , or the percentage of errors less the $r \times e_p$, is obtained. Conversely, if it is desired to find the limiting value of the error e when the percentage of errors less than

PROBABILITIES AS APPLIED TO ARTILLERY FIRING

TABLE OF PROBABILITY FACTORS.

p	r	p	r	p	r	p	r
.01	.02	.26	.49	.51	1.02	.76	1.75
.02	.04	.27	.51	.52	1.04	.77	1.78
.03	.06	.28	.53	.53	1.07	.78	1.82
.04	.07	.29	.55	.54	1.09	.79	1.86
.05	.09	.30	.57	.55	1.12	.80	1.90
.06	.11	.31	.59	.56	1.14	.81	1.94
.07	.13	.32	.61	.57	1.17	.82	1.98
.08	.15	.33	.63	.58	1.19	.83	2.03
.09	.17	.34	.65	.59	1.22	.84	2.08
.10	.18	.35	.67	.60	1.25	.85	2.13
.11	.20	.36	.70	.61	1.27	.86	2.18
.12	.22	.37	.72	.62	1.30	.87	2.24
.13	.24	.38	.74	.63	1.33	.88	2.30
.14	.26	.39	.76	.64	1.36	.89	2.37
.15	.28	.40	.78	.65	1.39	.90	2.44
.16	.30	.41	.80	.66	1.42	.91	2.52
.17	.32	.42	.82	.67	1.45	.92	2.60
.18	.34	.43	.84	.68	1.48	.93	2.69
.19	.36	.44	.86	.69	1.51	.94	2.78
.20	.38	.45	.89	.70	1.54	.95	2.91
.21	.40	.46	.91	.71	1.57	.96	3.04
.22	.41	.47	.93	.72	1.60	.97	3.22
.23	.43	.48	.95	.73	1.64	.98	3.45
.24	.45	.49	.98	.74	1.67	.99	3.82
.25	.47	.50	1.00	.75	1.71	1.00

e is known, enter the probability tables with the given value of p and the corresponding factor r is found such that $e = r \times e_p$.

To illustrate:

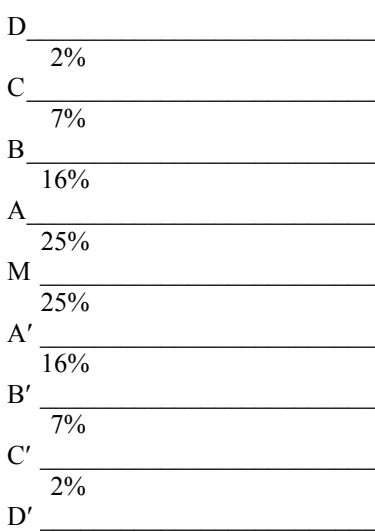
Find the probability that a given outcome will have an error less than $1\frac{1}{3}$ times the probable error.

In this case $r = 1\frac{1}{3}$. Entering the table for this value of r the corresponding value of p is .63; in other words, 63 per cent. of all the outcomes have errors less than $1\frac{1}{3} e_p$.

The probability that a given outcome has an error less than e is .75. Find e . Here $p = .75$ and the corresponding value of r is 1.71, or $e = 1.71 e_p$.

Distribution of Outcomes.—We can now construct the dispersion

pattern showing the distribution of the outcomes of a series of events. If $r = 1, p = .50$; this follows from the definition of the probable error. From this definition and the third law of errors we see that 50 per cent. of the outcomes have errors less than e_p , $\frac{1}{2}$ of these, or 25 per cent., will be greater than the mean value and 25 per cent less. Hence, if the line through M represents the position of the mean and MA and MA' each represent the value of the probable error e_p then 25 per cent. of the outcomes will be observed between M and A and 25 per cent. between M and A' . It follows also that 25 per cent. of the outcomes will be observed between A and the upper limit, and 25 per cent. between A' and the lower limit. Now from the probability tables if $r = 2, p =$



.823, that is, approximately 82 per cent. of the outcomes will be less than 2 probable errors from M . Let $MB = MB' = 2 e_p$. Since AA' include 50 per cent. of the outcomes it follows from the third law that AB and $A'B'$ will each include $\frac{1}{2} (82-50)$, or 16 per cent. Similarly when $r = 3, p = .957$, or nearly 96 per cent.; and if $MC = MC' = 3 e_p$ then BC and $B'C'$ will each include $\frac{1}{2} (96-82)$, or 7 per cent. Again, if $r = 4, p = .993$, or more than 99 per cent. Take D and D' so that $MD = MD' = 4 e_p$ then

for all practical applications D and D' are considered the limiting values of the errors referred to in the fourth law. This distribution of the outcomes will apply to any series of events in which errors are involved. In artillery firing it is applied not only to observations for range but to observations for lateral deviation and for height of burst as well. The outcomes for each series of events will have a definite probable error or unit error and all the outcomes will be included in a region which is approximately eight times this probable error.

PROBABILITIES AS APPLIED TO ARTILLERY FIRING

Center of Impact.—When a series of shots are fired under the same conditions the center of the points of fall is called the center of impact. It is the point of intersection of the line representing the mean range with the line representing the mean lateral deviation of the series, and all the points of fall will be symmetrically located with respect to this point. The trajectory passing through the center of impact is called the mean trajectory.

Zones.—A zone is a region containing a certain percentage of the outcomes of a series of events, half of them having positive errors and half negative. Hence every zone is bisected by the center of impact and positive and negative errors of the same magnitude are included between its limits. The width of a zone is therefore twice the value of the maximum error in that zone. Thus the 50 per cent. zone is that zone containing all errors less than one probable error. It is also called the probable zone z_p . By moving the bounding lines of the zone the same distance toward or away from the center of impact and keeping them parallel to the line representing the mean, zones can be obtained containing any desired percentage of the outcomes. If e is the maximum error in zone z , then, obviously, $\frac{z}{z_p} = \frac{e}{ep} = r$

Relation between the Mean Error and the Probable Error.—

D	_____	We can determine the
	2	approximate relation between the
C	_____	mean error and the probable error
	7	as follows:
B	_____	Consider the dispersion pattern
	16	representing 100 outcomes and
A	_____	assume uniform distribution
	25	throughout each of the regions MA ,
M	_____	AB , BC , etc. The mean error is found
	25	by disregarding the signs and taking
A'	_____	the mean of the numerical errors.
	16	Now the outcomes in MA and MA'
B'	_____	have an average error of $\frac{1}{2} e_p$; those
	7	in AB and $A'B'$ have an average
C'	_____	
	2	
D'	_____	

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error of $1\frac{1}{2} e_p$; in BC and $B'C'$, $2\frac{1}{2} e_p$; and in CD and $C'D'$, $3\frac{1}{2} e_p$. Hence the sum of the numerical errors is:

$$(50 \times \frac{1}{2} e_p) + (32 \times 1\frac{1}{2} e_p) + (14 \times 2\frac{1}{2} e_p) + (4 \times 3\frac{1}{2} e_p) = 122 e_p.$$

Whence $e_m = 1.22 e_p$; or $e_p = 0.82 e_m$.

A closer approximation is $e_p = 0.845 e_m$.

Example: Six shots have been fired from one gun with the same fuze-setting and the following heights of burst observed: 2 mils above, 4 mils above, 0, 2 mils below, 2 mils above, 0. Determine the mean error and the probable error of the height of burst.

Solution:

Observations.	Numerical Errors.
+2	1
+4	3
0	1
-2	3
+2	1
0	1
6)+6	6)10
1 + mil mean height of burst	1.67 mils mean error

Hence $0.845 \times 1.67 = 1.41$ mils probable error.

Classification of Errors.—There are two classes of errors: *constant* errors and *accidental* errors. Constant errors are those which have the same effect on each of the outcomes of a series of events. The causes of these errors are often known, in which case they can either be eliminated or avoided. Some of the causes are: Incorrect measuring instruments, defective or worn parts of the mechanism, incorrect position of an index, the constant error of the observer called his personal equation, etc. To illustrate, if the index of the panoramic sight scale reads 10 on the scale instead of 0, when the line of sight is parallel to the axis of the bore, then a correction of +10 must be made and

PROBABILITIES AS APPLIED TO ARTILLERY FIRING

if a deflection of 330 mils is required the corresponding scale-setting must be 340.

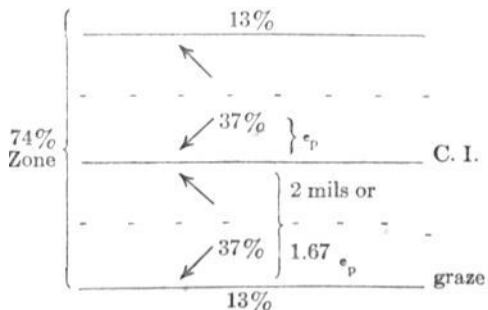
Accidental errors are those arising from a combination of sources which change with each event and produce a different effect on each of the outcomes. In artillery firing, accidental errors are grouped under two general headings: those due to *matériel* and those due to *personnel*. Under the former are those caused by variations in the construction and action of the gun, variations in the projectile, powder, and fuzes, also variations caused by atmospheric conditions. The errors of personnel depend on the efficiency of the gun squad and on the rapidity with which the firing is conducted. Service firing will produce larger errors than firing for proving-ground tests. For this reason the probable error of service firing, which is known as the *practical probable error*, is $1\frac{1}{2}$ or even 2 times the proving ground or theoretical probable error, and in the use of range tables it is essential to know whether the practical or theoretical unit is given.

Accidental errors cannot be eliminated, but since they must follow the Laws of Error it is obvious that an elementary knowledge of the application of these laws is essential for the effective conduct of artillery fire.

EXAMPLES

Example 1.—What percentage of shots will burst on graze if the burst center is 2 mils high and the probable error for height of burst is 1.2 mils?

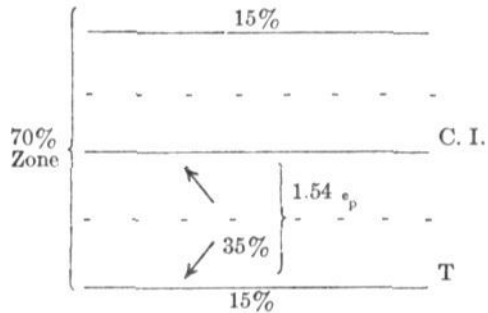
Solution.—Now the graze bursts will be at the edge of a zone which is $2/1.2$, or 1.67 times the width of the probable zone. That is, greatest error in this zone is 1.67 times the probable error.



From the Table, if $r = 1.67$, $p = .74$. Hence 74 per cent. of the bursts will occur in the zone having its lower limit on graze. Of the remaining 26 per cent. one-half of them, or 13 per cent., will burst on graze.

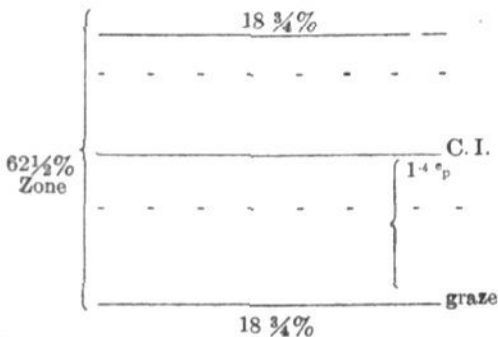
Example 2.—Where is the center of impact with respect to the target if from 5 battery salvos three shots fall short and the others over, the probable error for range being 33 yards.

Solution.—If three shots, or 15 per cent., are short of the zone which has the target at its short limit then 15 per cent. are beyond this zone, and hence the target is at the short limit of the 70 per cent. zone. For $p = .70$, $r = 1.54$; and $33 \times 1.54 = 50.82$ yards. Therefore, the center of impact is 50.82 yards beyond the target.



An approximate solution to such problems is obtained without using the Table of Probabilities by assuming that the distribution of the outcomes in each region is uniform throughout that region. Thus, if the target were $1\frac{1}{3}$ probable errors from the center of impact we assume that $.25 + \frac{1}{3}$ (.16), or $30\frac{1}{3}$ per cent. of the

outcomes are between the target and the center of impact.



Example 3.—What is the mean height of burst if out of four battery salvos 3 bursts are on graze? Assume $e_p = 1.6$ mils.

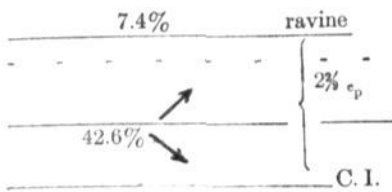
Solution.—Three-sixteenths, or $18\frac{3}{4}$ per cent., burst on graze. Hence

the graze bursts are at the edge of the 100-2 ($18\frac{3}{4}$), or $62\frac{1}{2}$ per cent., zone. Then $31\frac{1}{4}$ per cent. of the bursts are between

PROBABILITIES AS APPLIED TO ARTILLERY FIRING

the burst center and graze. That is, the burst center is $1 + \frac{6}{16}$, or 1.4 (nearly) probable errors above graze. Therefore height of burst center is $1.4 \times 1.6 = 2.24$ mils. Ans.

Example 4.—A target is 60 yards in front of a ravine. If the center of impact is adjusted on the target, how many shots will fall into the ravine? $e_p = 27$ yards.

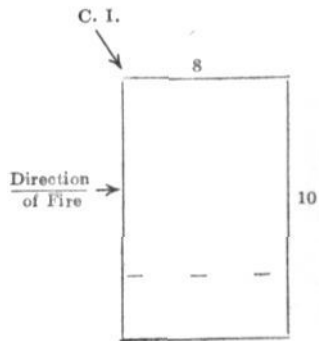


Solution.— $\frac{60}{27} = 2 \frac{2}{9}$ number of probable errors between the target and the ravine. Then $25 + 16 + \frac{2}{9} (7) = 42.6$ per cent. of shots between the target and the ravine. Hence 7.4 per cent. of the

shots will fall into the ravine.

Example 5.—A target has a width of 10 yards and a depth of 8 yards in the direction of the line of fire. Assuming the center of impact has been adjusted on the left front corner, what is the probability of a hit? Probable error for range 24 yards, for deflection 7.5 yards.

Solution.—Depth of target = $\frac{1}{3} e_p$ for range. Hence $\frac{1}{3} \times .25 = .0833$ probability of a shot correct for range. Width of target = $1 \frac{1}{3} e_p$ for deflection. Hence $.25 + \frac{1}{3} (.16) = .3033$, probability of a shot correct for deflection. Now the probability of a hit is the probability that a shot is correct for both deflection and range which (see compound event) is $.3033 \times .0833 = .025+$.



Example 6.—In example 5, assume the target to be a gun emplacement which can be demolished by 25 direct hits. With the same adjustment how many shots must be fired to completely destroy the target?

Solution.—Since the probability of a hit is .025, on the average one out of every forty shots will hit the target. Hence the number of shots required is $40 \times 25 = 1000$.

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DISPERSION DIAGRAM

	0.04	0.14	0.32	0.50	0.50	0.32	0.14	0.04	2.
	0.14	0.49	1.12	1.75	1.75	1.12	0.49	0.14	7.
	0.32	1.12	2.56	4.00	4.00	2.56	1.12	0.32	16.
Direction of Fire →	0.50	1.75	4.00	6.25	6.25	4.00	1.75	0.50	25.
	0.50	1.75	4.00	6.25	6.25	4.00	1.75	0.50	25.
	0.32	1.12	2.56	4.00	4.00	2.56	1.12	0.32	16.
	0.14	0.49	1.12	1.75	1.75	1.12	0.49	0.14	7.
	0.04	0.14	0.32	0.50	0.50	0.32	0.14	0.04	2.
	2.	7.	16.	25.	25.	16.	7.	2.	100%

The above diagram shows the dispersion pattern of a gun having the probable error in range equal to 4 times the probable error in deflection. The area enclosed by the heavy lines is called the 25 per cent. rectangle. It is the intersection of the 50 per cent. zone for range with the 50 per cent. zone for deflection.

Terrain Boards

PREPARED IN THE DEPARTMENT OF GUNNERY, SCHOOL OF FIRE FOR FIELD
ARTILLERY, BY CAPTAIN L. J. FORTIER, F.A.

AT the School of Fire at Fort Sill, Oklahoma, in order to prepare the students for service practice twenty-five hours during the ten-week course of instruction is devoted to terrain board work. There are four types of terrain boards used, known as Terrain Board A, B, C and D.

TERRAIN BOARD "A"

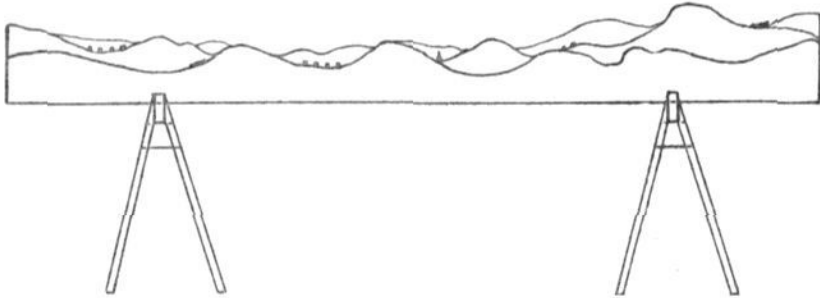
Terrain Board A is used for instruction in the principles of open warfare, axial observation, and is taken up simultaneously with the study of part 3, F.A.D.R. It consists of three planks having one edge lathed to represent terrain and so mounted on two horses that it shows a normal panorama. This terrain board is invaluable in training the officers to give commands, to think quickly in field artillery terms and by an ingenious instructor may be used to illustrate practically every principle of time fire.

The instructor designates a target and announces the tactical situation. Before announcing the data for the initial salvo the student describes the target, as to location and width in mils, states the bracket desired and the time of flight of the projectile. The student then announces his opening data and sensing the bursts shown by means of the pointer he fires through the problem until he has adjusted his deflection, distribution, height of burst and range. While the student usually estimates his shifts in deflection and distribution very well, he is apt to be careless in sensing the proper height of burst. To remedy this, the instructor should insist upon the assumption of a vertical scale.

As can be seen from the sketch the construction of terrain board A is very simple. The targets are of pasteboard cut to represent artillery, infantry, observation posts, etc., and are fastened to the board by means of thumbtacks. The pointer used

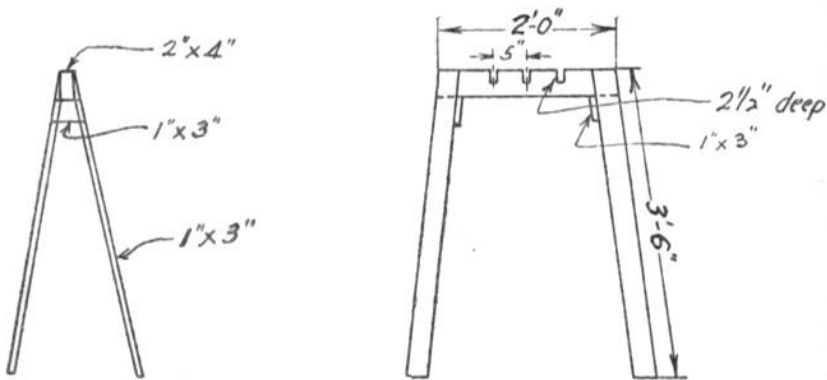
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by the instructor to represent the burst may be whittled out of wood, but care should be taken that the end be sufficiently small to allow a burst to show between two sections of artillery without



TERRAIN BOARD "A"

an overlap. A pointer twelve inches long, with a stem one-eighth inch in diameter and a tip one-quarter inch in diameter, white on one side to represent air bursts and black on the other to represent



DETAILS OF HORSE (TERRAIN BOARD "A")

graze bursts, has proven very satisfactory. The bill of lumber for the construction of this terrain board is as follows:

TERRAIN BOARDS

3 1" × 12" × 8' 0"

2 1" × 3" × 8' 0"

1 2" × 4" × 4' 0"

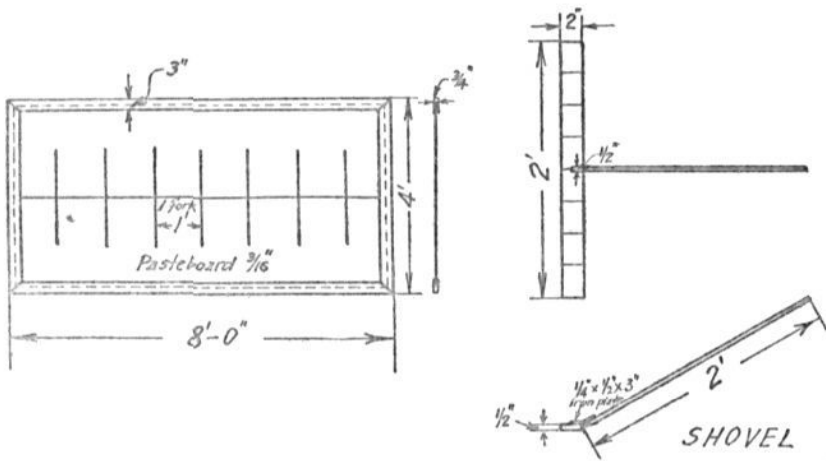
TERRAIN BOARD "B"

Terrain board B is the name applied to a board "shovel" and hitbag used to illustrate the principles of axial percussion precision fire. The board consists of a rectangular piece of pasteboard, properly framed, and pasted to the wall. In the center of the board a horizontal line is drawn which is divided at one foot intervals by vertical lines. The space between two vertical lines is used. The shovel has a two-foot blade, divided into eight strips; the entire blade representing eight probable errors or two forks or the 100 per cent. zone. The center of the blade is taken as the center of impact. One hundred numbers, ranging from one to one hundred, are marked on the top face of the blade. From the center of the blade toward the ends the four strips contain 25, 16, 7 and 2 numbers respectively. It has been found convenient to place all even numbers on the same half of the blade. The hitbag, a small box containing one hundred buttons, each bearing a different number from one to one hundred, completes terrain Board B.

In firing a problem by means of this terrain board the instructor assumes the battery to be located along the horizontal line prolonged and indicates the direction of fire. Using a thumbtack he fastens a target to the board on the horizontal line. The student announces his opening data. The instructor holds his shovel at some point along the horizontal line, and, drawing a number from the hitbag, he places a pencil opposite that number as it appears on the shovel and allows the student to sense the shot for range. The student then increases or decreases his range by the proper number of forks and gives his next command, the instructor measuring the range change with his shovel. The problem is continued to the completion of fire for improvement when the center of impact will be found to be within a probable error of the target.

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This terrain board serves its purpose of introducing the subject of trial fire and fire for improvement and illustrates graphically the necessity of verifying the short and over limit of a critical range and the value of fire for improvement in making a refined adjustment. It is particularly valuable in that it is introduced to the student immediately upon the completion of the course in field gunnery and it illustrates the practical application of probability. By means of this terrain board are brought out two situations that arise in percussion precision firing, viz., in trial fire, a



DETAILS OF TERRAIN BOARD "B"

contradiction, *i.e.*, a short and an over at the same range. And in fire for improvement the observation in the same sense of all six rounds of the first series. In a word the mechanics of axial percussion precision can be well learned without the expenditure of ammunition.

The disadvantage of this terrain board is that it affords no practice in adjusting the deflection and it gives no opportunity to learn to sense in situations where there is a slight observing angle, that is, one between twenty-five and one hundred mils.

The construction of the board and shovel are shown on sketch. An ordinary blackboard or any smooth surface may be

TERRAIN BOARDS

used equally as well as the pasteboard. The shovel can be made of lumber at negligible cost.

TERRAIN BOARD "C"

Terrain board C serves as an introduction to lateral observation. It was designed by ex-Major Torrance Fiske, formerly of the Department of Gunnery.

Referring to the photograph of the terrain board the following features are noted: At the lower central part of the board there is seen a peg representing the battery. The other three pegs represent observation posts. Along the gun target line is a slot permitting the shifting of the target from range 2800 to 6100, the scale of the board being 1" = 100 meters. Sixty-two inches from the battery there is a circular slot subtending an angle of 220 mils at the battery. It allows a deflection shift of 110 mils on either side of the G-T line. Through each 100 meters between ranges 2800 and 6100 arcs subtending an angle of 220 mils are drawn. The circular slots containing the wooden slides for the right, left and lower left observation posts are constructed with a radius of 38, 38 and 51 inches respectively. The wooden slides themselves subtend an angle of 200 mils at the right and left observation posts and of 140 mils at the lower left O.P. These wooden slides are in turn slotted to permit the travel of a small lead slider. Strings are fastened to the center of all wood and lead sliders. A portion of each string is of elastic, at the end of which is fastened a metal eye through which the string is pegged to the board. A small wooden disc slides along the battery string to represent the burst.

The adjustment of a battery with lateral observation is divided into three steps: First, preparation fire, or fire to get on the observer target line; second, trial fire, or fire to get a deflection bracket of 16 mils or less and a verified range bracket of one fork or less; third, fire for improvement or fire to get a refined adjustment by firing four series of three rounds. In

introducing the theory of lateral observation the Department of Gunnery first takes up the subject on the assumption that the battery commander is supplied with map data. The fork, the lateral fork Phi and the angle Omega subtended at the O.P. by the fork are all explained. The average student who has difficulty in understanding the ratios F/Ω , Φ/Ω , and Φ/F can be shown by means of this terrain board the shift at the guns based on an observation at the O.P.*

To teach the student the mechanical process of finding Phi and Omega a problem of this kind may be used.

Rn 4500 meters O.P. on left, observing angle 920 mils. Distance O-T 2450. Assume that the French 75 mm. gun is used with H.E. Shell, short fuze, normal charge. The fork is practically 100 meters.

First peg down the string running to the battery and the two strings to the left O.P. Slide the target to 4500. Place center of wooden slider so that it is on line with the observer and target. Swing the lead slider to the right until it intersects the gun target line at Range 4300. The scale on the wooden slider then reads 66 mils right. Now swing the lead slider to the left until it cuts the G-T line at range 4700. The scale then reads 60 mils left. The total angle is $66 + 60$ or 126 mils. Omega is therefore $126/4 = 32$ mils.

Now swing the lead slider of the battery to the right until its string intersects the O-T line at Range 4700. Read the battery scale and it gives 53 mils right. Then swing the same lead slider to the left until it intersects the OT line at Range 4300. The battery scale then reads 59 mils left. The total shift at the battery to stay on the OT line for a range change of four forks is $53 + 59 = 112$ mils. Phi is therefore $112/4 = 28$ mils.

In the case where no map is available and neither the GT and OT distances, nor the observing angle are known, the factors F/Ω and Φ/F must be established by firing a problem of this kind which may serve as an illustration. The student announces

* [See article on Principles of Lateral Observation in this number.—EDITOR.]

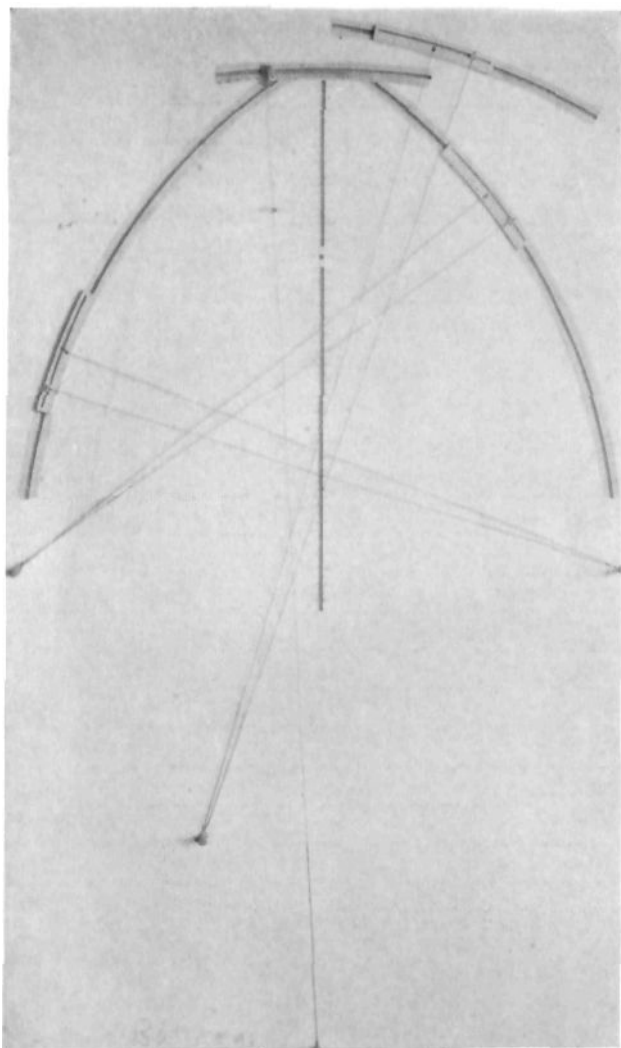


PHOTO 1
TERRAIN BOARD "c"

TERRAIN BOARDS

the following data: Base deflection No. 1 left 20; Nos. 2, 3 and 4 will not follow. Site 0, H.E. Shell, Normal charge, Short Fuze, No. 1 only 2 Rounds 5000. He takes his O.P. on left and estimates his observing angle to be between 300 and 800 mils; that is, he assumes a Phi of 16 mils. His fork is 100 meters. The instructor shifts the battery lead slider to a point sixty mils left of the G-T line. He slides the target to 5000. The wooden slider of the O.P. is shifted until its center or zero is on the O-T line. The disc is now brought to the 5000 arc. The lead slider on the O.P. scale is swung so that its string may intersect the disc or burst. The instructor reads 80 mils left on the O.P. wooden scale and announces this reading to the battery commander. His next command is 4800. Having lowered the disc to this range 4800, the O.P. lead slider is again shifted and a reading of 25 left is announced. Eighty mils - 25 mils = 55 mils. A change of 200 yards subtended an angle of 55 mils F/Omega is therefore $200/55 = 3.5$ meters. The next command is therefore $4800 - 125 \times 3.5$ equals 4700. This gives a line short. The next command is Right 32, 4900. This gives 10 left. The next command is 4900 - (10×3.5) or 4875. This gives a line short. In shifting 32 mils in deflection the range had to be increased 175 meters to stay on the OT line.

$$\frac{32}{176} \therefore \frac{\text{Phi}}{100} \text{ or Phi} = 18$$

Terrain board C is also useful in illustrating this situation. Assume the O.P. on the left. If two rounds at 5000 are sensed line short and 5 Right, then both observations are short in range. If the sensings had been line short and 5 left, then one observation is short in range and the other is doubtful.

Besides introducing the subject of lateral observation this board may also serve to illustrate the principles of combined flank and bilateral observation.

The principal objection to the board is the fact that it allows no dispersion, consequently neither fire for improvement nor the necessity of firing two rounds to get a line observation can

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be shown. Its use is therefore confined to the teaching of the elementary principles. Furthermore, the problems work out so much more accurately than they actually do in service firing, that this is apt to be misleading.

The following information is valuable to anyone desiring to use the board:

Scale of board 1" = 100 meters	
Coördinates (Approximately)	
Gun Position	x 26,000 y 92,200
Right O.P.	x 27,950 y 95,200
Left Upper O.P.	x 24,050 y 95,200
Lower O.P.	x 25,300 y 93,550

With the target in various positions its coördinates can be calculated from the known gun positions.

Size of observing angle for the Right and Left O.P.

Rn.	Observing angle.	Rn.	Observing angle.
5200	730 mils.	4000	1110 mils.
5000	780 "	3500	1330 "
4500	920 "		

From the lower left O.P.

5000	190 "	3500	315 "
4500	220 "	3000	400 "
4000	260 "		

The construction of the board is rather complicated, as may be seen from the photograph. The board is made of $\frac{1}{2}$ " planking, four feet wide and six feet long, and is framed with $1\frac{1}{4}$ " \times $3\frac{1}{2}$ " lumber. The slots are $\frac{3}{8}$ " wide \times $\frac{1}{4}$ " deep. One-half inch strips are inlaid to form the slots. Three 2 " \times 2 " \times 4 '0" nailed to the back of the board serve as braces and prevent warping. The cost of the board is \$26.

TERRAIN BOARDS

TERRAIN BOARD "D"

By means of Terrain board "D" the principles and practice of axial, lateral, combined, bilateral and flank observation may be studied. This terrain board was designed by Colonel Odell, Field Artillery.

A study of the photograph and sketches gives one a clear idea of the construction of this terrain board. It consists of a table containing sufficient sand to permit the formation of a normal terrain. A stationary framework supported at the four corners of the table supports another frame which can be moved over the terrain in the direction of range. This movable frame is slotted to receive the ends of the range dispersion scale, thereby permitting deflection shifts. The terrain board provides no scale for deflection but dispersion in deflection is accomplished in dropping the pegs in dispersion scale.

The room in which stands the terrain board is laid out on a grid system, the scale of which is 1 cm. = 5 meters. The terrain board is placed in such a manner that its center is at coördinates $x = 25,000$; $y = 24,000$ and the battery is assumed to be at $x = 25,000$; $y = 20,000$. The range therefore from the battery to the center of the terrain board is 4000 meters. The terrain board permits firing at ranges varying from 3400 to 4600. The range scale is cut into the top face of the stationary framework on both sides of the table; ranging in meters from 3400 to 4600 and in degrees and minutes from $6^{\circ} 23'$ to $10^{\circ} 31'$, the latter being the corresponding elevations for the French 75 mm. gun, using explosive shell, short fuze, normal charge. The deflection scale which is marked on the top face of the movable frame is computed for a range of 4000 meters. The errors in the deflection scale at ranges other than 4000 meters are not great enough to prevent the practical working of the board. It allows a total deflection shift of 180 mils; that is, 90 mils on either side of zero. Dispersion in range is laid out on a scale corresponding to the aforementioned data of the French 75 mm. gun at 4000 meters and has a total length of 180 meters or 2

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forks. There are seven pegs representing the dispersion scale. The center peg is at the center of the 50 per cent. zone, the others being 1 probable error apart. These pegs are marked -3, -2, -1, 0, +1, +2, and +3. In the hitbag there are the following buttons: five -3s, eleven -2s, twenty -1s, twenty-five zeros, twenty +1s, eleven +2s and five +3s.

This terrain board is used principally in lateral observation and due to its dispersion scale serves to illustrate nearly every phase of this type of adjustment. In firing a problem the normal procedure is as follows: The battery commander stands in any part of the room and locates himself by means of the grid system. He estimates or computes his O-T distance and his observing angle. A target having been indicated to the battery commander, he estimates the shift of his battery from the base-point. One student writes the commands of the battery commander on a blackboard, another handles the hitbag, while the instructor often handles the dispersion scale. The battery commander having announced his Phi, Omega, fork, etc., gives this command "Base deflection No. 1 left 50, Nos. 2, 3 and 4 will not follow, site 0, explosive shell, short fuze, normal charge, No. 1 only, 2 rounds $8^{\circ} 20''$ ". The instructor moves the frame to the elevation called for and shifts the dispersion scale to a point 50 mils left of zero. A button is drawn from the hitbag and the peg corresponding is then dropped. The B.C. reads the deviation of the round with the B.C. ruler. The button is returned to the hitbag and another is drawn. The peg called for by the button is dropped and the deviation is again read. The battery commander bases his range or deflection change on the mean of the two readings and announces his next command. The problem is continued, all commands being recorded, and after the completion of fire for improvement a critique is held. The accuracy of the board is proven by the fact that the adjusted range is practically always within the probable error.

This terrain board has proven invaluable with instruction of terrestrial observation. With the dispersion scale it illustrates the results which are usually obtained in service firing. Its terrain

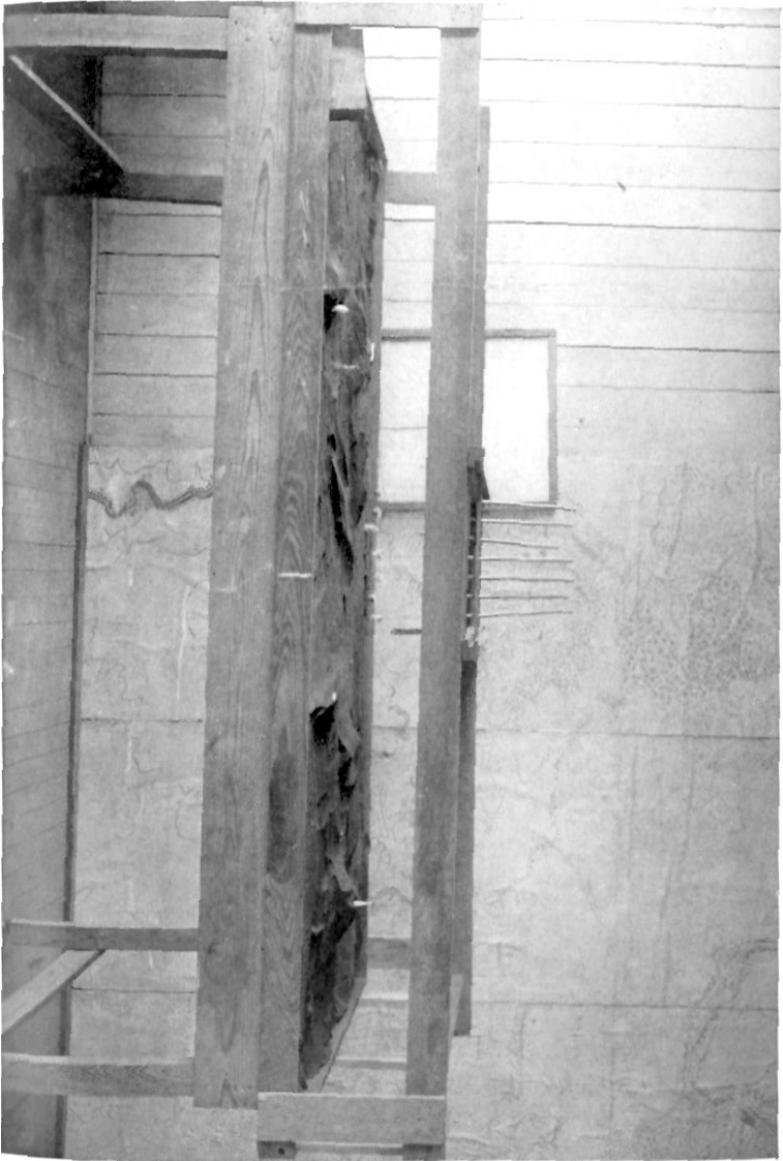
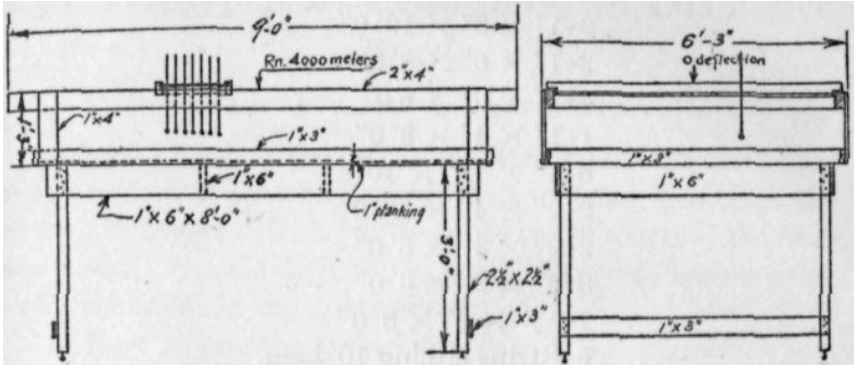


PHOTO 2.
TERRAIN BOARD "D," SIDE VIEW

TERRAIN BOARDS

may be used for practice in terrain sensing. Practically every type of percussion precision problem may be fired with satisfactory results. While the board herein described is laid out for firing the



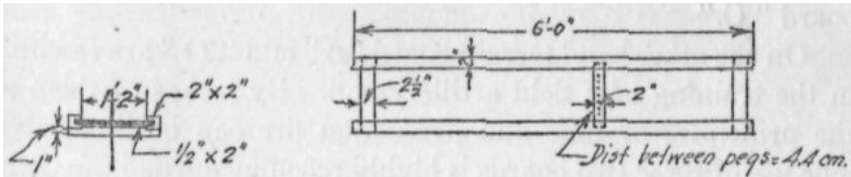
SIDE VIEW

END

DETAILS OF TERRAIN BOARD "D"

French 75 mm. it is possible to adapt to it a scale for any gun.

The only objection to this terrain board as now used at the School of Fire is the fact that it is too bulky and that it requires



END VIEW

PLAN

DETAILS OF MOVABLE FRAME

(TERRAIN BOARD "D")

too large a class-room for its operation. It would be advisable to construct the board much smaller so that it might be used in the ordinary section rooms with the advantage that each student would fire more problems.

The dimensions of the board and details of construction are shown with sketch.

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The bill of lumber is as follows:

2-2½" × 2½" × 6'0"

4-1" × 3" × 6' 0"

2-1" × 3" × 10' 0"

2-1" × 6" × 8' 0"

4-1" × 6" × 6'0"

1-1" × 4" × 8' 0"

6-1" × 12" × 10' 0"

2-2" × 4" × 10' 0"

2-2" × 4" × 6' 0"

3-2" × 2" × 6' 0"

1-½" × 2" × 3' 0"

6-Strips lathing 10' long.

CONCLUSION

Terrain Boards "B" and "C" serve their purpose of illustrating fundamental principles but both of these can be substituted. Several substitutes for terrain board "B" will readily occur to any instructor. A neat sketch on the blackboard with clear explanations is an excellent substitute for terrain board "C."

On the other hand terrain board "A" and "D" are essential in the training of a field artilleryman. By means of them all the principles of time and percussion fire can be illustrated. The use of these two boards is highly recommended.

The Principles of Command in Defensive Battle

TRANSLATION OF A GERMAN DOCUMENT OF SEPTEMBER 29, 1918

A NEW edition of Part 8 of the "Manual of Position Warfare," revised in accordance with the experience gained in the present defensive battles, will be issued in the course of the next few weeks. Special attention is invited to the following principles contained in the new manual:

1. Part 8 contains *principles and definitions which are binding*, but leaves sufficient latitude for *local variations* from them. The underlying idea was that special tactics in each Army Group, Army or Corps are not practicable, especially when the frequent transfers of troops are taken into consideration. A uniform basis had to be established, which should obviate as far as possible the necessity for orders regarding the theory of tactics being issued by subordinate commanders, which, unfortunately, they frequently have a habit of doing. Whenever special instructions amplifying the general manual are issued, they should be confined to the particular case in point and should, as far as possible, be reserved for formations which are permanent organizations (divisions and regiments). Regulations and orders should never be taken *literally*; a *broad interpretation* should be placed on them.

2. For success in *battle, discipline and organization*, not numbers, are decisive. The principal object of the Higher Command must, therefore, be to raise the moral value of the troops. This is effected by sympathetic examination of their reasonable requests.

Self-reliance, independence of action and willingness to accept responsibility must be fostered to a greater extent than hitherto; supervision must be exercised in a more trustful spirit,

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more by personal enquiry on the spot and less by generalizations in the form of written results of experience, remarks on visits of inspection, sketches, orders, special and routine reports, and instruction. Mistrust represses sense of duty and mutual understanding between the Higher Command and the troops, trust strengthens and increases them.

3. The Higher Command must be more patient, must have more regard for considerations of time and space, must assign battle tasks on broad lines instead of giving orders on matters of detail. These last should be left to the responsible subordinate commander concerned.

4. Liaison between the various arms is of decisive importance. Only artillery well provided with information can fire properly from a tactical point of view; only airmen who know the requirements of the artillery will assist this arm properly, etc. The various arms must be brought into close personal contact in the lower formations. Independent channels for the various arms with regard to tactical matters short-circuiting the divisions must be forbidden.

5. Preparations to meet various contingencies must be limited to what is useful, and orders to meet such contingencies must be avoided more than has hitherto been the case. At critical moments, commanders must act as seems best at the time; preconceived ideas are harmful. Paper work and the excessive number of sketches and reports must be reduced.

6. The greatest importance must be attached to the construction of positions, and the use of spade and wire.

The selection of a position is dependent on artillery observation, by which the ground in front of and behind the main line of resistance must be watched. This generally entails a reverse slope position. The possession of high ground is not of so great importance for the infantry defense.

More stress is laid on the necessity for the artillery machine guns being utilized to form a machine-gun zone in the battery area, and for the battery positions to form holding-on points for the infantry, which must be held at all costs and where the

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infantry must consequently stand in all circumstances. Everyone must know that infantry (machine-gun) ammunition is stored in them, *that the guns will fight to the last and that their fire over open sights forms an extraordinarily effective support to the infantry.*

7. The greatest importance is attached to the offensive action of all arms. The enemy must be surprised and deceived by the measures taken by the defender. The troops must be convinced on this point and must be induced to cooperate on their own initiative. Orders alone are not sufficient. Special emphasis is laid on the engagement of the enemy during his deployment for the attack, particularly in increased artillery fire at the proper moment.

8. Distribution in depth, which is undoubtedly of very great importance, must not be exaggerated either in the case of the infantry or the artillery.

There must always be a certain amount of cohesion in the infantry. When fighting strengths are low, this may necessitate concentrating towards the main line of resistance, though the formation must always retain a certain amount of depth as a protection against envelopment and attack from the flanks.

The mass of the artillery must always be ready to afford protection to the infantry by its fire. Excessive dispersion by distributing it into many isolated sections and single guns must be avoided. The manner which this can, in individual cases, be reconciled with the distribution in depth, which is essential, and with the necessary mobility, cannot generally be laid down in orders.

9. The organization of the infantry into first line, support and reserve battalions has become too rigid. Frequently it is better to dispose the infantry with two battalions in front and one in rear. The front line battalions are then better able to effect distribution in depth. It involves less change and consequently makes for increased output both in fighting and work. Details should, as a rule, be left to the regimental commander.

10. An outpost zone cannot be insisted upon everywhere,

although its advantages—possibility of giving warning, splitting up the attack, deception and elasticity in meeting the attack, security against surprise and envelopment—rarely make it appear sound to forego entirely the use of any kind of outpost zone. Its disadvantages lie in the danger of splitting up the infantry defense and in the difficulty of providing artillery support.

The details of the organization of the outpost zone and of the method of fighting in it cannot be laid down by higher orders.

It may be taken as a general guide, however, that the depth of the outpost zone should normally be from at least 100 yards to over 1100 yards. When the outpost zone is deeper, special rearguards must be detailed in certain circumstances.

The outpost zone must be occupied and defended like an outpost position, and must consequently be evacuated when seriously attacked. On the other hand, the main line of resistance must be fought for decisively. This must be absolutely clear. Details must be left to the commander on the spot, who will be given a clear and simple battle task.

11. This last also applies particularly as regards the engagement of the reserves, who will either counter-attack or hold the attacker to his ground. It is just as wrong to issue orders that a counter-stroke or a methodical counter-attack will be made on principle, as it is to abstain, on principle, from counter-attacking. Counter-strokes which are made too late fail just as hasty, insufficiently prepared methodical counter-attacks. Both are very grave errors in command.

Even in the minor operations of the infantry fighting, it is going too far to insist on an automatic counter-stroke in all circumstances. It should only be carried out when there is a prospect of success.

12. In the infantry fighting, good, aimed fire and boldly coming to grips with the enemy are the main factors. Waste of ammunition can and must be combatted by proper fire discipline. The counter-stroke requires infantry and, whenever

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possible, artillery fire support. This is still too frequently overlooked.

13. As regards artillery, bursts of concentrated fire are emphasized. We are in a position to carry this out with the assistance of good survey work and calculations (error of the day, meteorological reports), if the material is kept in good order.

Artillery must fire a good deal, especially before a hostile attack. Time must, however, be given for making the necessary arrangements, for rest, and for keeping the detachments fit and the matériel in good order. Only under such conditions will artillery do accurate shooting. And accurate shooting is more important than firing a large number of rounds.

The most important targets are living targets and fleeting targets. The importance of and necessity for good observation is strongly emphasized.

Automatic, unobserved fire, delivered in response to signals from the infantry, cannot be dispensed with. This fire, however, cannot be put down rigidly and without any gaps in front of our infantry, as the former barrage fire was; it must be concentrated on those areas in which the enemy actually is at the time of delivering the fire. The ground swept by fire must, consequently, be varied according to the probable action of the enemy. The preparations for and the delivery of this fire must not, however, make excessive demands on the detachments, matériel or ammunition of the artillery. Offensive fire which is opened at the proper tactical moment by a definite order, and is accurate and observed, is of more value to the infantry.

14. The new manual contains no new principles as regards anti-tank defense. The existing ones are sufficient provided they are properly applied. The engagement of tanks is principally a matter of nerves.

15. The infantry and the artillery must be made better acquainted with the functions of the air forces (cf. par. 4), in order to secure the full utilization of our own air forces in the battle, and to facilitate the engagement of those of the enemy.

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This is especially the case as regards artillery observation airplanes, artillery patrol airplanes, and the anti-aircraft guns.

The increased extent to which the enemy's low-flying airplanes molest us has necessitated more emphasis being laid on their engagement from the ground by means of machine guns. In this matter, better results can and must be obtained.

(Signed) LUDENDORFF.

COMMENTS

1. In the above memorandum referring to a new edition of "The Principles of Command in the Defensive Battle" which was about to be issued, Ludendorff touches upon the main points of difference in the new manual.

2. He has a good deal to say regarding the attitude of the Higher Command, implying that they do not trust their subordinates sufficiently, do not sufficiently exert their personal influence, but rely on issuing written matter. The Higher Commanders are also taken to task for interfering in details and for not always considering the question of time and space; they are enjoined to limit the number of schemes to meet various contingencies and to reduce paper work generally.

3. The idea of the artillery machine guns forming a definite machine gun zone is new (see par. 6). This paragraph appears to have been prompted by the heavy losses in artillery suffered by the enemy owing to the infantry having failed to stand when driven back to the artillery protective line.

4. Deception is twice definitely referred to as a necessary factor of defensive tactics (see par. 7 and 10).

5. Rigid adherence to the method of holding a regimental sector with the three battalions one behind the other is condemned. It may frequently be better to have two battalions in front and one in reserve.

6. As regards the outpost zone, Ludendorff now definitely states that it may not always be necessary, and he now advocates a much shallower zone, viz., 100 to 1100 yards as compared

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with 1100 to 3300 yards advocated in his memorandum of August 8, 1918.

7. Automatic arrangements for delivering counter-attacks, both large and small, are deprecated.

8. The abolition of the artillery barrage in defense is again referred to, its place being taken by bursts of concentrated fire on actual living targets.

9. No new principles regarding anti-tank defense are enunciated.

10. The action of our low-flying airplanes has evidently had considerable effect, and the necessity for better results when engaging them by machine guns from the ground is pointed out.

CURRENT FIELD ARTILLERY NOTES

Equitation and Care of Horses

BY COLONEL LEROY P. COLLINS, FIELD ARTILLERY U.S. ARMY

THE army is now returning to conditions of peace time training and already the field artillery has its plan drawn up and under materialization for its part in the making of an efficient army for future needs. The lessons learned by us as field artillerymen in this war are many, but when resolved into concrete terms by complete analysis they appear to show that the ideas embodied in our Drill and Service Regulations of 1916 are the correct ones and that the changes necessitated are an amplification of details to meet new conditions rather than a change in principles as already laid down. This applies to all phases of artillery work—maneuvering of units, with the necessary knowledge of the care of the motive power, whether it be horse or tractor, as well as methods of fire.

It is the present intention to instruct officers in draft and riding at Fort Sill during the year's course which all field artillery officers must take, and to have this instruction so complete that officers graduating from this school will be able to act as regimental and battery instructors when they return to their organizations. But this is not enough—it is essential that only such officers be assigned to duty with horse-drawn regiments as are specially qualified for such duty in that they are horsemen bred, with a love of horses and an ability to work with them, which are only secondary to their likes and abilities in getting the maximum use of their guns in action.

It appears to be a fact testified to by all officers having knowledge of conditions abroad and at home that, due to the speed necessary in organization and training, instruction in riding and care of horses was sacrificed to instruction in conduct of fire, and even the latter was so influenced by trench warfare

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conditions that the qualifications of officers in this respect were lacking in essentials. This condition would probably not have existed to the extent it did had the time been available to train our regiments according to pre-war programs. And yet the presence of many senior officers of coast artillery and other arms in our midst coupled with the ever present field artillery officer who minimizes the need of any systematic instruction in riding, driving, and care of horses assisted very much the lack of time in giving a lack of results. Cases have come to notice of the inability of drivers to get even fair draft work out of their teams in regiments at the front, of the inability of officers to correct or instruct their men. A case is reported where an American battery serving with French troops got stuck in the mud. The drivers were powerless and even the example of one of the battery officers who picked up a club and beat some of the horses with it was not effective. Finally French drivers took the guns out.

The Reconnaissance Course at the School of Fire at Fort Sill has shown to a marked degree how sad but true it is that a poor horseman naturally devotes all his thoughts to the business of staying more or less gracefully on his horse's back, with the consequence that the possibilities for the use of his guns in the country he is traversing, the tactical and technical consideration of his mission, and other ideas which should occupy his thoughts, are as a closed book so that he doesn't begin to think until he gets on the ground again and even these thoughts are rather ruffled. Like the high cost of living it works in a circle, this particular kind of officer refusing to get on a horse unless he has to. The result is a lessening of mobility of the unit. The writer has seen a colonel of field (light) artillery (he is one no more and was not one before the war) just naturally fall off his horse at a trot after ineffectual efforts to choke his horse to death. Another, a lieutenant-colonel, who was not mounted before the war, after messing up a problem, gave as his excuse at the critique that he was in the coast artillery. These are not

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rare cases. Of what value is such an officer in horsed artillery? Perhaps you will say that colonels in France always rode in motor cars or on motorcycles. Perhaps this is one reason why they did, and it would be a calamity if the gas gave out.

Added to these disadvantages under which our artillery had to work in France were dirty billeting stables, epidemics of lice and mange and scratches caused by mud. It is evident that nothing short of a thorough knowledge of horse ailments including their prevention and cure will suffice for an officer of field artillery if his command is to be on its toes all the time, ready for instant and constant service.

What can we do to correct these conditions and prevent their recurrence?

First: Assign to light artillery only those officers who are adapted to such service. In peace time, due to transfers in the arm, it would be desirable if every field artillery officer were picked with this in view. Those assigned to motorized regiments should be attached to light regiments for periods of their service and the prohibition against officers of motorized regiments owning mounts should be removed. Reserve officers should be listed as qualified for heavy or light field artillery. When they are called to active duty due regard should be had to suitability for assignment. Encouragement should be given to have officers own and ride high-class suitable mounts.

Second: Detail to the Mounted Service School only such officers as are reasonably certain of graduating creditably and keep the full quota there allowed by existing regulations. The graduates of the First Year Course should be used as regimental instructors and should be given every encouragement and reasonable assistance by their commanding officers. These officers are also qualified to instruct classes for stable sergeants, farriers and horseshoers working in coöperation with the veterinarians in this. The officers who show superior qualifications in equitation by being retained at the Mounted Service School for the Second Year Course should be made use of as instructors at our special schools at Fort Sill, Camp Taylor and Camp

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Bragg. In this way we can be assured that our methods will be the best in existence and uniform with those obtaining in the cavalry.

Third: In addition to this we must have at these special field artillery schools real courses in draft so thorough that graduates of these courses will be draft experts. This is a subject which has always been neglected by the ordinary field artillery officer and its application left to the few who were interested enough to make experts of themselves. Probably our drill regulations could be improved in this respect, and the right men are available to do it. The instructors in equitation would naturally be the ones to instruct in draft after themselves being made experts. This subject should not be confined to instruction of the men but should include systematic exercises for the horse continued over a sufficiently long period to assure highly trained saddle and draft horses.

Finally: There must be a recognition with us that matters pertaining to the horse have not had the attention in the past which they merit and there must be the determination to see that this criticism will never apply in the future. The tendency is to eliminate the horse in favor of the motor, but the facts of the war show that the net result is to *confine* his use but to *assure* it within these limits. If the time ever comes when we can get along in the field artillery without the horse, then, and not until then, will it be time enough to cease to treat him with the wise consideration commensurate with the help we expect from him.

Action of the Artillery in Battle

TRANSLATION OF A GERMAN DOCUMENT

1. Artillery can never be too *mobile*. It must therefore be kept fresh. With this object, each division must arrange that the batteries, in the same way as the infantry battalions, etc., are withdrawn in turn from their positions and billeted well behind them. A portion of this artillery should be kept in instant readiness at the disposal of the division. Thus, in conjunction with the resting infantry, mixed detachments can be

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formed within a division in the line, and will be immediately available in case of a surprise attack.

2. Artillery must be distributed in *depth* like the infantry. This, too, cannot be overdone.

3. In *ordinary trench warfare*, a portion of the artillery (in addition to anti-tank and close-range guns) must be pushed well forward, in certain circumstances even in front of the main line of resistance in order to be able to engage the hostile artillery, which is also deployed far back, and to open harassing fire on important enemy organizations, such as roads, railways and signal communications, billets, fleeting targets, etc. This does not require a large number of batteries, but careful preparations, the use of every favorable opportunity for observation, quick decision and full utilization of the rapid fire of our guns.

The mass of the artillery, distributed in considerable depth, is deployed farther back, in such a way that it can engage the enemy's advanced batteries and open annihilating fire on surprise attacks in our own outpost zone in front of the main line of resistance, and, above all, can engage the enemy even after he has broken through.

The siting and distribution in depth of *anti-tank and close-range guns* will depend on the nature of the ground and the special task of each gun. These guns must remain silent until required for their own particular task, *i.e.*, until the enemy's attack is launched.

4. *If a hostile attack on a large scale is imminent—i.e.*, if the enemy reinforces his artillery and pushes it forward—we must, if we do not succeed in decisively frustrating the hostile preparations, withdraw our artillery as far as the necessity for supporting the action of our own infantry permits. Thus a withdrawal and at the same time a further extension in depth will take place. This is necessary in order that we may be able, even with inferior artillery, to maintain our fighting strength to resist an attack on a large scale.

The mobile employment of artillery makes it necessary to have a large number of battery positions fixed by survey, and

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supplied with ammunition, and distributed over a considerable depth.

5. With reference to the action of the artillery in battle, mention must be made of the following points, in addition to those already touched on:

(a) In quiet periods and before an offensive the chief task is *counter-battery work* with a view to destroying personnel, matériel, means of observation, ammunition, etc. It must be repeatedly emphasized that this procedure has always led to good results when it is carried out energetically and after careful consideration. We must also remember that the *hostile artillery is the most dangerous enemy of our infantry*, and also that the hostile infantry is very reluctant to advance to the assault without *strong artillery support*.

(b) Other important targets must not, of course, be neglected.

(c) *If a hostile attack on a large scale is imminent*, timely gas shelling (yellow cross) of the artillery and the most important points in assembly zones of the infantry can decisively weaken an attack.

(d) *When a hostile attack on a large scale has been launched*, the best method at first is to open a short, sharp *burst of fire* from all batteries—except close-range and similar guns—against the hostile artillery and approach zones, in order to cut the enemy's communications. After this, the most important task in the ensuing defensive battle is again counter-battery work. This should consist in a very heavy bombardment of those batteries which are most dangerous for our infantry, and especially, therefore, of those batteries which accompany the hostile infantry.

(e) As far as direct observation permits, the artillery must support the *defense of the outpost zone* by engaging the first waves of the attacking infantry, together with their accompanying artillery and tanks. To those batteries which have no means of direct observation and no special tasks individual *zones for annihilating fire* must be allotted, upon which they

will then direct their fire. According to the depth of penetration by the enemy they will shorten their fire toward the main line of resistance. In any case, heavy annihilating fire must be put down in front of our main line of resistance, by the time the enemy reaches it. A *systematic* withdrawal of the outpost garrison will facilitate this task of the artillery.

Special measures must be taken to control this annihilating fire in case of poor visibility (fog, night).

(f) Even during the further course of the hostile attack the task of the mass of the artillery still consists in carefully considered *annihilating fire* directed against all targets which are recognized or presumed with a fair degree of certainty (advancing hostile infantry or artillery, reserves which have been assembled, routes of approach crowded with troops, etc.). The above-mentioned distribution of the artillery in depth in areas which lie comparatively far back is the best means of enabling the artillery to support the infantry properly and with certainty.

(g) A part of each battery must, in addition to the close-range and anti-tank guns, be detailed exclusively to engage the enemy after he has broken through.

(h) Careful organization of *observation* is specially necessary. Observation must not only include the ground in and in front of the outpost zone, but also the whole of the ground comprised in the defended zone (and this should be possible from a point near the battery), in order that the enemy can be engaged with direct observation or even with direct laying after he has broken through.

(i) All batteries must be perfectly clear as to their tasks and must make use of all auxiliary measures (*e. g.*, aeroplane and field survey observation, firing from positions fixed by survey, with due allowance for error of the day, etc.). Ground observation alone is not sufficient. The necessary auxiliary means of observation must be *placed directly under the orders of the artillery*.

(k) A rigid scheme of artillery defense by means of *barrage*

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fire must be discarded. It has no effect, the fire is very seldom accurate, is too thin, is usually opened too late, uses up a large quantity of ammunition, and is a considerable danger to the infantry in mobile warfare. Barrage fire must, in any case, be absolutely forbidden in ordinary trench warfare. It must be replaced by properly combined (*zusammengefasste*) annihilating fire.

(1) This so-called *combined fire* is particularly effective; but care must be taken when employing such combined fire during a *battle*, since the data are often insufficient and the passing of orders is very uncertain. The technical difficulties of execution and control often lead, in this case, to the bombardment of our own infantry, which is thus more often hampered than helped in mobile warfare. Long-range batteries firing at extreme range are specially dangerous for our own infantry, since in this case they frequently shoot much shorter than is expected.

Strict orders alone cannot cure this. In certain cases, they would only lead to batteries firing aimlessly in order to avoid reprimand (*e.g.*, for being idle, or for firing on our own infantry). Thus combined fire very often only exists on paper. *It is better to fire little and well than much and badly.*

(m) In this connection, there exists a certain "*gun-mania*" (*Rohrfanatismus*)—*i.e.*, the endeavor to have as many guns in position as possible. This is also wrong, not so much on account of the difficulties of ammunition supply, which can usually be overcome, as out of consideration for command, matériel and personnel. Too many batteries, with insufficient ammunition, render command difficult. Matériel which is not kept in proper repair and thoroughly tested from time to time (for loss of muzzle velocity), and officers and men who are insufficiently trained or are over-tired, tend to poor shooting. Thus the artillery must be given time for testing its matériel and for training and resting its personnel. It is the duty of the higher commanders to see that this relief is allotted equally to divisional and army artillery (both light and heavy).

Artillery Fire of Protection

EXTRACTS FROM A GERMAN DOCUMENT

XVIIIth Army.

The systematic defense by means of barrage fire, in effect until now in case of a hostile attack, will hereafter be forbidden in ordinary position warfare, in conformity with instructions of the Chief of the General Staff of the Field Army, August 8, 1918. *Barrage fire is replaced by concentrations of fire of destruction.*

These automatic bursts of fire of destruction opened on the appearance of light signals, and carried out without the aid of observers (*Feuerschutz*) are directed at first in front of the first outpost line, on the presumed concentration points (trenches, ravines, woods and ruined villages). The selection of artillery targets will vary according to the reports received on the distribution of the enemy. If the areas to be fired on are considerable in extent or depth, and if it is necessary to assign a larger target to each battery, *because of our insufficient proportion of artillery*, we will have to see that by changing the laying of the guns in elevation and direction the entire sector is covered by our fire.

If one single salvo is not sufficient to cover all of the objectives, it will be well to fire a second salvo, at the same time changing the objective. In that event, the order in which the successive objectives are covered will not always remain the same.

The field howitzers generally take part in this fire. The participation of the mortars is possible only by special order. When heavy flat trajectory artillery must coöperate, it is necessary to use it in flanking fire as much as possible.

To fix the intervals of fire, *it must be considered that many batteries have but three pieces, one of which we know by experience, is often out of order*, and that, on the other hand, the rapidity of fire, varying according to the number of cannoneers and the nature of the emplacement, is very different in various

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batteries. It is furthermore recommended that in determining the salvos, the number of shots to be fired and not the rate of fire, be specified.

When the enemy has penetrated the outpost zone, the fire of destruction directed against him must be carried out with observation. If, however, the enemy attacks under cover of darkness or fog, or if the batteries have no view of the outpost zone, the fire directed in front of that zone will be automatically shortened to in front of the main line of resistance, on a front varying according to local conditions, and increased fire in places where the attack is most probable. This fire of destruction, for which only general calculations have been made, will then be governed more accurately by observation.

Instructions, carefully studied, are necessary for governing the shortening of the range, for errors or misunderstandings can be deadly to the infantry. It is necessary to define exactly who is in charge and has authority to shorten the range to in front of the main line of resistance and whether it is necessary to give an order to that effect, or send up rocket signals. It is most important that the fire with shortened range arrive on time in front of the main line of resistance. An order will arrive too late especially if the outpost zone is not deep, as is the general rule, *in view of our small number of effectives*. If then it is necessary to shorten the range by an order, transmitted by telephone, ground telegraphy, radio or visual signals, with the exact indication of the sector, and through the intermediary of directing batteries, it is not less true that it will be necessary to have recourse to light signals to assure the shortening of the range.

In any case, the decision must be known definitely to the infantry and to the artillery. It will be necessary also, that the artillery know exactly the position of the front line, and that it be always notified, accurately and at once, of every change in the line.

If the enemy advances into our lines, the range will not be

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shortened further on signals only, but only after observation by the batteries, or on an order.

The weaker our artillery is, the more important it is, in case of a local attack by the enemy, that the neighboring sectors carry out supporting fire (*Unterstützungsfeuer*) in front of the sector attacked.

If the supporting fire is opened on an order, it will usually come too late. It is necessary also that the neighbor who is not being attacked start his supporting fire as soon as he sees the signal rocket for automatically bringing down the barrage, and that he open fire as rapidly and as accurately as if he were firing on the zones assigned to him for fire of destruction in his own sector.

The fire of destruction on an order (this is not a question of fire opened automatically at a signal given) must be capable of changing easily and meeting quickly each new situation. The artillery commander will be prepared, by giving an order to open concentrated fire of destruction on the important positions, for preparation or for attack, whether they are situated in advanced terrain, or in the outpost zone.

The divisions have made different dispositions for this mobile fire of destruction. They have generally, however, adopted the following method: Each of the zones of action designated by numbers, receives the fire of a certain number of batteries assigned to that mission, which fire either simultaneously or successively.

The Army Command draws attention to the following points: (1) The zones as determined depend on the activity of the enemy and are consequently subject to variations; (2) the order adopted for covering the zones with fire must not always be the same; and (3) the intervals left between the zones must be subjected to harassing fire, so as to deprive the enemy of all possibility of avoiding our fire.

Commanding General of the Army,
(Signed) VON HUTIER.

NOTE.—The above document contains interesting admissions of weakness in artillery and effectiveness in the clauses italicized.

THE MIL SCALE

LIEUTENANT-COLONEL IVENS JONES, FIELD ARTILLERY, U. S. ARMY
(ASSOCIATE PROFESSOR OF MATHEMATICS U. S. MILITARY ACADEMY)

1. THE following is an interpolation for the Trigonometry text and was prepared with a view of its being a help in explaining to students just what a mil is.

2. The obvious reason for explanation lies in the simplicity of the subject, as a person who knows what a mil is cannot realize that another might find it difficult to understand and, therefore, the instructor is apt to spend too little time on the elementary work of teaching the student to think in terms of a new unit.

3. To remedy this difficulty it is suggested that all students of trigonometry in high schools and colleges be required to study this interpolated text sheet or a modified form of the same.

4. If students be required to study the Mil Scale, which requirement has the approval of the Chief of Field Artillery, United States Army, the next time we require the services of say twenty-five thousand of the Youth of our country as officers, and twice that number as noncommissioned officers capable of computing firing data, they will be able to talk mils at the end of their first week of training as well as they do now after three weeks.

5. The examples appended are deemed sufficient for an elementary course.

In this connection it may be stated that while the use of the mil scale has special application to field artillery work, its use has now been adopted by the Infantry arm of our service, and it also provides a simple decimal method for use in any form of angular measurement, examples of which will readily occur to the students from time to time.

A Mil is an angular unit equal to $\frac{1}{6400}$ of four right angles. The MIL—the word Mil meaning one thousandth—originated

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from the idea of adopting as a unit the angle that subtends an arc equal to $\frac{1}{1000}$ of the radius; that is, the angle equal to 0.001 of a radian. Such an angle subtends 1 foot at a distance of 1000 feet, 1 yard at a distance of 1000 yards, etc. This manifestly furnishes a quick method of estimating the distance of an object whose size is known. There would under these circumstances be $\frac{2x}{0.001}$ or 6283.18 + such units subtended by a circle. This number is too inconvenient to be of practical use in calibrating instruments. The circle is therefore divided into 6400 equal parts and each of these is called a mil. The mil equals $\frac{2x}{6400} = .00098$ + radians. The arc subtended by a mil is, therefore, so nearly one one-thousandth of the radius that it may be so taken for purposes not demanding great accuracy. This property, coupled with the knowledge that in small angles the chord very nearly equals the arc, enables us to say for rapid and rough approximation:

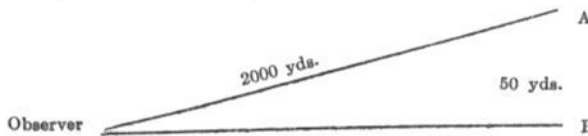
A mil subtends a chord equal to $\frac{1}{1000}$ of the distance to the chord. And, with due regard to the degree of approximation, a small number of mils (several hundred) subtends a chord equal to the small number times $\frac{1}{1000}$ of the distance to the chord.

The following examples illustrate the methods of rapid approximate measurement of angles and distances by the use of the Mil System.

These methods were first developed by the Field Artillery in computing firing data. Their use was extended to mapping, sketching and reconnaissance. During the World War the Infantry adopted the system, and it has now become general.

The mil as a unit has the advantage of being conveniently small for physical measurements without being too small. The decigrade is not small enough and the centigrade is unnecessarily small.

Example 1.—Two points, A and B, are 50 yards apart and 2000 yards away. How many mils should they subtend?

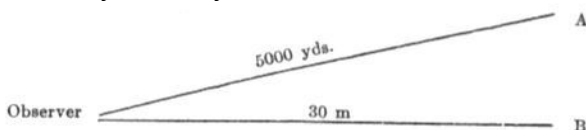


Solution: 50 divided by 2000/1000 = 25.

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Or, at 2000 yards, 2 yards corresponds to 1 mil; therefore 50 yards correspond to 25 mils.

Example 2.—An observer measures the angular distance between two points A and B, 5000 yards away to be 30 mils.

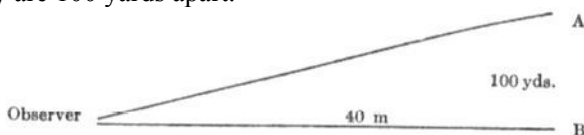


How far apart are A and B?

Solution: $5000/1000 \times 30 = 150$

Or, at 5000 yards 1 mil subtends 5 yards; therefore 30 mils subtend 150 yards.

Example 3.—The angular distance between A and B is observed to be 40 mils. They are 100 yards apart.



How far away are they?

Solution $100/40 \times 1000 = 2500$.

Or, 40 mils correspond to 100 yards; therefore 1 mil corresponds to $2\frac{1}{2}$ yards, but $2\frac{1}{2}$ is $1/1000$ of 2500 yards.

Example 4.—A battery of 60 meters front is observed from a point 3000 meters away measured on a line normal to the battery. What angle does the battery subtend? (Or, what is its front in mils?)

Example 5.—A four gun battery 4000 meters away has a front of 15 mils. How many meters between muzzles?

Example 6.—The guns in your battery have wheels $1\frac{1}{2}$ meters in diameter. You measure a wheel as 5 mils.

How far are you from the battery?

Example 7.—An observer measures the front of the target to be 40 mils at a point 6000 meters away.

What should a scout (a) 3000 meters in front of the same observer measure it to be? (b) 4000 meters in front of the observer?

Example 8.—Two targets, T and t are 20 meters apart. The range TG, perpendicular to the line of targets, is 5000 meters. Two guns, G and g, are also 20 meters apart, the angle TGg being 1500 mils. Take t and g both on same side of TG.

- (a) What is $\angle tgG$ in order that gun g may land on t?
- (b) What change in deflection of G must be given to lay it on t?

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Example 9.—A hostile trench measures 80 mils from your position. A scout 500 meters in front of you measures it 100 mils. What is the distance of the trench from your position?

Example 10.—You signal to a man at a distant tree to post himself 20 yards from the tree measured perpendicular to the line from the tree to you. The man is now 8 mils from the tree.

How far away is the tree?

Example 11.—An observer finds that he is on the same level with the top of a distant tower which is 34 yards high. The angular depression of the base of the tower is 8 mils.

How far away is the tower?

Example 12.—From D a distant object B appears to the right of an object A, which is 6,000 meters away.

An observer at D measures the angle ADB to be 35 mils. He moves to C, 180 meters to the right on a line normal to AD, and measures the angle ACB to be 15 mils.

How far away is B?

(Hint: Sum of angles of a triangle is constant.)

Example 13.—From Trophy Point the angular elevation of Fort Putnam is 210 mils and its distance is 600 yards. Also the elevation of the top of the West Academic is 120 mils and its distance is 250 yards. The West Academic and Fort Putnam are 500 yards apart.

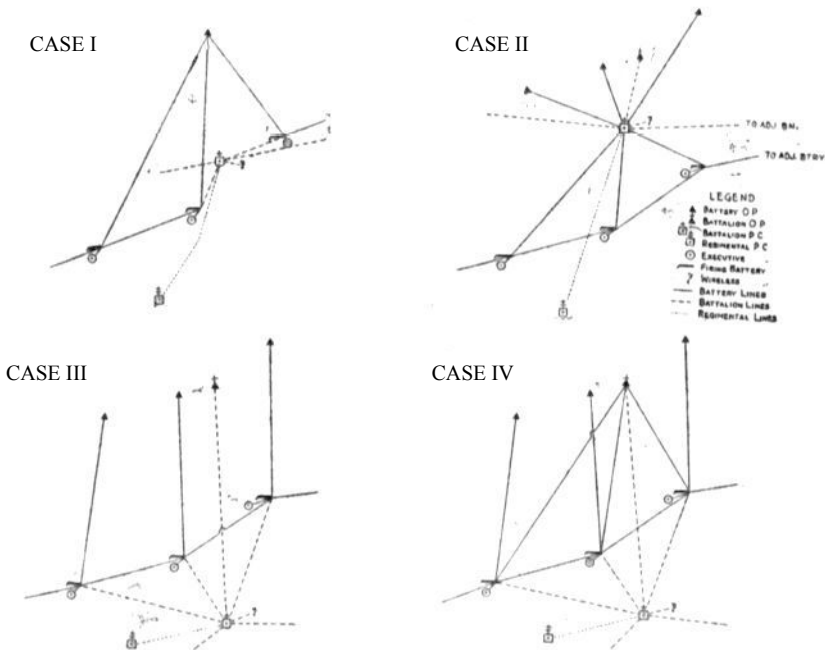
What is the angular elevation of Fort Putnam as measured from the top of the West Academic Building?

TYPICAL EXAMPLES OF BATTALION TELEPHONE NETS DEVELOPED BY THE INTRODUCTION OF SWITCHBOARDS

DEPARTMENT OF RECONNAISSANCE, SCHOOL OF FIRE FOR FIELD ARTILLERY, FORT SILL, OKLAHOMA

THE following diagrams of battalion telephone nets are intended to show how wire may be conserved by properly locating the battalion switchboard and by consolidating the observation posts.

It should be noticed that each scheme provides at least two lines for intercommunication between the battalion units. A study of the diagrams will bring out the advantages and disadvantages of each case. All four systems have been used in battle and gave satisfactory results.



The relative length of lines and number of switchboards are:

	Length of lines.	Number of switchboards.
Case I	4350	1 8-drop and 4 4-drop.
Case II	5050	1 12-drop and 3 4-drop.
Case III	6700	1 8-drop and 3 5-drop.
Case IV	9450	1 8-drop, 3 6-drop and 1 4-drop.

EDITORIAL

Delenda Est Carthago

THIS is the age of specialization! Our great national industrial success is due to an appreciation and the practical application of this fact. It is also one of the important lessons of the present war. In the military profession we encounter it everywhere. Whereas Sherman in 1864, in marching his army of 60,000 men from "Atlanta to the Sea," conducted the operation with a numerically insignificant staff, we find in 1918 a large organized staff divided into several sections, G to Gn, all specializing in different phases of the staff work.

A member of Congress recently stated: "They think because a man is an army officer that he can do anything." This statement is based upon a certain amount of truth in that during the emergency and turmoil of war, and due to unavoidable casualties and occasional failures, strict necessity has compelled the immediate assignment of a man to a duty for which he had not been trained. Undoubtedly better results would have been obtained had we had a man trained and fitted for the job. To fit a round hole you must use a round peg, not a square one.

The question naturally arises: Will greater efficiency be attained by a reasonable specialization which enables a man to master his profession, or by a superficial smattering of knowledge which makes him a "jack of all trades but a master of none"? Even the least sophisticated will perceive at once that these two qualifications are rarely found in the average man, because in their nature they are conflicting. Any endeavor to harmonize them in all men will surely lead us into pitfalls which will prevent us from reaching our goal.

It has always been an accepted principle that the mobile army, meaning thereby the troops which operate in the field to engage the enemy on any terrain and at any time, should be

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under a single and responsible direction which will train these troops to function together so that they may efficiently perform their mission on the field of battle. This superior authority must see that specialization and generalization receive relatively the proper amount of study and training. It must see that the mobile army, when called upon to function as a whole, works as a team. All the elements of command under this superior responsible authority must be interdependent; each is in need of the support of the other. Each must be imbued with the conviction that in the presence of the enemy, the failure of any one service will paralyze the other services, that this failure will endanger not only its comrades in the other arms but the whole army. Unless this feeling of interdependence exists—and it is a true, live, proved and well known feeling—the training of the team as a whole will be poor, discord and confusion will result, and defeat, or even worse disaster, will stalk in its midst.

Every officer in this team must know his job and know how to direct his efforts so as to harmonize with the efforts of others toward the attainment of the objective designated by the directing authority. Every officer must study and attain proficiency in those duties and functions which he will be called upon to perform on the field of battle. No matter how desirable knowledge of other subjects not connected with his profession may be, such knowledge can be considered only as a side light, an attainment which will have only a minor if not a negligible influence upon his efficiency as a part of the team.

Would any officer in such a team, a field army, study for professional advantages the fine points of our wonderful Coast Guard Service? Would this enthusiastic officer study for the same reason, the methods of how a battle squadron should approach a hostile mine infested harbor? Would this officer study "Janes' Fighting Ships" in order that he may recognize the ships of different nations? Would this officer study the navigation of mine planters and the operation of mine laying in harbors? Would this officer study the defense of harbor mine fields? Would he study the care and operations of dynamos,

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motors, storage batteries, steam boilers and search lights? Would he worry his head over the relative value of direct and alternating currents? Would he study systems and control of harbor defense batteries, and the battle tactics of a coast defense district against a hostile fleet? In the crisis of battle would such teaching, study and training lead him toward the mutual support of the other members of his team, Cavalry, Artillery, Engineers, etc.? We have the authoritative statements of eminent officers of our army, including three distinguished general officers who successively held the position of Chief of Coast Artillery, that reasonable efficiency in such subjects is the result of a life of specialization.

In his annual report for the year 1914, Major General Weaver, then Chief of Coast Artillery, in discussing the handling of siege artillery by the Coast Artillery, stated as follows:

"In this connection it should be pointed out that if (i.e., siege artillery) assigned to the Coast Artillery it could only be taken up as a secondary and incidental training. The experience of the Spanish War and of the Civil War made it perfectly clear that the inhabitants of seacoast cities are so hysterically excited by the presence of hostile warships off the coast line that it would be impracticable to detach any of the Coast Artillery personnel from their coast defense duties for service in the interior with the mobile army as long as even a single hostile warship should be operating along the coast. For example, it is well known that during the Spanish War, as soon as Cervera left Spain with his fleet in his movement westward, the whole Atlantic coast from Maine to Texas was in a state of hysterical alarm. It would have been entirely impracticable at that time to have taken even one company of Coast Artillery from the coast line for service in the interior.

"On the other hand, it is believed that the principle should be laid down definitely that the field army is entitled to an efficient siege artillery service in a primary way, and that this arm should be available to the field artillery in its military operations, IMMEDIATELY, WHENEVER NEEDED, regardless of the military

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necessities or emergencies existing elsewhere outside the theater of operations of the field army.

*"While, therefore, the Coast Artillery may, as a secondary and incidental proposition, continue the instruction of its personnel in siege artillery service, in so far as this may be done without detriment to its primary functions of making itself efficient seaward against a naval enemy, it is believed that it is not in accordance with the highest degree of military efficiency and not in the interest of the field army to prescribe that the siege artillery needed for the field army shall be supplied by the Coast Artillery troops. * * * (Ed.—By the law of January 25, 1907, siege artillery is definitely assigned to the Field Artillery.)*

"The whole matter was referred to the War College on June 18 1913, in the following memorandum by the secretary of the General Staff:

"The Chief of Staff directs that in the organization for the field army being prepared now by the Army War College that there be included provisions for the permanent organization of such units of siege artillery as may be considered necessary for the successful operations of armies in the field. This siege artillery will be of caliber greater than the 6-inch howitzer, and will probably include guns and mortars from 7.6-inch to 12-inch calibers. The organization should prescribe what is needed for the proper service of the guns, ammunition trains and supply and repair parts: in fact, everything essential to the complete organization of this class of Artillery.

"The organization will form part of the Field Artillery."

"It would appear, therefore, from this memorandum that the policy of the department has been definitely prescribed, that permanent organization of siege artillery units should be provided for the land forces."

The fact, born of long experience, that their service is all too short to attain the desired standard of proficiency in the technic of their own specialty, in the tactics of their arm and in the combined tactics of the mobile army, is frankly admitted by efficient officers of the mobile army.

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Does the mobile army wish that the artillery officers of the field army devote their time and study, their ability and efforts, to subjects which are wasted as far as team play within the mobile army is concerned? Will the troops of the mobile army feel encouraged and have their morale increased by the knowledge that they are depending for artillery support upon artillery officers trained not in the offensive tactics of maneuver warfare but in the defensive tactics of coast defense?

Will we feel secure knowing that the protection of our coast, our first and most important line of defense, is being provided by a Coast Defense Corps which, being somewhat impregnated with a false doctrine of opportunism, is devoting a part of its time and effort, not to a solution of the problem of our coast defense and the protection of our naval bases, but to the hope that an opportunity may some day arise for it to abandon these coast defenses and function as field artillery with the mobile army?

Will the mobile army risk the hazard of depending for artillery support upon a Coast Defense Corps which cannot leave its coast defenses because the enemy still threatens our coasts?

There is but one answer to these questions: "*Shoemaker, stay by thy last.*" The Coast Artillery is to-day the land artillery of our Coast Defense. Heretofore it has only served as Harbor Defense. Its action, its tactics, its fate, its life, its very existence is inevitably bound up with that of the Navy. The Navy is the offensive, the Coast Artillery is the defensive organization of our Coast Defense. Whereas in the past it was able to function as Harbor Artillery, the use of railway artillery has now extended its sphere of action and will permit it to cooperate with the Navy in Coast Defense. The defense of our coast is strictly a naval problem. If the offensive and defensive alliance of our Navy and Coast Artillery in the protection of our coast fails in its mission, then the protection of our country from invasion becomes a function of the mobile army.

The Field Artillery includes *all the artillery which accompanies*

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a mobile army in the field. This artillery must be woven together and into the mobile army, not only tactically but also in spirit. All groups or groupings of artillery of the field army must function under one tactical command. The commanders of Corps and Divisional Artillery will command at times all calibers up to the railway artillery. The subdivision of the artillery of a field army into Divisional, Corps and Army artillery is artificial, made not for the purpose of creating separate and distinct kinds of artillery but for convenience in making proper tactical allotment of forces, and in order to insure proper economy of forces. In a general way it carries out the well-known principle of firing line, supports and reserves, common to all combat tactics. For this reason all the different groupings of artillery of a Field Army must be imbued with a single tactical doctrine, must learn to function together and with the Infantry Division, which is the basis of organization of all armies.

Officers of artillery, in carrying out their function in the army team, in properly preparing themselves to give the infantry and the cavalry that support which these, our comrades of the battlefield, have a right to expect, have a duty before them in which success will be assured only by years of experience, specialization and study. These officers have no time to study the problems of local coast defense. Furthermore, the insidious influence of the passive defense so inevitably bound up with all our problems of coast defense is destructive of that offensive spirit of the Field Artillery, which in the present war has found its characteristic expression in the accompanying gun and in the infantry battery. That these lessons came so very late in the present war is all due to the enervating influence of the defensive tactics bound up with position warfare.

This false doctrine is entertained only by those who fail to see the simple and self-evident principles which underlie the tactical employment of the artillery operating with a field army and the artillery operating with the Navy. Such persons propose to carry the idea of generalization to an absurd if not an

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impossible degree, which is fraught with great danger. Energy, ambition and will to accomplish are most admirable traits of character, but he who believes that one man is qualified at the same time both as a local coast defense *technician* and as a field *tactician* imbued with an offensive spirit ever ready to push forward his artillery to the support of the other combattant arms, is over-optimistic.

Shall we be mocked by an ambition so impossible of attainment? Do we believe that "because a man is an army *officer*, he can do anything?" The view is held by many who are not a part of the mobile army, that under a consolidation of the artillery of the mobile army with the artillery of the coast defense, those officers who are qualified in Coast Defense will always serve with it, while those who are qualified as Field Artillerymen will always serve and train with mobile troops. But what assurance have we of this? Our experience prior to January 25, 1907, the date the Field Artillery was separated from the Artillery of the Coast Defense, is sufficient to convince every one to the contrary, and no assurance or guarantee would ever induce a true Field Artilleryman to recede one step from the principles in which he believes, in order to bargain for or to subscribe to a change which is so violent and which promises such disastrous results.

Is it not right that those officers to whom the operations of artillery in the field, combined tactics and mobility in war, is a life work, shall by law serve in the mobile army? And should not those who prefer to study naval operations and the problems of coast defense serve by law in the Coast Defense Corps? Certain it is that a man superior enough to be excellent in both is a very rare exception.

EDITORIAL

Co-operation

THE observant officer can hardly fail to see ahead of us a year which, perhaps, is the most critical in the history of our army. The aftermath of the war is upon us, and as always before, after every war in which we have been engaged, some of those amongst our countrymen who consider themselves without sin are beginning to cast their stones. This fusillade promises greatly to increase in its intensity. The army does not resent—in fact, it needs and can profit from honest, just, unimpassioned, constructive criticism—criticism that will acknowledge and set forth achievements, as well as that which sets forth mistakes and deficiencies. The army, however, does and should resent villainous abuse, and should take effective measures to counteract and combat it.

It is clear that the great American army which made possible the complete defeat of the enemy, was not created by the efforts of any one element alone—by the Regular Army, the National Guard or the National Army—but by the united efforts of all three. At the first, the brunt of the initial organization and training fell on the professional soldier of the Regular Army. Nothing else could have been expected. As the civilian soldiers of the National Guard and National Army gained in military experience, they shouldered their share of the burden and it was not long before all elements stood on common ground. The recognition of this came in the War Department order of August 7, 1918, which began:

"This country has but one army—The United States Army." Distinctive appellations were abolished and the letters U. S. went onto the collar of every man. Thereafter, as each looked into the eyes of the other he saw only a red-blooded American soldier—a brother in the finest and grandest fraternity in the world. Now, when the great task has been done—and so creditably done—serpents seem to have crawled from their lairs, and, apparently with the studied cunning of the blackest-hearted Hun, they are busy sowing dissension. Cleverly they seem to be seeking to array Regular against Regular;

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National Guardsman against Regular; Reserve Corps against National Guardsman; the overseas officer and man against the officer and man who ate out their hearts at home; the Staff of the A. E. F. against the Staff in Washington; the Staff against the line; the enlisted man against the officer; and so on *ad infinitum*. In all this flood of organized fault-finding not a single suggestion for improvement can be found. Motive, apparently, is lacking, unless it be conceived that this wholesale attempt to sow dissension is intended to wreck the entire military establishment and to array the nation against further maintenance of any armed forces.

If this be the case, the purpose of the propagandist is clear—to so bewilder, perhaps, to so disgust and enrage our people and Congress and to so confuse and discredit the Staff, the War Department, and the Army by arousing dissension, disagreement and antagonism, as to prevent our nation profiting from the lessons of the war; to prevent the adoption of the only safe, sound, democratic and economical principle, that of universal training for national service as the American military policy for the future.

Are our officers and men to be the dupes of these clever propagandists by handing to them for sensational elaboration and distortion the petty grievances or the trifling injustices that a few, unfortunately but inevitably among so many, hold in their hearts?

As never before in the history of the army, our officers should stand together and work together harmoniously, with an eye and a purpose single to the welfare of the service and of the country. The Field Artillery desires to do anything in its power to further a harmonious coöperation on the great tasks now confronting us. It stands ready to meet its comrades of the other arms, in any plan to promote the efficiency and to secure the proper tactical reorganization of the army. If promotion is the stumbling block, it must be removed.

In the last number of the JOURNAL we touched on this subject, and by way of emphasis here repeat: "Any reorganization

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of the army on the great scale that undoubtedly will soon become necessary should be based upon a reassignment of regular officers, so that the proportion in each arm is approximately the same. An expanded Field Artillery wants, and should have, the officers of the other arms who have been serving with it during the war; and it wants, and should have, its proper strength and proportion of other regular officers, be they Coast Artillery, Cavalry or Infantry, provided they are anxious or willing to transfer to it. The policy must be to take these officers without unjust discrimination and without loss of relative rank. After that a single list for promotion, line and staff, with perhaps the pace set by the main fighting branch, the Infantry, could, we believe, settle all promotion worries and fears in time of peace, and permit all officers to see military problems in their true perspective."

At the present time the Field Artillery holds the advantage in promotion; two years ago it did not, and two years hence it probably will not. In the past the advantage has constantly shifted from one branch to another with consequent jealousies and heart-burnings.

As probably nothing else can do, equalized promotion will bind us together in such a way that personal interests will be lost in the larger interests of the army and of the nation. Legislative projects emanating from our General Staff will not be studied with distrust by our Congressmen in order to find the joker—an alleged promotion scheme, and the individuals or arm which it is to benefit. Promotion and promotion injustices will cease to be the constant topic of conversation and argument in all offices and bureaus of the War Department.

It is believed that the adoption of the principle of equalized promotion need not destroy the important principle of specialization. Transfer of officers from one branch to another must be avoided. An officer must remain in the arm of his selection and for which he has specialized. With the proper number of extra officers in each grade, specialization in each arm may be preserved.

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The Field Artillery presents to the other services the real need for harmony, coöperation and teamwork. The need is serious and paramount.

The Field Artillery does not desire to be understood as advocating equalized promotion as the only or even the best method of solving this problem; it merely suggests this as a basis from which to start in an earnest and sincere effort to get together upon some plan which will be both equitable and just to all concerned.

EDITORIAL

"The Probable Error"

WE have recently received Vol 1, No. 1 of "The Probable Error," the Field Artillery Central Officers Training School Weekly, which now becomes an alumni quarterly magazine.

As a weekly it did wonders to "keep them rolling" and was read with great interest by those who were so fortunate as to get hold of a copy.

The alumni of the School at Camp Zachary Taylor have formed an Association—"The Field Artillery Central Officers Training School Association"—with headquarters at No. 37 Wall Street, New York City, from which office will be published "The Probable Error."

The magazine will appear four times a year and has as its editorial board the following: George Palmer Putnam, John Kirby, and Arthur B. Baer.

The yearly dues of the Association are \$2.00; \$1.00 of which is the subscription price for "The Probable Error."

The editors state: "As we see it, the magazine's chief function is to maintain contact between the men who worked at Taylor, and to help promote interest in the objects of our training there—the safeguarding of democratic ideals through ability to fight for them, if needs be."

To the above we heartily subscribe and take this occasion to welcome "The Probable Error," and the F.A.C.O.T.S. Association, into the field of journalism.

Their purpose is a laudable one; several thousand members of the association are also members of the Field Artillery Association; we have with them a common interest in matters pertaining to field artillery and that interest it should be our duty and pleasure to foster in the years to come.

We wish the Association all possible success and assure its members our heartiest support and coöperation.

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Field Artillery Reserve Corps

OFFICERS of the Field Artillery Reserve Corps are advised that the Field Artillery does not propose to lose interest in them, nor, if possible to prevent it, a close personal touch with them.

Plans for a proper kind of organization for the Reserve Corps are now being considered and discussed with much interest in the office of the Chief of Field Artillery. Although any plan of this kind would be subordinate to the ultimate military policy adopted by Congress, it is believed that an Officers' Reserve Corps organization into brigades by locality, will prove feasible and practicable. The logical outcome of such an organization would be opportunity for summer training by brigade with a regiment or higher unit of the regular field artillery. This would afford an association of officers that would develop local pride and esprit, as well as one to keep up interest in the field artillery, and one that would efficiently serve to keep the Reserve Corps officer and the regular in close touch and sympathy with each other. The Field Artillery does not want to lose touch with a single officer who, during the emergency just passed, has proved his qualifications as a field artilleryman.

Roll of Honor

PRO PATRIÂ

FROST.—Died at sea on September 30, 1918, when the Ticonderoga sank, Lieutenant Cleveland Cady Frost, Field Artillery.

STORER.—Died of wounds in France, October 2, 1918, Second Lieutenant Willis D. Storer, Jr., Battery C, 107th Field Artillery.

GOLTFELTER.—Died of wounds in France, about October 5, 1918, Second Lieutenant George R. Goltfelter, 130th Field Artillery.

EDWARDS.—Died of wounds in France, October 6, 1918, First Lieutenant Fred T. Edwards, 18th Field Artillery.

BAILEY.—Killed in action in France, October 9, 1918, Second Lieutenant Kenneth A. Bailey, Battery B, 102nd Field Artillery.

SMITH.—Reported missing in action, October 30, 1918, First Lieutenant John H. Smith, Battery C, 107th Field Artillery.

LEWIS.—Killed in action in France, October 31, 1918, Second Lieutenant Stevenson P. Lewis, Battery E, 124th Field Artillery.

KIRKPATRICK.—Died of wounds in France, November 1, 1918, Second Lieutenant John Kirkpatrick, 148th Field Artillery.

EDMON.—Died of broncho-pneumonia at Fort Sill, Oklahoma, November 4, 1918, Second Lieutenant John M. Edmon, Field Artillery, School of Fire.

HATTEMER.—Killed in action in France, November 4, 1918, Second Lieutenant Leon H. Hattemer, Battery E, 305th Field Artillery.

SWOFFORD.—Died of broncho-pneumonia at Fort Sill, Oklahoma, November 7, 1918, Second Lieutenant James J. Swofford, Field Artillery.

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ROGERS.—Died of pneumonia in France, November 13, 1918, Captain George C. Rogers, 81st Field Artillery.

INGE.—Died of empyema at Camp Taylor, Kentucky, November 16, 1918, Second Lieutenant Thomas Roy Inge, Field Artillery.

PARMELY.—Died of broncho-pneumonia in France, November 19, 1918, First Lieutenant Miles M. Parmely, 124th Field Artillery.

KERLEY.—Killed as a result of a railroad accident in France, December 5, 1918, First Lieutenant Lindolph R. Kerley, Battery D, 119th Field Artillery.

MAYETTE.—Died of broncho-pneumonia in France, December 5, 1918, First Lieutenant Annolm J. Mayette, Chaplain, 12th Field Artillery.

SMITH.—Died of lobar pneumonia at the Base Hospital, Camp Taylor Kentucky, December 6, 1918, Second Lieutenant Henry J. Smith, 3rd Training Battery, Field Artillery.

MESSELHEISER.—Died of broncho-pneumonia in France, December 10, 1918, Second Lieutenant Emil R. Messelheiser, Battery E, 76th Field Artillery.

CABEEN.—Died of pneumonia in France, December 16, 1918, Captain Wayland H. Cabeen, 329th Field Artillery.

SHEPARD.—Died of tuberculosis in France, December 16, 1918, Captain Francis B. Shepard, 313th Field Artillery.

DODD.—Died of lobar pneumonia at Cambridge, Massachusetts, December 17, 1918, First Lieutenant Eugene Dodd, 4th Field Artillery.

PINCKNEY.—Died of lobar pneumonia at Camp Taylor, Kentucky, December 20, 1918, First Lieutenant Charles E. Pinckney, Headquarters Company, 5th Regular Field Artillery.

MCNAB.—Died of influenza-pneumonia at his home, Rochester, New York, December 21, 1918, First Lieutenant Robert Roy McNab, 49th Field Artillery.

ROLL OF HONOR

JACOBUS.—Died of lobar pneumonia in France, December 24, 1918, First Lieutenant Harold F. Jacobus, Battery E, 342nd Field Artillery.

LAUBACH.—Died of lobar pneumonia at the Base Hospital, Camp Taylor, Kentucky, December 24, 1918, Second Lieutenant Arthur Henry Laubach, Field Artillery.

MCLAURIN.—Killed in a railroad accident, December 25, 1918, Second Lieuteaant James H. McLaurin, Field Artillery, unassigned.

STEPHENS.—Died of broncho-pneumonia in France, January 4, 1919, Brigadier General John E. Stephens, Headquarters 61st Field Artillery Brigade.

REYNOLDS.—Died of lobar pneumonia in France, January 5, 1919, First Lieutenant Matthew G. Reynolds, Jr., Battery E, 115th Field Artillery.

MOUSER.—Died of cardiac dilatation following broncho-pneumonia, in France, January 7, 1919, Second Lieutenant Vivian K. Mouser, Battery A, 115th Field Artillery.

SABINE.—Died at New York City, New York, January 7, 1919, Captain George Krans Sabine, Jr., Field Artillery.

TABNOSKI.—Died as the result of an aëroplane accident in France, January 7, 1919, Second Lieutenant Alexander S. Tarnoski, Field Artillery.

CAMPBELL.—Died of broncho-pneumonia in France, January 8, 1919, First Lieutenant Allan L. Campbell, Battery C, 115th Field Artillery.

REYNOLDS.—Died of typhoid fever in France, January 10, 1919, Captain Charles P. Reynolds, 101st Field Artillery.

WILSON.—Died of broncho-pneumonia in France, January 12, 1919, Second Lieutenant Orville K. Wilson, Bandmaster, 318th Field Artillery.

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WATERS.—Died of broncho-pneumonia in France, January 13, 1919, Captain Frederick W. Waters, Battery E, 149th Field Artillery.

BROWN.—Died at Washington, D. C., January 14, 1919, Second Lieutenant Louis D. Brown, Field Artillery.

EUARD.—Died of typhoid fever in France, January 16, 1919, Second Lieutenant William R. Euard, Field Artillery.

REDDEN.—Died of lobar pneumonia in France, January 16, 1919, Lieutenant Colonel Curtis G. Redden, 149th Field Artillery.

MCCLELLAND.—Died of disease (nature to be determined) in France, January 17, 1919, Major Guy W. McClelland, 102nd Field Artillery.

GUNN.—Died at Camp Kearney, California, January 18, 1919, Captain Alvin L. Gunn, Field Artillery, 16th Trench Mortar Battery.

WATTERSON.—Died of broncho-peumonia in France, January 27, 1919, First Lieutenant Orville R. Watterson, Battery A, 135th Field Artillery.

HUGHES.—Died of pneumonia in France, February 1, 1919, Captain Reginald W. Hughes, 164th Field Artillery.

MCCLEVERTY.—Died of broncho-pneumonia in France, February 1, 1919, Second Lieutenant John A. McCleverty, 148th Field Artillery.

BUELL.—Died of broncho-pneumonia in France, February 4, 1919, Major Frank A. Buell, 7th Field Artillery.

PINKHAM.—Died of broncho-pneumonia in France, February 5, 1919, First Lieutenant Louis Pinkham, 148th Field Artillery.

HOUSE.—Died of pneumonia, February 6, 1919, at the Base Hospital, Camp Custer, Michigan, First Lieutenant Charles Wood House, Field Artillery, 14th Division.

ROLL OF HONOR

HUNT.—Died from monoxide gas in France, February 6, 1919, Second Lieutenant Harry F. Hunt, Veterinary Unit, 130th Field Artillery.

MURRAY.—Died of pneumonia in France, February 7, 1919, First Lieutenant Joseph H. Murray, Jr., 148th Field Artillery.

ROBINSON.—Accidentally killed by train in France, February 10, 1919, Second Lieutenant Arthur A. Robinson, 306th Field Artillery.

WORD.—Died of broncho-pneumonia in France, February 10, 1919, Captain William E. Word, Jr., 151st Field Artillery.

FOOTE.—Died of broncho-pneumonia in France, February 11, 1919, First Lieutenant Marshall W. Foote, Battery C, 10th Field Artillery.

MCGILL.—Died of broncho-pneumonia in France, February 11, 1919, Captain Arthur H. McGill, Battery A, 311th Field Artillery.

HENDERSON.—Died of brain tumor in France, February 12, 1919, Captain George E. Henderson, 330th Field Artillery.

ZIESENIS.—Died of wounds received in action in France, February 12, 1919, First Lieutenant Harry C. Ziesenis, 314th Field Artillery.

CLIFFORD.—Died of lobar pneumonia in France, February 15, 1919, First Lieutenant Robert C. Clifford, 103rd Field Artillery.

BRAINERD.—Died of lobar pneumonia, February 17, 1919, at the Base Hospital, Camp Taylor, Kentucky, Second Lieutenant Edward Rankin Brainerd, Field Artillery, 3rd Company.

BUOL.—Died of lobar pneumonia, February 23, 1919, at Camp Taylor, Kentucky, First Lieutenant Paul A. Buol, Field Artillery, 2nd Company.

BOOK REVIEWS

MESS MANAGEMENT. By Lieut. Colonel William E. Dunn, 344th Field Artillery. 16mo. Flexible cloth. \$1.00 net. J. B. Lippincott Company, publishers.

"The secret of running a good mess is to put plenty of work on it, and the kind of work that counts is headwork." But the secret of making headwork count is having a definite idea of what is to be done and how it can be accomplished. The inexperienced officer who is given responsibility for the mess will find exactly the aid that he needs in Colonel Dunn's practical manual.

It is a small volume which can be carried in the pocket, ready for consultation whenever needed. For mess officers, it is a guide on how to organize and supervise the operation of the mess, so as to insure the men being well fed on the Government money allowance for food.

For mess sergeants, the manual contains detailed directions on how to keep mess accounts, how to plan menus, and how to plan purchases. A special feature is the listing of sample menus prepared by experienced mess sergeants. This will prove particularly helpful to newly appointed mess sergeants, and will undoubtedly be valued also by men of longer experience as an aid to quicker work.

When it is considered that an army is said to fight on its stomach—for it is certain that no body of ill-fed troops can possibly be effective for any length of time—the importance of making the best possible use of the food money allowance is seen to be a vital need. With the same amount of money an experienced man will give his men ample variety and quantity of good energy and muscle producing food, while the inexperienced man will only succeed in producing a spirit of revolt and inefficiency among the members of his mess. Colonel Dunn's book points out just how these two results are achieved, giving specific instances. He covers The Problem of Mess Management, The Garrison Ration, Planning Menus, Sample Menus, Stock Sheets, Daily Mess Statement, Cost and Weight Percentages, Monthly Mess Statements, The Mess Sergeant's Account Book, and Battery Fund and Monthly Statement of Mess Accounts. This little manual should be in the hands of every mess officer and sergeant in the army, and will be welcomed in the navy as well.

BOOK REVIEWS

THE ENGLISH OF MILITARY COMMUNICATIONS. By Major William A. Ganoë, Infantry. George Banta Publishing Company, Menasha, Wisconsin.

The ability to express oneself clearly and to use correct English is as important to the soldier as it is to any other professional man. No one will contend that the principles of rhetoric applied to military communications differ from those applied to communications of other professions. Communications are usually characterized by a professional style. The military style is characterized by clearness and conciseness. It avoids all artistic effect. That this style be brilliant is not necessary.

It is undoubtedly true that to many an officer "rhetoric is a big part of his profession." Some officers indulge in too much of it. Thus, for example, the officer who writes a letter requesting a leave of absence, as given on page 167 of the book. Very probably the author here had in mind that "the student must be cudged and enticed," and therefore gives as an example, a request for a leave of absence which presents to many older officers some amusing if not contradictory ideas.

As the author points out, every officer should start as early as he can to practice clear and brief form within the bounds of rhetorical and military rules. These rules, after all, are nothing more than those of common sense. But in order to be able to write clearly, an individual must first learn to think clearly. The author indicates this necessity, but does not emphasize it sufficiently. In fact he is more or less inclined to the idea that "a man thinks in pictures and that he conceives his idea as a painter imagines objects." This, of course, reflects the author's appreciation of the artistic talents of a good writer. The practical man will, however, be inclined to agree with those who believe that most men grope for language because their ideas are not definite enough to be expressed.

Many items have been intentionally repeated and highly colored, in order to drive home the points to the readers for whom this book was primarily intended, namely, the Cadets of the Military Academy. If we will but recall how we ourselves had to be amused by our former instructors, we can agree with the author that the book has met with an unexpected success and will also accomplish its purpose in all colleges and institutions at which a unit of the R. O. T. C. has been established.

E. L. G.

THE FIELD ARTILLERY JOURNAL

THE A-B-C OF AVIATION. By Captain Victor W. Page, Sig. R.C.A.S. Member Society of Automotive Engineers; Late Chief Engineer, Signal Corps, Aviation School, Hazelhurst Field, Mineola, L. I. Published by The Norman W. Henley Publishing Company, 2 West 45th Street, New York, N. Y. 1918. Price, \$2.50 net.

The best book of its kind we have seen. The author is so well known as an authority on aviation and internal combustion engines that merely an announcement of the publication should be sufficient.

This practical volume gives the student a very clear explanation of the subject discussed and answers every question one can ask about modern aircraft, their construction and operation. It is a non-technical manual for all students of aircraft and is especially adapted for home study.

RECRUIT MANUAL. By George C. Thorpe, Colonel U. S. Marine Corps. Authorized for publication by the Secretary of the Navy. Published by J. B. Lippincott Company, Philadelphia and London, 1919.

This volume is pocket-size; puts in the hands of the enlisted man who has just joined the Colors a considerable amount of necessary information pertaining to the customs of the service, together with important chapters from the several service manuals which he will later have to study in detail.

The first twenty-one sections are founded upon experience and custom. Sections XXII and XXIII give information about the rifle. Section XXIV presents an easy method of learning signals. Section XXV is a codification of saluting requirements. Section XXVI contains extracts from Infantry Drill Regulations and Marksmanship, Instructions. Section XXVII, Notes on First Aid Measures. Section XXVIII, Pertinent Selections from "Articles for the Government of the Navy." Section XXIX, Military Definitions.

The book is not properly indexed, but is otherwise useful. It is also intended for use of the civilian who intends to join the Marine Corps, to save him the embarrassment of arriving utterly "raw."

BOOK REVIEWS

OUR MANY-SIDED NAVY. By Robert Wilden Neeser. Second Printing. Price, \$3. Published by the University Press, 120 College Street, New Haven, Conn., and 280 Madison Avenue, New York City, N. Y.

This book was received too late for review, but we quote the following from the *Nation* concerning the author, Robert W. Neeser:

"Not only is he a close student of, and an acknowledged authority on, Naval affairs, but for months at a time he has been permitted by the Navy Department to live on board one or other of our battleships, so that what he tells us is based on personal experience and observation. Copiously illustrated, and written in a familiar yet engaging style."

Index to Current Field Artillery Literature

Compiled from monthly list of military information carded from books, periodicals and other sources furnished by the War College Division, General Staff.

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