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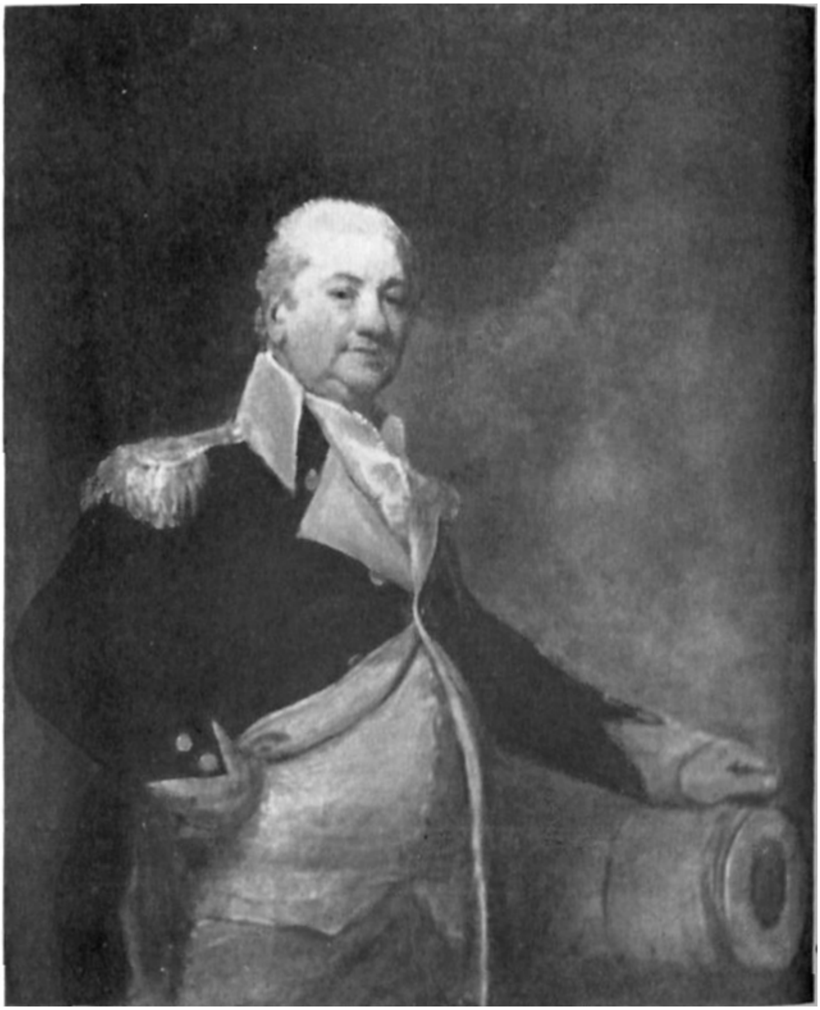
Contents

No. 3



(MAJOR-GENERAL HENRY KNOX)
(After the original portrait by Gilbert Stuart)

THE FIELD ARTILLERY JOURNAL

VOL. VI JULY-SEPTEMBER, 1916 NO. 3

The Adaptability of Motor Transportation for Field Artillery Use.

BY JOHN E. McMAHON, JR., 2D LT. 3D F. A.

CONSIDERABLE sums of money have been spent during the past five or six years by all the important nations with a view of determining definitely the adaptability of motor transportation for military needs. The primary cause of this was the fact that for a long time the governments had been making a full study of the probable course of the next war under modern conditions and had come to the conclusion that the motor would be one of the prime elements of success in a conflict of this nature. There are four factors which have had most to do with making the present European war so radically different from any of its predecessors. These four are modern artillery, motor vehicles, aircraft and submarines. There is a difference in opinion among military experts as to which of the first two should head the list in importance. One of the believers in the motor vehicle said, "in this war the exploding of gasoline is playing a more important part than the exploding of gunpowder." It was predicted by General von Bernhardi "that the means of communication in the coming war would be more varied and effective than in any other of the past and would constitute one of the most momentous factors of future conflicts. This prediction has been found to be correct and is shown primarily through the improvement and development of motor transportation and by the fact that it has become absolutely necessary to the efficient prosecution of a campaign. Few realized at the beginning of the war what the possibilities of the motor were and it can well be said that it has far surpassed the expectations of its most ardent advocates.

It is unnecessary to go into details concerning the various ways which man's ingenuity has found employment for the motor vehicle because they ought to be more or less familiar to everyone. Perhaps not the most important but one of the most important developments has been the adaptability of motor transportation for field artillery use. Artillery of every type, from the famous French "seventy-fives" to the equally famous German "forty-two" centimeter siege guns, has been carried or hauled by motor transportation, and the extent of its employment for this work seems to have been limited only by the number that could be secured or spared from other tasks. The modern fight being essentially of a siege character, defence works having to be heavily bombarded before an assault can be delivered with any chance of success, the siege gun must advance or retire with the troops, and the power, by the aid of the motor, to move heavy guns is of great value. Long before the war ever began, however, experiments had been going on with a view of determining whether or not the motor could be relied upon to replace the horse for field artillery use.

Mechanical transportation was first used for this purpose in 1770. A steam engine was built which could draw about five thousand pounds at the rate of three miles an hour. It was designed primarily to transport artillery, but the inventor was a century ahead of his time and the military men of the day did not realize the possibilities of this kind of transportation. In the interval between 1770 and 1870 attempts were made in England, Belgium, and France to develop steam road tractors to carry passengers. However, the roads were poor and could not stand the wear and tear of the heavy vehicles, so that they went out of use. In 1873 France had a few left and used them mainly for artillery purposes. In 1885 Daimler, a German, invented the internal combustion motor which was the first step in the production of the modern self-propelled road vehicle. The patents having been secured by a French firm, were improved upon and led to the development of the motor car. France began a series of tests with an automobile battery and with tractors, but the problem did not find a solution that was perfectly satisfactory. Attempts were made a little later to develop the four-wheel drive mechanism; few officers realized what its future would be. Colonel Deport, who as mechanical adviser of the Chatillon-Commentry Company had been trying to devise a suitable four-wheel drive car, predicted the possibilities of this type. Nobody believed him and it has remained for recent years to bring about his predictions.

In 1906 the French started in earnest to test the practicability of motor transportation for field artilley. In conjunction with their annual manœuvres, they worked out the problem and in 1909 decided on their subvention plan, appropriating $378,000 for subsidizing army type motor trucks. Tests were carried on with tractors and trucks during the military meets in 1911, 1912, 1913, and in the early part of 1914, in order to try out all available makes. Competition was encouraged as much as possible and in that way the best results were obtained. These tests proved to the French government conclusively that tractors were the most efficient means of transporting heavy artillery and its ammunition on the field of battle.

Although France was ahead of all of her neighbors in developing automobile transportation, England realized its possibilities soon enough, but did not carry out the realization. Steam tractors were used a great deal for heavy hauling in the Boer war. In that particular country, due to the bridges, light trucks were found to be more valuable than the heavier vehicles. The next year the War Office decided to conduct competitive tests for motor trucks. These were carried on intermittently until 1909. In this year tractors were tried out and demonstrated that nothing was impossible to a strongly constructed motor vehicle. In these tests the caterpillar type of tractor was considered too complex for military use. However, in 1912 England inaugurated her subsidy system, but commercial types prevailed and when the war broke out all were not adaptable to military use. The result was that England found herself unprepared with respect to a proper motor equipment.

Germany began to develop her scheme for military transport in 1908 and continued the annual trials until 1912. In this year they were made very severe and tests were confined to those motor vehicles drawing trailers. The next year Germany appropriated a sum of money for subsidizing machines and a certain degree of standardization was obtained. At the beginning of the war Germany was able to mobilize a huge fleet of motor vehicles quite as complete as any of her enemies.

These three countries were the pioneers of motor transportation. Russia, Italy and some of the smaller European states have found it necessary to adopt the ideas already developed. The fact that they did not realize the possibilities of the motor has been a serious handicap to them as well as a financial loss. Russia has found it necessary to import practically all her cars and to the United States falls the lot of being the chief source of her supply.

The development of motor transportation for military use is in its infancy in the United States. The first official attempt took place in 1903 when a combined battery and store wagon was constructed. Nothing has been done to determine the most advantageous types of vehicles until recent years. In 1912 an attempt was made by the Board of Ordnance and Fortification to have a tractor test. The initial step was interrupted by a recommendation that the test be delayed until a Panhard tractor could be purchased from France. That type of vehicle had been reported upon as producing remarkable results. Delay after delay ensued until finally the attempt was abandoned. In 1914 the War Department conducted the first real tests of motor trucks for military use. A Jeffery four-wheel drive car was tested at Fort Myer, but the first model did not come up to the requirements. A year later a series of tests took place at Fort Sill and Rock Island Arsenal to determine the efficiency of trucks in ammunition supply, in traction of elements of the firing battery and on the march. Tractors were given a thorough try-out in order to compare their powers to those of animal transportation. The Jeffery Company had improved its old model truck, so the government gave it a chance to redeem itself; the new truck is a great improvement and approaches the ideal army type. Other tests have been going on in the Quartermaster's Department to secure a desirable truck, but until recently nothing definite had been decided upon. While the United States is many years behind other countries in the development of the motor for military purposes, such rapid strides have been made within the last two years, that a definite policy will probably be adopted very soon.

In considering the types of machines adaptable for field artillery use, they divide themselves into two general classes—those used for the traction of elements of the firing battery and those used for the ammunition supply. The special classes of machines used for these purposes are the steam and motor tractor and the truck. The essential differences between a tractor and a truck should be noted before proceeding further. The tractor is designed to haul a load, while the truck is intended to carry a load. In the first case, the engine and the load-carrying vehicle are two separate units coupled together; in the second, they form one unit. However, there is practically no exact dividing line between the two types because trucks are very often used both for carrying and hauling loads.

The steam tractor is used for artillery purposes exclusively abroad, where England and Germany employ them in great numbers. Lord Kitchener describes the utility of this kind of mechanical transport in the Boer war and says, "that as a rule the steam tractors did useful work, but questions of weather, roads, water and coal distinctly limited their employment as compared with animal transportation, to which they can only be regarded as supplementary." Since that time such great progress has been made in efficiency and power that the steam tractor has been found to be indispensable. In the present war the increase in size of the guns has made some form of engine power essential. The steam tractor has provided the solution although very heavy; with the good roads and considering the fact that if the bridges are strong enough to support the guns they will support the engines which haul it, steam transport is very efficient. The steam tractor used for military purposes differs little from the commercial type used for steam rollers and threshing machines. They have been developed to a high degree of efficiency commercially, but have been deemed inadvisable for military use in this country because of the great number of unimproved roads. Europe has the advantage in this respect and has made use of it by changing commercial types to conform to military needs. When the war broke out, although England had developed the steam tractor, there were no heavy guns to speak of, consequently it was a long time before the heavy mechanical transport was needed. On the other hand, Germany, with her usual foresight, had a great number of both on hand, a condition which made possible the rapid advance through Belgium. Plate I is a picture of a heavy tractor showing the general type used in Germany.

For lighter work the internal combustion tractor is better adapted. Its great advantages lie in its mobility and independence of constant renewal of fuel and water. The French have made a more thorough study of this type of tractor than any other country and have developed five or six of them. The one that proved most efficient in the trials was the Chatillon-Panhard traction motor, mentioned before, a machine which

Plate I

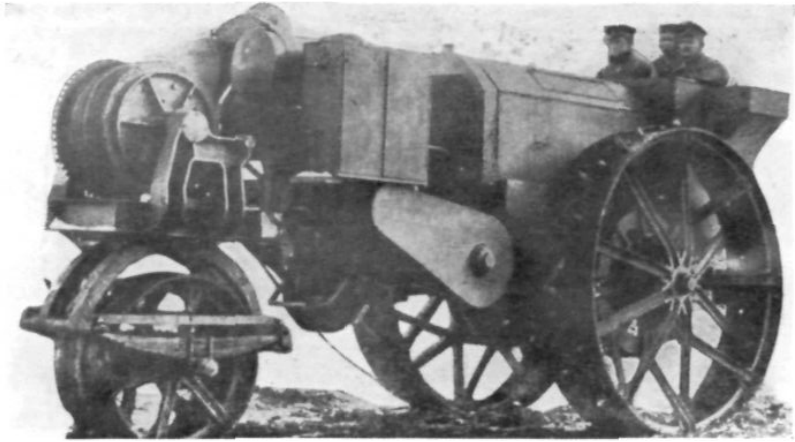


Plate II

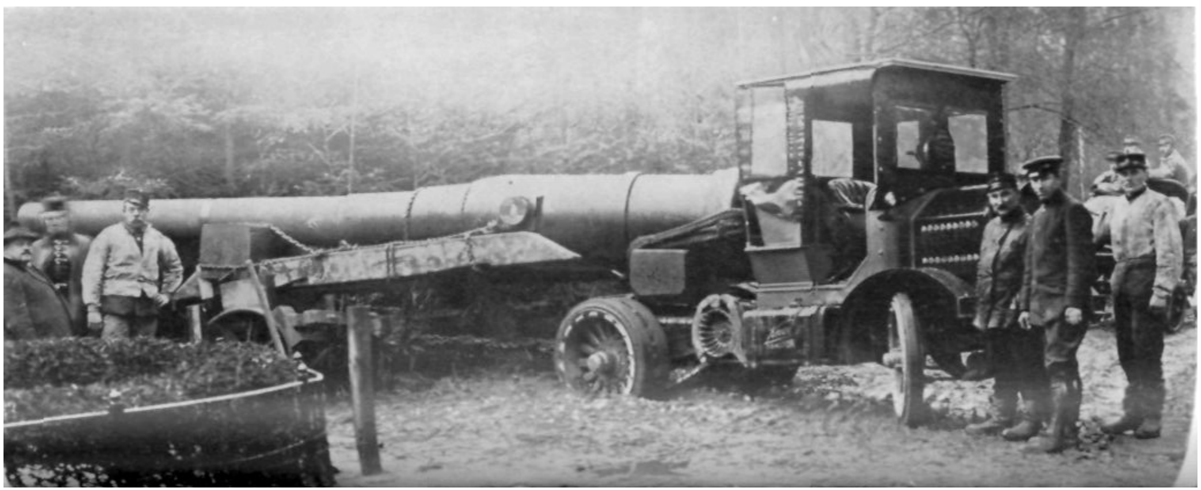


PLATE III

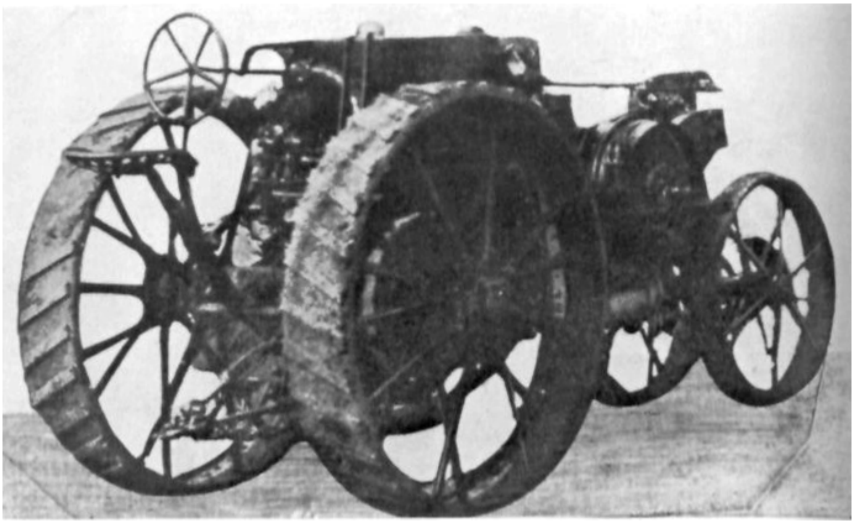
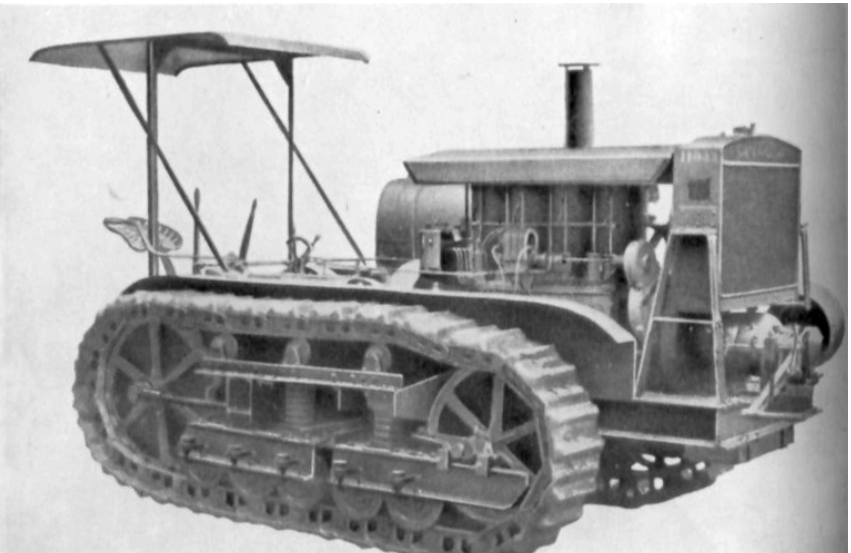


PLATE IV



applies the power to any or all of the four wheels. The development of this type solved the problem of a powerful military tractor capable of hauling heavy loads at a moderate rate of speed. At the beginning of the war there were from 200 to 300 of this type available for military use in France.

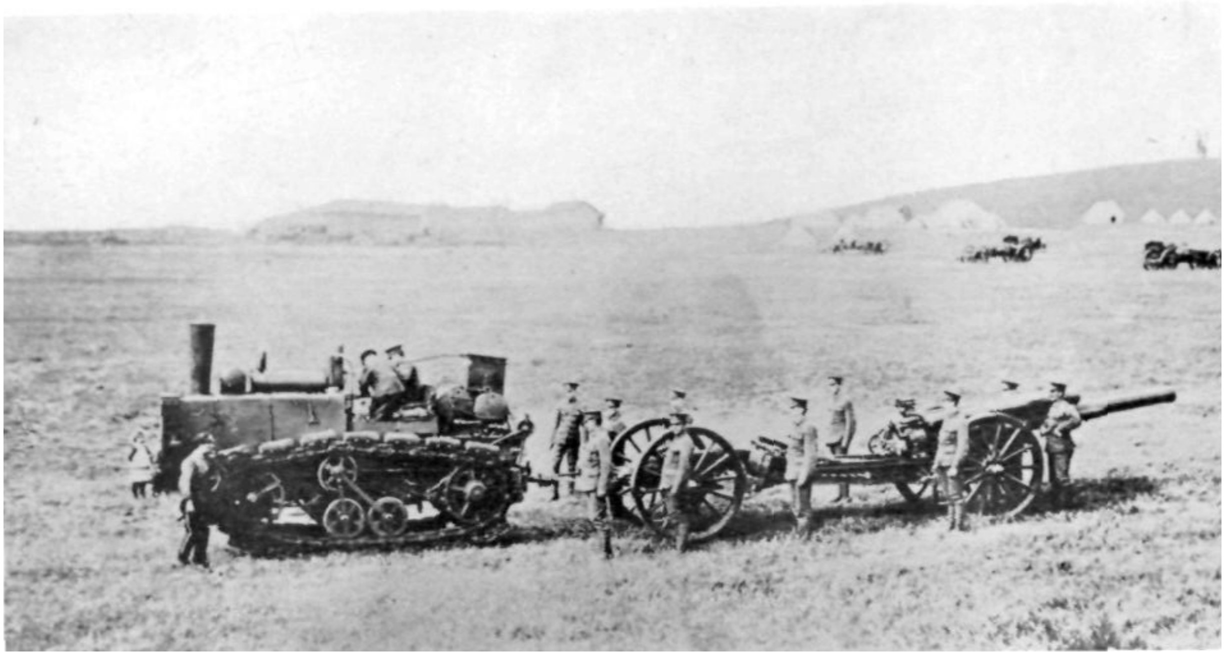
In this country there are at present one hundred and fifty tractors on the market, no two of them alike. Out of these may be taken two general types—the caterpillar and the wheeled. Up to the present time the former is the only one which has been tested out by the government, but both kinds are being sent abroad in great quantities. Plate II is a photograph of the Knox tractor which represents the main features of the wheeled type as developed in this country. It is comparatively new and was selected because so many have been shipped to the European nations. The load is supported on three axles—two on the tractor and one on the trailer. The photograph shows a 20-ton gun being drawn by the Knox tractor, thus distributing the load which makes it easier on bridges and tires. In 1914 the same company designed what they termed a motor limber to be used in hauling guns of large calibre. It was essentially the same type as above except that the rear end of the tractor had limber chests mounted on it and a pintle placed on the rear to which the gun was limbered. This did not prove satisfactory and was never adopted. The Knox has a chain drive by side chains on the rear wheels only. This is a great disadvantage in many ways; the chains become clogged and the machine cannot apply enough power to the two wheels to get it out of difficult places. The bearing surface on the wheels is not great enough and they sink so far into the ground that when the power is applied they simply slip and cannot pull the machine out of the mud. All these faults are corrected in the caterpillar; the wheeled type, however, has a greater maximum speed and weighs 5000 pounds less. Other types are made varying between the two extremes. A good example of this intermediate type is shown in Plate

III—a commercial tractor used for farming purposes in the United States. It was found by the Ordnance Department that this type only developed the necessary draw bar pull on fairly good roads, which is a great drawback. The drawbar is too low and attaching a gun or caisson to this tractor may raise the front end off the ground.

The caterpillar is a product of recent years and it has not been tested for use with artillery until lately. Plate IV is a picture of a caterpillar tractor made by the Holt Manufacturing Co., showing the details of its construction.

It automatically lays out and travels on a smooth, practically level track which is strong and flexible. This makes the vehicle practical on soft ground, gravel and snow—in other words, it is the best tractor for all around work. The track shoes are made heavy enough to withstand the most severe usage. All of the weight of the tractor is carried on ten truck wheels—five on each side—which run on a steel track. One of the interesting points in its design is the fact that the machine can turn in its own length. The steering is done by means of two clutches, both of which are engaged when going forward and when turning the one on the inside flank is released. The bearing surface of the 13-inch track, which is the smallest, is about 2100 square inches, an enormous increase compared to that of the wheeled type. As a result the weight is distributed over a much greater area and is not as severe on bridges as a smaller wheeled type machine. There are two speeds of travel, forward and reverse, 2⅛ and 3½ miles per hour. The Field Artillery Board recommended that the tractors adopted for field artillery use have three speeds instead of two, varying from 1½ to 4½ miles per hour in emergency. The two types of Holt tractors tested were of 75 and 45 horsepower. The former is capable of towing a long line of carriages, but the power and weight are too great for the present calibres. A section forms a sufficient load for ordinary purposes and is the best division from a tactical standpoint. The

PLATE V



STYLE OF CATERPILLAR TRACTOR USED IN ENGLAND

PLATE VI

45 horsepower machine, taking everything into consideration, proved to be better adapted to hauling a load of this size and has been adopted.

The caterpillar has proved its superiority for hauling heavy loads over all other types that have been developed up to this time. In the tests it hauled a complete section of 4.7-inch and 6-inch material, a tow of 17,000 pounds over country where horses could never have done the same work. The hauling power of a tractor of this type can be judged from Plate VI. This ground could never be crossed by a battery with animal transportation. A railroad trestle is a formidable obstacle for an animal drawn battery. The ties make a good road-bed for the tractor, however, and the material can be pulled across with the greatest ease. This might be absolutely necessary sometimes, when bridges of this nature are the only ones available. In loading a battery for transportation by rail the tractor can be used to haul the matériel up on the loading platform and then can load itself without the aid of ramps. Up to this time no attempt has been made to have the commercial types built with a view of using them for military purposes. The result is that some changes are absolutely necessary. The mobility of a tractor as it is now constructed is limited to a maximum speed of 3½ miles an hour. This would be sufficient for ordinary marching, but there would be occasions when a greater speed would be highly advantageous. The Field Artillery Board recommended that the commercial types now in use should not be changed radically because of the fact that they will be mobilized in time of war. In Europe the governments altered the commercial machines to suit the military needs, but their systems were in working order years ago, while it would take quite a little time in our country to accomplish the same thing. The board did recommend, however, minor alterations for the commercial types which probably will be embodied in the tractors bought for government use in the future.

The types of trucks available for military use divide themselves into two classes—the four-wheel drive for wheel steer and the two-wheel drive. The latter resembles the ordinary type of machine which may be used in most cases, but the tests which a truck will undergo in war will be much more severe than at any other time, with the result that something more powerful will be necessary. The four-wheel drive truck has been devised which approximates closely this type. It was developed independently in Europe and America at the suggestion of Army officers with the object of obtaining a vehicle which could go any place a mule team could. Not considering the size and technical details, most trucks have the same general features.

The mechanism of the two-wheel drive is practically the same as that of the ordinary pleasure car. The steering apparatus operates the front wheels only, compelling the car to turn on a large circle. Most of the country roads are not wide enough to permit this unless the machine is backed. An illustration of this disadvantage took place during the German advance into France. There were seven trucks travelling along a narrow road when suddenly they met their retreating infantry closely pursued by the enemy. The trucks could not be turned around in time and had to be abandoned with their loads. The brakes needed on a military truck should be strong enough to meet all emergencies. In this type the brakes are applied to two wheels only and will not hold on steep grades. The power is applied to the rear wheels and the weight of the truck on the front wheels does not add to the grip of the power wheels at all. The result is that when a truck of this type tries to cross a fair-sized ditch, the front wheels simply push against the far side of the ditch and do not pull themselves out. In this case the ditch can only be crossed by getting a start and bumping the front part over, a practice which ultimately racks the machine to pieces. The differential which adjusts the relative speed of the wheels does not lock. The action of locking differentials

PLATE VII

PLATE VIII

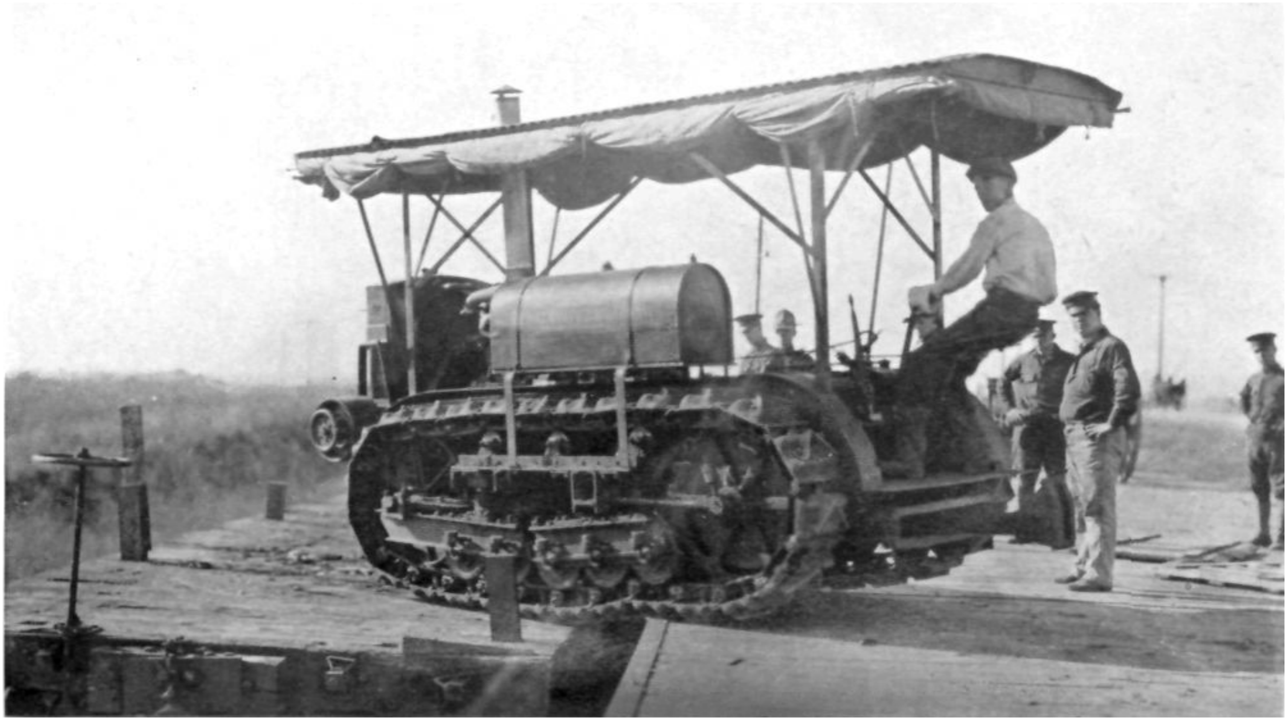


PLATE IX

PLATE X

is such that none of the road wheels of the vehicle can lag in speed behind the motor. The result is that when any wheel tends to do this the differential automatically locks and the driving shaft is made virtually solid from wheel to wheel. The need of this is shown in the two-wheel drive when one wheel is in soft mud, it spins and buries itself while the other stands still.

The general features of the four-wheel drive are the same for all makes. However, the Jeffery Quad has proved itself far superior to any of its competitors and has been recommended by all boards which have tested it, so that this particular make will be discussed. The steering gear operates all four wheels which enables the truck to negotiate a sharp turn without backing. The rear wheels track perfectly with the front ones. Power is transmitted to all four wheels, thus taking advantage of the fact that the weight of the truck and its load increase the gripping powers of the wheels. There are four speeds forward and one reverse, so that by using the lowest gear a great deal of power can be developed. The quad has the locking differentials. If one wheel gets traction and the others do not, the latter immediately receives all the power and as long as it can get traction it will pull the vehicle out of the hole. If this fails there is a winch on the back of the truck which is operated by the motor and by attaching a cable to something solid the truck can pull itself out. Plate IX on the right shows the truck getting itself out of a bad mud hole by this method. The picture on the left shows the truck attempting to cross the same hole without the use of the winch. In the tests at Fort Sill it was found that chains on the wheels were absolutely necessary on soft ground. In addition to the chains a device was tested out by the Jeffery Company, which is shown in Plate X. The additional bearing surface is large enough to prevent the truck from sinking very deep in the mud. The rims may be put on by two men in fifteen minutes. The brakes on the quad are five in number—four internal expanding in each wheel drum and one external contracting on the driving shaft. The four brakes can be operated by a foot pedal or the five brakes can be operated by a lever. The maximum speed of this vehicle with full load on fair roads is 14 miles per hour.

The truck has been tested for two distinct purposes—for traction and for carrying loads. In Europe the two have been combined, the trucks hauling from one to two trailers and carrying a load besides. In our country, due to different conditions, the truck has proved to be at its best when carrying loads only. The types recommended for this particular class of work are those of 1½ tons and 2 tons capacity. Abroad, while all kinds of trucks are used, the 3 and 5 ton predominate. Owing to the heavy axle loads these are very destructive to the roads, especially in war time, when the roads cannot be kept up.

The four-wheel drive truck has been thoroughly tested as a tractor. The results have shown that the heavy types of material cannot be pulled by trucks. In every case where the machines stalled, animal transportation went through without any difficulty. In hauling the lighter types of guns little experience has been had in the United States. It seems reasonable to believe, however, that a truck cannot pull the material to the difficult places where horses can go and cannot develop the speed that is needed in emergencies. The Marine Corps tested out motor transportation for hauling 3″ gun matériel in expeditionary work. It was found that the four-wheel drive was the best type of machine for that purpose. The trucks were used on good roads carrying a load of 15 men, 100 rounds of ammunition and towing at the same time a loaded caisson and gun. The matériel was not able to hold up when hauled at a speed exceeding 8 miles an hour. Several militia batteries have tried out motor trucks and tractors and have highly recommended them for hauling the 3″ batteries. Their views are probably distorted because the marches have only been made on the best kind of roads and they find a machine much more comfortable than a horse's back. If the powers of

PLATE XI

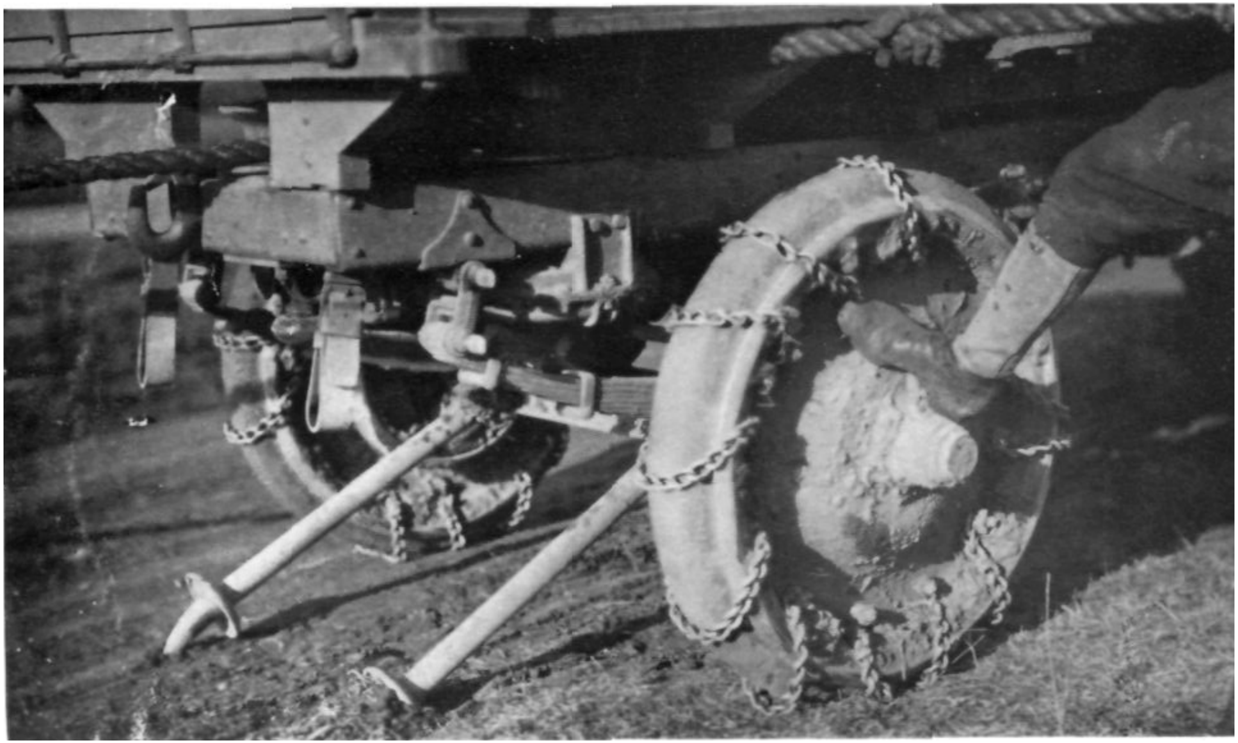
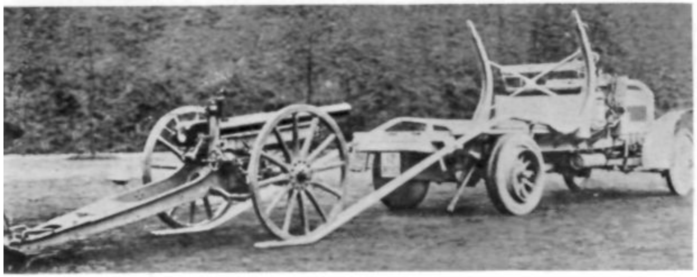


PLATE XII

A BRITISH TRUCK USED AS A TRACTOR

PLATE XIII

Plate XV



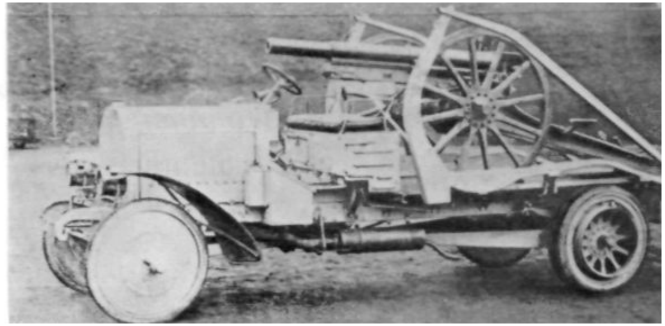


Plate XIV

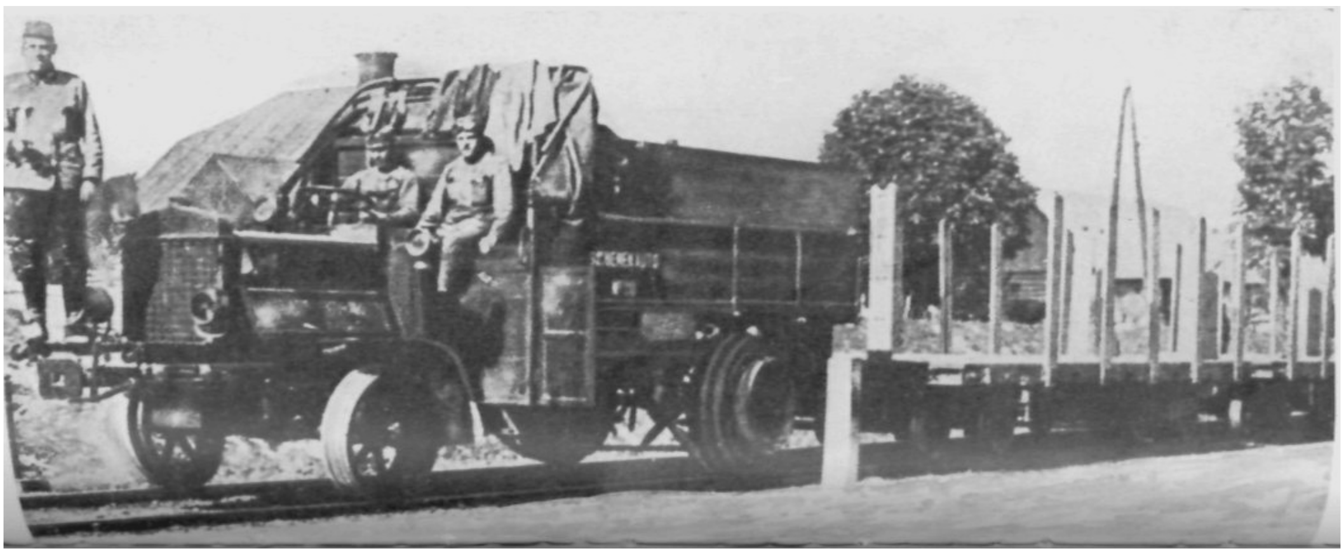


PLATE XVI

A FRENCH TRUCK.

trucks could be developed more it might be advantageous to supply militia batteries with motor transportation in order solve the horse question, which at present is a difficult one. Plate XIII is a picture of a British 3″ battery going into action. The question of hauling the lighter calibres might be solved as it is abroad by carrying the gun on the truck. Ramps are constructed on which the gun is run up; the ramps are then used to hold the gun in position. In the French model the platforms are made strong enough to permit the gun to be fired on the truck. These designs permit rapid movement over good roads, of guns assigned to special roles. Trucks are also fitted out with rims so that they can be used on railroad tracks of standard gauge. Ordinarily railroad cars carrying ammunition and matériel are used as trailers.

There are numerous types of tires that have been found to have their advantages for use on tractors and trucks. The caterpillar track has been discussed at length in the first part of this article. The prevailing type in Germany consists of two shoes, the outer about 22 inches wide and 26 inches long. The inner shoes are flanged so as to engage the wheel rim and are hinged in the middle to the outer ones. Two of the outer shoes are always on the ground at the same time. The shoes are made of steel, wood and iron. Some of the tires are cleated in order to get their grip. In one design the rear wheels have in addition to cleats, a system of steel blades operated by an adjustable eccentric on the axle and cut at right angles in the tire rim. By proper adjustment of the eccentric, the blades can be set to project beyond the surface of the wheel rim. Spikes are placed in the wheel rims sometimes, but the obvious disadvantage of this method is that they tear up the roads. A fairly good idea of the proper type of truck tire has been obtained from the numerous tests in this country. Experts unanimously agree on the solid rubber tires with chains for difficult places. On ground that is bad, but not bad enough for chains, the nonskid type is desirable. It quickly cracks, however, due to small pebbles embedding themselves in the tread. The French use the solid type for their heavy truck and the pneumatic for their light truck companies.

Since the war started motor transportation has so far exceeded the expectations of military experts that a shortage of gasoline has resulted and provisions have had to be made whereby the vehicles could burn more than one kind of fuel. The French government in order to make themselves independent of any temporary stoppage in the imports of fuel have compelled all of the cars to use a great variety—petrol, benzol and a half-and-half mixture of benzol with denatured alcohol. A considerable quantity of beet is grown in France, from which sugar or alcohol can be produced, and in emergency it can be utilized for the production of a quantity of commercial alcohol, thus increasing considerably the stock of home produced fuel. Due to the export demand, the war, and the domestic demand, the price of gasoline in this country has soared so high that it would be well to look around for some substitute. The majority of cars burn nothing but gasoline and would have to be altered if some substitute were used. Experiments have been going on in the commercial world with kerosene and a low grade of gasoline. So far, nothing satisfactory has been found. Kerosene leaves an excess of carbon in the cylinders and a low grade of gasoline deposits so much sediment in the carbureter that its use is limited. It seems reasonable to believe that the engineers will solve the problem in some way and relieve the difficulties arising from the shortage of gasoline.

In considering the subject of automobile transportation it might be advisable to touch upon some of the desirable features in the construction and maintenance of the machines used—the tractor and the truck. All vehicles should have enough clearance to allow their passage over ordinary obstacles and should the clearance be too low, a substantial part of the mechanism ought to strike first. The vital parts of the motor should be covered with light armor. This would apply particularly to the engine, radiator and gasoline tank. It should be a question, however, of whether the protection afforded would offset the disadvantage of the increased weight. Tractors should have a winch on the front like most of the types of trucks that are now in use have. The supply of gasoline should be sufficient for a day's run with a surplus carried either in a separate part of the tank proper or in a separate tank attached to the body of the machine. The tank itself is most advantageously placed when the gravity feed will supply gasoline with the machine on any grade. The carbureter ought to be high enough in order that it will not become submerged when crossing a stream of ordinary depth. Powerful brakes are necessary and should be applied to all four wheels of the truck, so that they would hold the machine on any slope that it might have occasion to pass over. The lighting system should provide for two methods of illumination—one for ordinary use and one for emergency. An electric generator or storage battery could be used for electric lighting and kerosene in case that system failed. All machines should have the artillery type of pintle, which ought to be so placed as to accommodate the artillery lunette without deranging the machine. Trucks should have the four-wheel drive, four-wheel steer and locking differentials. The spoke type of wheel should be replaced by the steel plate type with hard rubber tires. Chains are absolutely necessary for hard pulling on difficult ground. Trucks should have the same impulse attachment that tractors are provided with, so that the engine can be started with a quarter turn of the crank. All types of vehicles ought to be standardized and should be limited to standard parts, especially bolts and nuts. Interchangeability of parts is a great advantage and makes the upkeep of the machines cheap. Spare parts should be carried with the machine, but only those that are necessary. All important parts of the machine should be easily accessible, so that in case of break down no time will be lost in repairing the damage. Periodical inspection of all motor equipment should be provided for. In this way defects would be detected and break-downs anticipated, with the result that the machines would always be doing their best work. Records should be kept in times of peace, of the mileage, loads, fuel, oil consumption, and tire replacement, so that if there are any defects they will be corrected before the machines are put into actual service.

Ammunition is pushed up much closer to the front line by auto trucks than it was in previous wars. Whether or not this can be accomplished in the United States is a question to be decided by actual experience. It is safe to assume at the present time that motor vehicles will be used in the division ammunition trains and along the line of communications, leaving animal transportation to play the same part as hitherto contemplated in immediate contact with the regiment. The size, weight and amount consumed of the modern war ammunition makes it imperative that trucks be used. If the heavy batteries are to be drawn by tractors, trucks must be utilized to carry the ammunition in order not to mix animal and motor transportation in the same unit. With light gun batteries organized for special roles trucks should carry both guns and ammunition. In the ordinary case it seems, at present, that animal transportation is superior to the motor for small calibres and will continue to be unless the percentage of improved roads increases.

It might be well to consider what some of the countries have done in the organization of motor batteries and ammunition trains. The German 42 cm. battery consists of two pieces, each piece and its accessories requiring five carriages and as many tractors. The battery is divided into ten units, each unit consisting of wagon and motor. In addition, four trucks accompany the battery carrying small parts. All of the tractors used above are essentially the type developed in Germany for agricultural purposes, having engines of 60 to 80 horsepower. The ammunition for these guns is transported in a special motor truck column. Plate XVIII is a picture of

PLATE XVII

PLATE XVIII

one of these batteries on the march. The Germans also have a 13 cm. gun mounted on a special car from which it is fired, the car being drawn by a tractor. Almost all of the German ammunition columns employ motor transportation.

In France there are two kinds of truck companies—the heavy and the light. The heavy company consists of 5 touring cars and 88 trucks used for personnel and ammunition. The light—2 touring cars and 36 trucks. Trailers are used a great deal, carrying the same load as the truck. In the trains carrying ammunition for the heavy guns, tractors and trailers are used more than trucks. An ammunition supply section for 3 batteries of 120 cm. guns consists of 6 two-ton trucks, four ten-ton tractors drawing two trailers of 2½ tons each, one repair shop and three touring cars.

In the United States it has been authorized to equip one of the 4.7″ batteries with motor transportation, according to the recommendations of the Field Artillery Board. This battery is to have eight trucks and five tractors furnished as soon as possible. Although the tractors have been tested out, this battery will be experimental, and if it proves satisfactory, all heavy batteries will probably be motor drawn. In regard to the ammunition trains, nothing has been definitely decided. Recommendations have been made to have the companies consist of 27 trucks of 2 or 3 ton capacity, a different number of companies being assigned to the different calibre guns, according to the plans submitted to the War Department.

Due to the war, the factories in the United States have been pushed to the limit to supply the demands of the nations for tractors, trucks and touring cars. The result is that the automobile exports have grown continuously until they have reached an enormous figure. Up to last June 14,500 trucks have been sent abroad. This increased output has required new and extensive plants to be added to the original factories. While Europe is getting the benefit of this now, if we should become involved in a war, there ought not to be any difficulty in obtaining an unlimited supply. Some idea of the speed with which domestic government orders have been filled recently, can be obtained from the record made in forming the new truck companies for the Villa chase. The awards were made for 54 trucks on Tuesday afternoon and the shipment left that same night. Of course this is probably an abnormal case, because the trucks might have been on hand, but it goes to show that if our demands can be supplied together with those of the European countries, in time of war we could rely wholly on domestic manufacture.

One of the most serious problems that we will have to deal with is the training of competent mechanics and chauffeurs. In all the tests which have been made lately with motor vehicles, the cars have been driven by experts sent from the factory, thus obtaining the maximum efficiency out of the machines. This will not be the case in service. Only in time of war will the government be liable to get chauffeurs from the factory. In the meantime what is being done to remedy the difficulty? Practically nothing. Something must be done on a large scale to educate a corps of men who can be used as competent chauffeurs and mechanics. The War Department is sending a few noncommissioned officers to some of the different factories for instruction. They are graded according to the work they do and when the course is finished the company sends in a report to the War Department, stating the proficiency or deficiency of the men. Captain Gordon Johnson inaugurated a school in New York City for the training of enlisted men. Applicants from the surrounding coast artillery posts attend classes at the automobile school of the West Side Y. M. C. A. An example of the conditions that will exist unless something radical is done was the lack of chauffeurs for the truck companies that went with the Mexican expeditionary force. Chauffeurs had to be hired from the factories at a great expense to the government. Perhaps, when motor transportation becomes more developed for military purposes in this country, a definite scheme of training will be put in operation. In France, as soon as the trucks are put together, men of the reserves are taught to act as chauffeurs. Their training consists of running up and down the street a few times under the instruction of a demonstrator. The results of this method show in the condition and life of the machines. In Germany a great many of the chauffeurs are taken from the factories and the Krupp works. This is typical of the German policy of using nothing but the best of everything. All drivers should have to pass a certain time in the repair shops; at the end of this time they should be qualified according to a standard with an increase in pay for the best drivers.

The Field Artillery Board sums up in a few words the advantages of motor transportation: "It is more expeditious, reliable, efficient and economical for artillery purposes than animal transportation." The saving alone in the original cost of a battery is $40,000, while $31,000 is saved annually in its upkeep. If the saving on forage were spent on fuel and lubricants, the battery could travel about 30 miles a day, a condition which would not be necessary very often. In addition to the above, there are countless other items in which there would be a saving—recruiting, shoeing animals, overhead at remount depots, quartermaster equipment of personnel, reduction of stable and barrack space and reduced cost of transportation by rail. The depth of the columns on the march would be very much less in motor batteries—about one-third the length of one that is animal drawn. The personnel would be fresh and capable of accomplishing more at the end of a march; horses would not have to be eared for and the question of water for the animals would be solved. The care of the machines in camp and on the march would be nothing compared to the care of the animals. Batteries would be able to manœuvre by night as well as by day if a suitable electric lighting system was installed. Heavy loads could be hauled at a much greater speed and through impossible places. While this work might be accomplished by increasing the number of horses, good draft would be impossible. Heretofore the question of transportation has been a serious one, but with the advent of the motor vehicle the problem has been solved.

Motor transportation in whatever light it is considered has more than proven its worth. Although the problem is still in an undeveloped state in this country, due to the lessons learned from abroad, great progress will undoubtedly be made within the next few years. Whether the limit of the adaptability of the power vehicle has been utilized or whether there are greater developments to come, there can be no doubt but that already its services have proved of immense value and that no combatant can take the field without it.

The Graphics of an Artillery Position

BY MAJOR LE ROY S. LYON, 4TH FIELD ARTILLERY

THE extent of artillery reconnaissance varies with the situation and between very wide limits,—between the surprise attack of cavalry, against which no preparation has been possible, and the deliberate detailed scouting, subsequently reduced to sketches for possible future use under conditions which may or may not arise.

The remarks following deal with a method of recording graphically a more or less deliberate reconnaissance and of utilizing this sketch or plot to secure and record thereon the principal initial data to be used by the firing units.

Since the gun is used in two planes, the vertical and the horizontal, a graphic system, if complete, should also employ both. Since the initial deflection, the angle of site, the height of mask, etc., with reference to the gun, are usually deduced or calculated from data measured at an observing station, some distance from the gun, the graphic system should similarly provide a simple means for making the transformations or relocations in question without the use of the algebraic formulæ at present employed for that purpose.

When the situation demands and time and opportunity are available for making a sketch of our own and the enemy's situation, it would be an advantage to so construct such sketch as to exhibit graphically (and thus permanently record) all the initial data to be used by the Battery Commanders, either at the guns or at the Battery Commanders' stations, or at both. The Battalion, or other higher, Commander, can thus more surely direct and control the fire units and, in case of necessity, conduct the fire of a unit against a target not visible to the commander of that unit.

The word "target" as used in this paper refers not only to hostile personnel, matériel, and animals, but also to any *point of* the observed *terrain* at which such targets are expected to appear.

In connection with the general subject of the reconnoissance, preparation, organization, and occupation of a position by several fire units, it is not infrequently noticed that deliberation and resulting accuracy in the battery, and efficient control and direction of Battery Commanders by the Battalion Commander, are both sacrificed on the altar of speed, even though the tactical mission neither requires nor justifies a surrender of control by the Battalion Commander nor the extravagant expenditure of ammunition used in proving that the initial firing data are estimates and not calculations. Often the early opening of hurried unprepared fire advances the time of disclosure of position without a corresponding advance in time of effective hitting.

In minor affairs, like the recontre of small forces, abbreviated reconnaissance and firing methods are sometimes necessary. On the other hand, when the main bodies have completed deployment and when the opposing infantry lines have stiffened and stopped, the intervening neutral ground ceases to be peopled with fleeting and sometimes inconsequential targets. Rapid methods must now be replaced by advanced, careful, slow and dangerous scouting, even up to our own infantry trenches, near which, in all probability, the artillery officer must conduct the fire of his guns located a mile or more to the rear.

The guns will remain for days and perhaps weeks immobile or, if moved, merely shifted at night to other prepared emplacements in the vicinity: targets must be scouted out not merely observed; our own infantry, but a few hundred yards from the hostile trenches, must be safe-guarded against our own artillery fire; communication to the guns in rear must be made secure and sure; above all the fire must be accurately timed and delivered, at an hour prearranged with the immediate superior

Infantry Commander who is charged with the execution of a definite mission by the employment of a force of which the artillery is a *part,* but only a part.

Our limited supply of ammunition, as a rule, has been dedicated to the training of the individual conductor of fire, two or more batteries seldom firing simultaneously under the direct control and direction of the higher Artillery Commander. The Battery Commander seeks a post near his guns the better to control his battery. In target practice he can see from the selected position the single target in his limited sector of observation, forgetting that in service he may be suddenly called forward and assigned a target which can be seen only from a point distant many hundreds of yards from the guns. Due to the customary limitations of our target practice and of ammunition supply, these more difficult problems are seldom attempted in firing practice, with the result, that, as a rule, definite plans have not been formulated for conduct of fire from the advanced position, for the calculation of firing data at such position, for the training of reconnaissance details in finding the target and assuring communication between the advanced position and the guns far in rear. In large affairs and battles, the problem just referred to will be the rule, rather than the exception, often involving many battalions. Though difficult and dangerous, ample time will be afforded to make the necessary preparations to deliver rapidly effective fire where and when needed,—it may be to-day or it may be next week.

With respect to communication it is believed that the development of a practical, simple, wireless telephone system of limited range, say three miles under all atmospheric conditions, and one not subject to interference by our own or hostile wireless system, is the present most pressing need of the Field Artillery. The telephone, buzzer, and semaphore do not and cannot so perfectly meet all the requirements of field service as a successful wireless telephone.

1. THE PLACE SKETCH (Horizontal Plane)

Normally this is made from the position which gives the maximum sector of observation for the mission assigned. This point is also the Battalion Commander's position, and should be the common observing station of all the Battery Commanders, if sure communication to the guns can be maintained. It is the logical position for all for the reason that it is the *best,* that it gives to the Battalion Commander *verbal* control and direction of all battery sheafs of fire, and because it gives to *each* Battery Commander the best view of the entire battalion sector to any part of which he may have to turn his battery fire. Assignment of battery sectors is a normal procedure, but if the Battery Commander is isolated and his observing station covers only his own battery sector, then it is impossible for him from his station to attack targets in other sectors which he cannot observe. This means either moving the Battery Commander to the Battalion Commander's station, or having the latter take over the battery, which is inadvisable when avoidable. In cases where the common observation station is impossible, the isolated Battery Commander practically becomes independent of control and direction, especially when sudden and unexpected tactical emergencies arise. It is often impossible to indicate, in time, to a Battery Commander at a distance, an ill-defined, indefinite target requiring immediate attack.

See Fig. 1, which is a copy of the chart, engraved on opaque celluloid. It is used for making the original place sketch. Around the centre, *O,* the Battalion Commander's position, are the range circles at 100-yard intervals. From the same centre diverge a series of radial lines marking mil readings, contraclockwise, as on the Battery Commander's telescope for each quadrant. The scale of range, 1 inch equals 500 yards, is such that at 3000 yards, 25 mils, the smallest division, is represented by a little over ⅛ inch, which is readily divisible by the eye in thirds or to about 8 mils. The exterior dimensions of the white

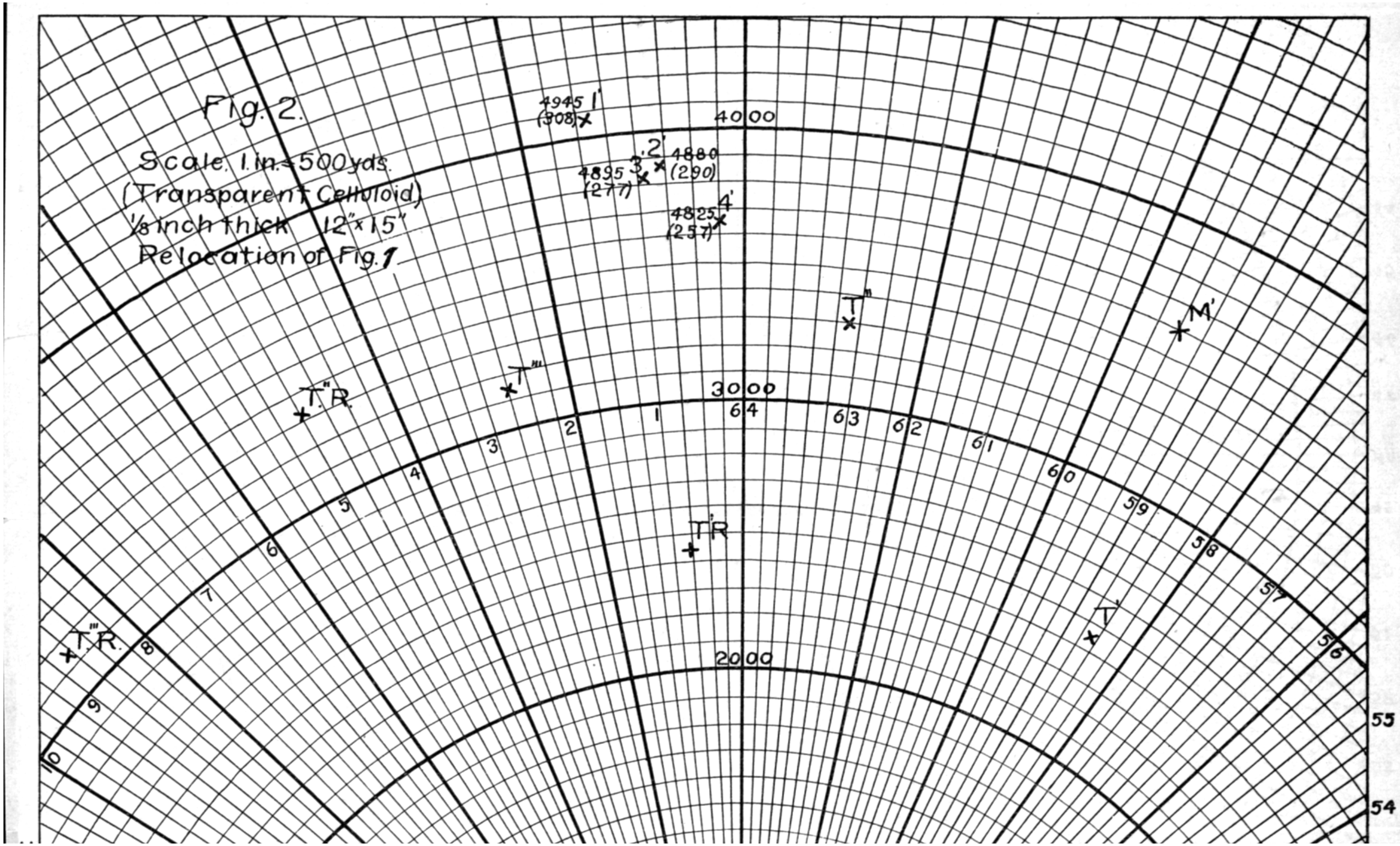
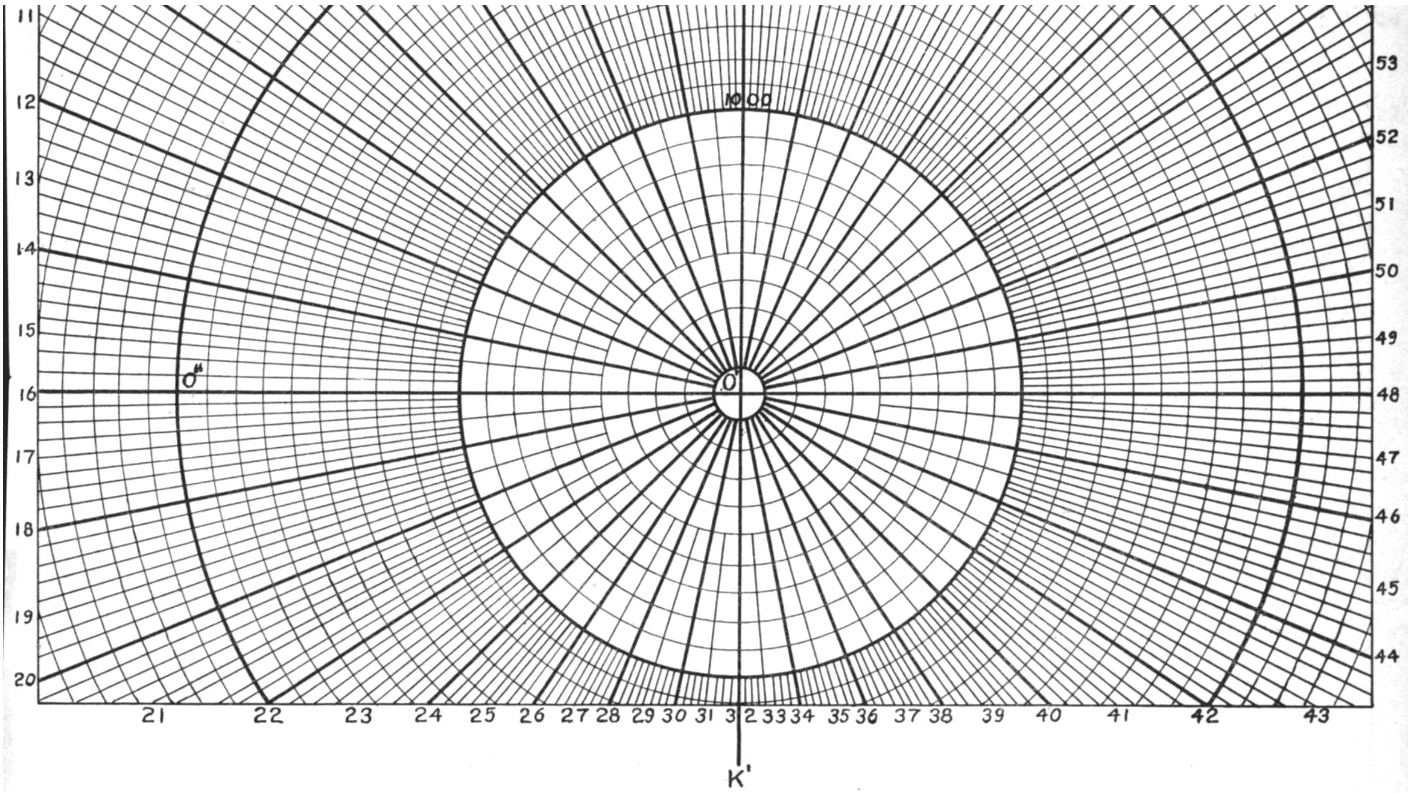


Fig. 2.
Scale. 1 in.=500 yds.
(Transparent Celluloid)
1/8 inch thick 12"x15"
Relocation of Fig. 1



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53
1000
O'
O"
K'

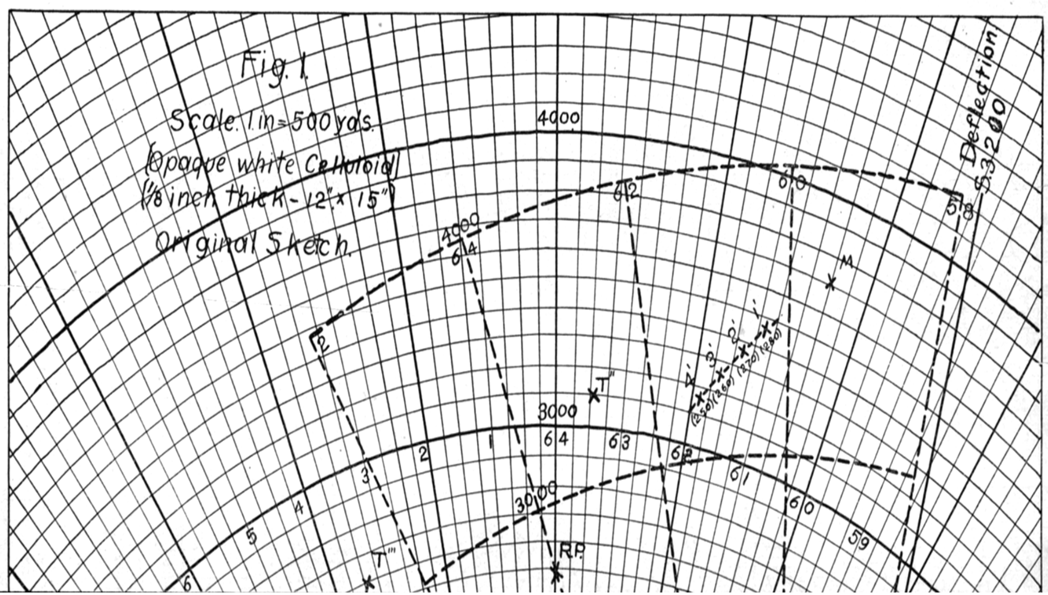
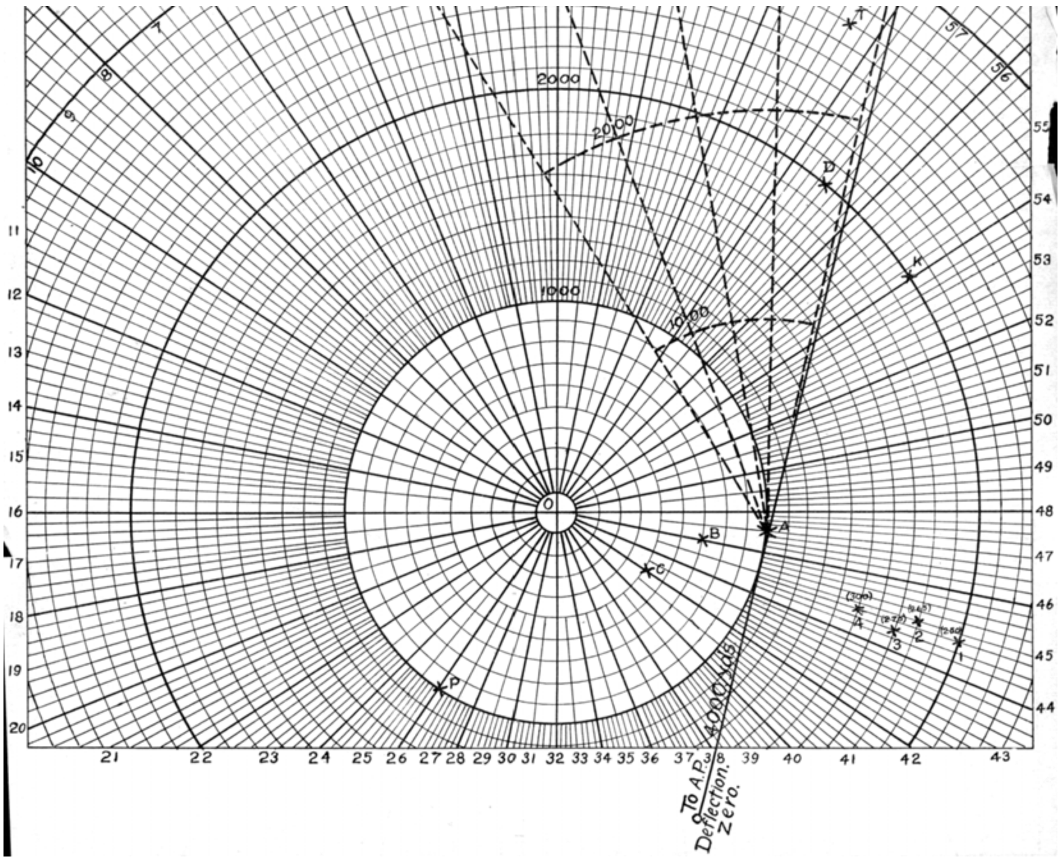


Fig. 1.
Scale. 1 in = 500 yds.
(Opaque white Celluloid)
(1/8 inch thick - 12" x 15")
Original Sketch.
Deflection
S.3200
4000
3000
R.P.
T''
T'''
M
(250) (260) (270) (280)



To A.P.
Deflection.
Zero.
4000 yds
2000
1000

opaque celluloid sheet ⅛ inch thick (see photo, Fig. 4), is 12 by 15 inches. There is available at *O* (Fig. 1) a Battery Commander's telescope and range finder. Select a reference point, *R.P.,* (Fig. 1) to the front, measure the range (say 2500 yards), and plot *R.P.* by a crossmark at that range on the *O*-64 line. Similarly measure at *O* the range and deflection from *R.P.* to the right guns of Batteries A, B, and C and to the targets *T′*, *T″*, and *T‴*, and plot all as shown on Fig. 1. Required: The ranges and deflection from Battery A to *T′*, *T″*, *T‴*. Take the *transparent* celluloid protractor, Fig. 2 (an exact copy of Fig. 1); place its centre *O* over *A* of Fig. 1, so that the line *O′*-64 coincides with *A-R.P.* of Fig. 1. Trace through *T′*, *T″*, *T‴*, which then show on Fig. 2 as indicated, and *read off* from Fig. 2 the relocated deflections and ranges for Battery A. For example, the original ranges and deflections of *T′*, *T″*, *T‴* from *O*, on Fig. 1, and the relocated ranges and deflections of the same targets from *O′* (on Fig. 2) are as shown in the following table:

	ORIGINAL (Fig. 1)			RELOCATED (Fig. 2)		
	T′	*T″*	*T‴*	*T′*	*T″*	*T‴*
Deflections.......................	5850	6350	350	5860	6287	275
Ranges	2700	3100	2600	2450	3300	3150

Similarly relocate the three targets for Batteries B and C (not shown in Fig. 2). The dotted lines on Fig. 1 represent, in outline, how the transparent protractor, Fig. 2, is superposed on Fig. 1. The relocation is simple, rapid, and well within the probable error of measuring instruments and guns. These duties may be safely delegated to an enlisted man. Fig. 2 has now become a permanent record of the initial ranges and deflections required to lay any battery on any one of the targets, or to lay *all* batteries on *any one* target. If we regard *A, B* and *C* as the Battery Commander's stations, and not the right guns, then the relocated deflections and ranges on Fig. 2 are the ones to be used by the Battery Commanders at *A, B,* and *C,* to *find* the targets indicated at *T′*, *T″*, and *T‴*.

It should be noticed that this system relocates *all* targets for any one battery by *one* operation, and automatically makes a permanent record of the transformations; that formulœ are not required; that no calculation involving plus and minus signs, obliquity, etc., are involved; that the accuracy of results is identically the same for all distances and directions of the guns from the observing station.

For a complete problem involving terrain and the plotting of our own and enemy dispositions, as seen or known at *O,* with relocations, see Figs. 4 and 5, which are reduced photographs of the celluloid sheets.

Suppose the aiming point (*A.P.*) 4000 yards to the rear, and that *T′*, *T″*, and *T‴* have been plotted from this point, instead of from *R.P.,* on Fig. 1, as shown. The deflections at *O,* from *A.P.,* in order, are then 2650, 3150, 3550. What are the relocated deflections for *A?* First, the initial or zero line through *A* to *A.P*. (in rear) must be established. Take (Fig. 2, place its 4000-yard mark over *O* (Fig. 1), the line *O*-64 (Fig. 1) coinciding with *O′*–64 (Fig. 2), *O′* to the rear. *O′* is now at the position of *A.P.*, and a line through *O′* and *A*. marked *A–S,* on Fig. 1, is the desired line. Relocate as before by placing *O′* over *A*, the line *O′*-*K′* coinciding with *A–S* prolonged. Read off the deflections and ranges from Fig. 2 at T'_r, T_r'', and T_r''' as follows, the zero being at *K′*, Fig. 2:

T_r''' Range 3150, Deflection 4085
T_r'' Range 3300, Deflection 3700
T_r' Range 2450, Deflection 3285

The ranges of course, remain the same as when the aiming point was in front at *R.P*.

Similarly for any aiming point to the right or left. From the above it is seen that although only a sector of the circumference is charted the relocator may be used as an "all round" plotter. The charts, however, were designed primarily for fire direction and control, for which purpose a reference point in *front* is the most usual and logical selection as it is the "front" that Battalion and Battery Commanders must keep under observation.

PROBLEM.—From a scout at *K,* Fig. 1, a knoll on the right of our infantry line, is reported the discovery of an important target at *M,* not visible from *O* or *A*. An officer is sent forward to *K* to conduct fire of Battery A against *M*. Before starting from *O* the officer plots *K* on chart at deflection (*R.P.* aiming point) 5400, range 2000, takes a copy of chart with him. He cannot see *R.P.* from *K,* but can see *O*. At *K* he reads angle in mils from *O* to *M* as 2033 mils and measures or estimates the range from *K* to *M* as 2400 yards. Plots *M* with this angle and distance, using Fig. 2 as a protractor. Then with Fig. 2 relocates *M* for Battery A, using the plotted *R.P.* as aiming point, tracing *M* at *M′*, Fig. 2. The relocated deflection is read 5950, range 3600 yards and he opens fire with that data by telephone from *K* to Battery A.

PROBLEM.—The fire of Battery A is being conducted from *O* against *T′* (Fig. 1). A target appears at *D,* 150 mils to the right of *T′,* and 2000 yards from *O*. What change of deflection to reach *D* is announced for Battery A? Inspection of chart shows that there is no change of deflection. Without the use of chart and range finder, this problem frequently requires an extravagant use of ammunition to find the correct shift, the practice being to use an inaccurate estimate.

PROBLEM (Fig. 1).—In rough terrain, it is found that the four guns of a battery must be placed on the shelves of a sloping ridge, at wide and different intervals and levels as indicated at 1, 2, 3, and 4, representing the positions of these guns. The angles of site of the guns from *O*, Fig. 1, are shown in parentheses. A good aiming point is at *P*. At an observing station, *O,* 2000 yards to the left front of the right gun, the flashes of four entrenched hostile guns can be plainly seen at 1′, 2′, 3′, and 4′. The ranges and deflections are measured and plotted as shown on Fig. 1, the angles of site from *O* as marked in parentheses. Targets are assigned from right to left. What is the initial range, deflection, and angle of site to be used by each gun against its assigned target? Relocate for deflection and range as previously described, centering *O′* (Fig. 2), in succession on 1, 2, 3, and 4, (Fig. 1), the zero line *O′ O″* coinciding with lines 1-*P,* 2-*P,* 3-*P,* and 4-*P,* in succession. The successive targets are traced through and the deflections and ranges are read off and marked as indicated on Fig. 2. Relocate for difference of level on Fig. 3, as described in the next section (the vertical plane). See thereon 1′, 2′, 3′, 4′.

From right to left the required ranges, deflections and angles of site are: Gun No. 1, 4050, 4945, 308; Gun No. 2, 3850, 4880, 290; Gun No. 3, 3825, 4895, 277; Gun No. 4, 3650, 4825, 257. From which it is seen that the deflection differences are different and as follows: —65, +15, and —70. The ranges vary from 3825 to 4050, the angles of site from 257 to 308. This is an unusual, but not impossible, case in the terrain assumed.

The above problems are simple examples of the very general application of the charts. A little consideration and ingenuity will suggest a solution for any problem of relocation in the horizontal plane, no matter how difficult.

The scale of chart, for range, is one inch equals 500 yards. For deflection there is of course no scale. The chart may therefore be used without change, for deflection, as a protractor, on any map and for range by remarking the ranges in accordance with the scale of the map. For aiming points beyond the limits of the chart, for instance at 9000 yards, multiply chart range figures by 3/2 and write products in pencil over principal range circle figures. Or, if the regular scale is desired, the line through battery to 9000-yard point is easily constructed.

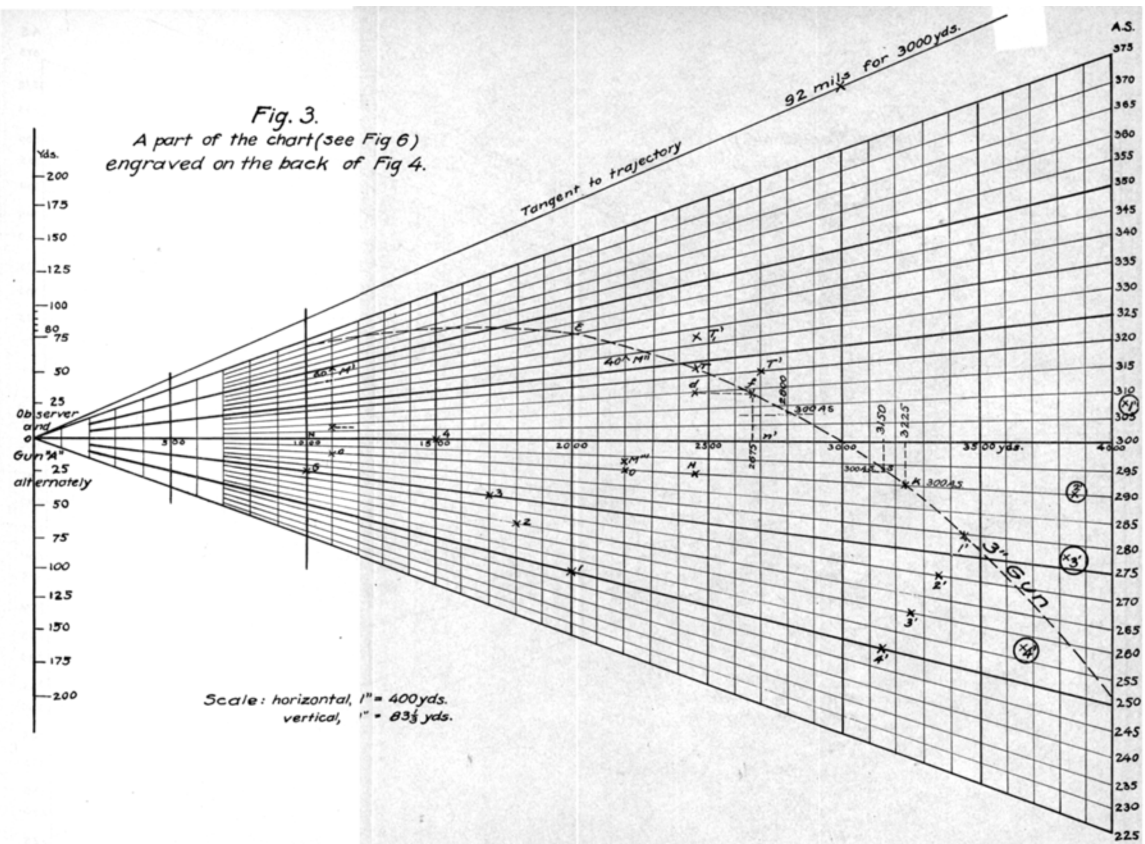


Fig. 3.
A part of the chart (see Fig 6) engraved on the back of Fig 4.

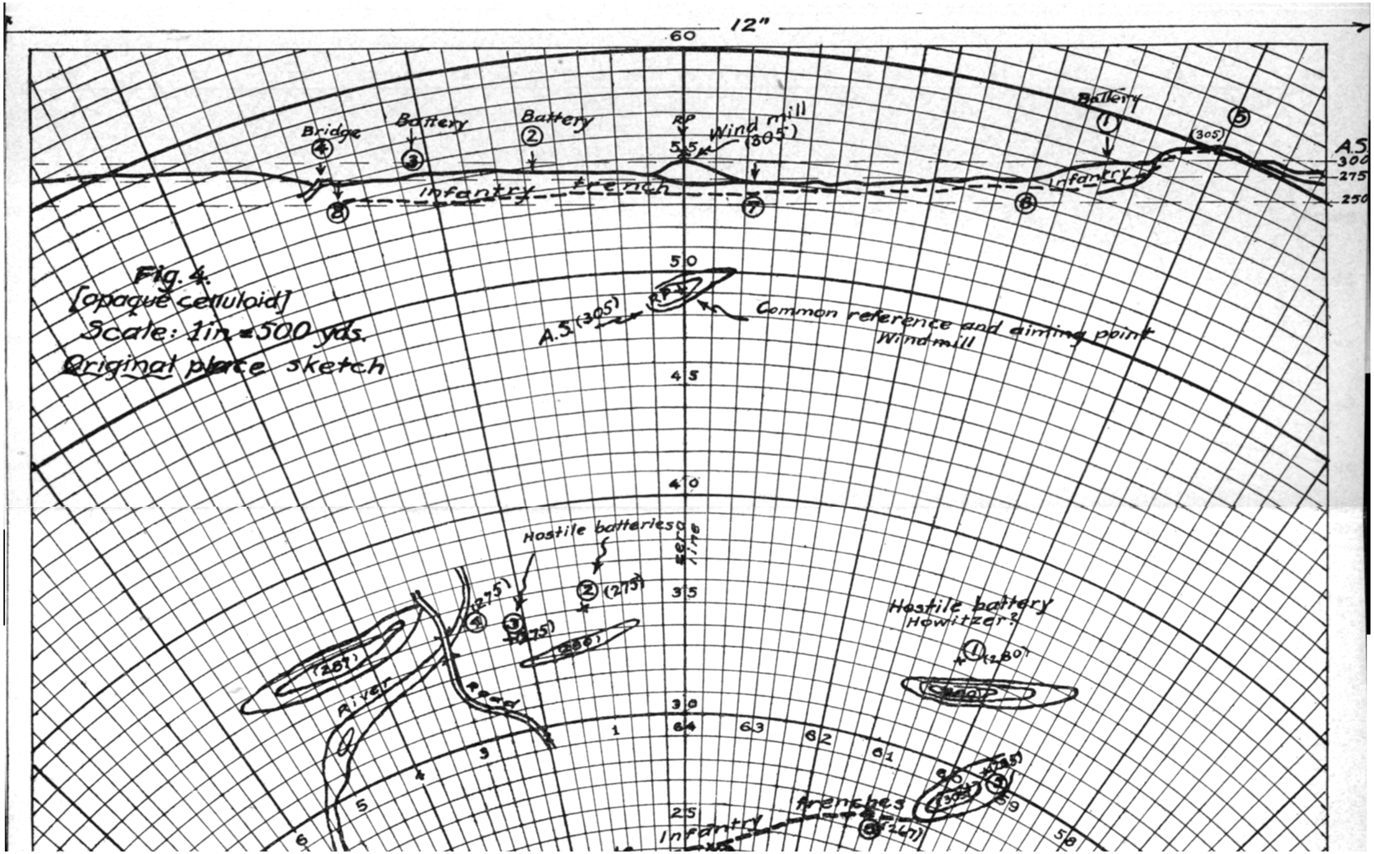
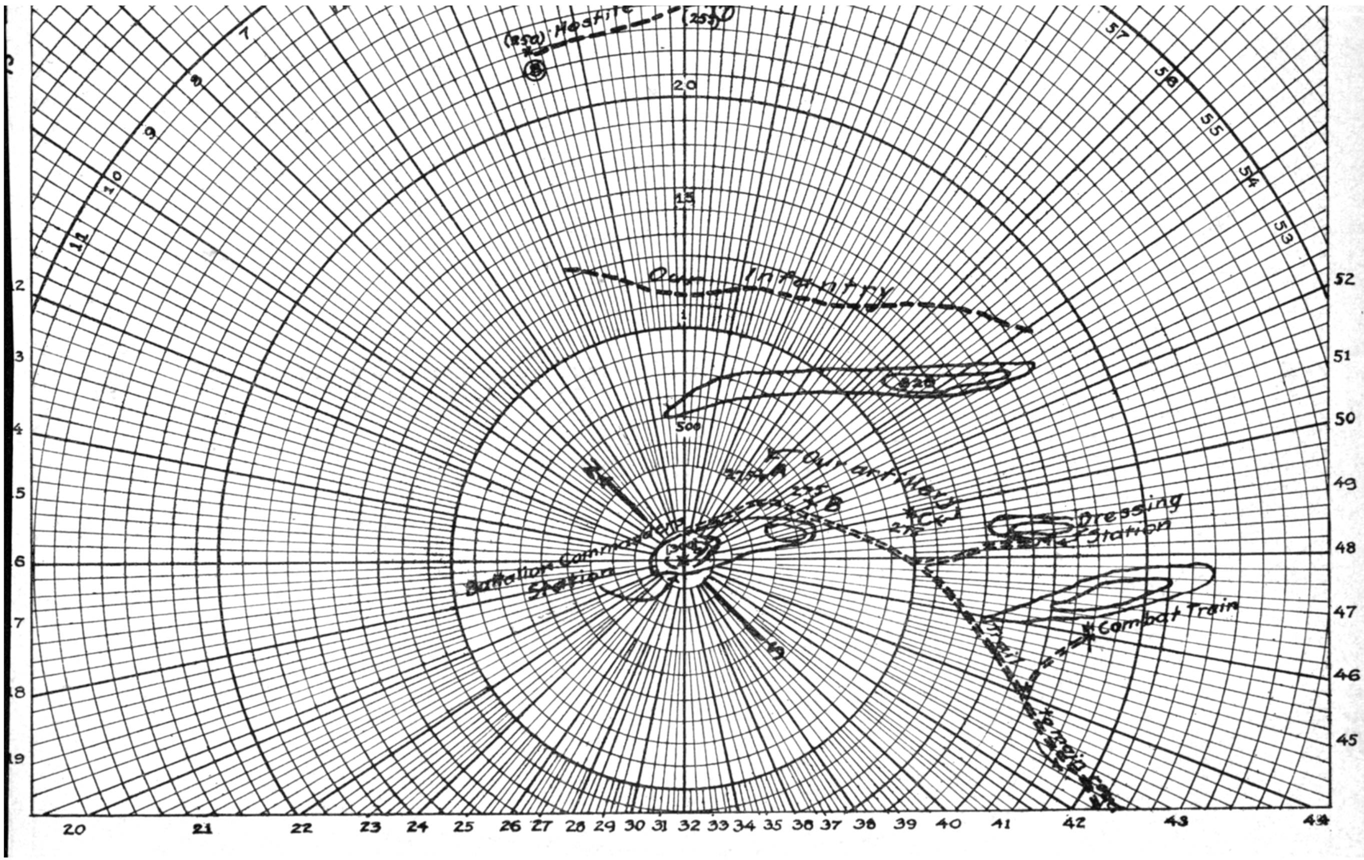


Fig. 4.
[opaque celluloid]
Scale: 1in = 500 yds.
Original place sketch



(250) Hostile
(253)
Our Infantry
Our artillery
Dressing Station
Combat Train
Battalion Command Station
to main

2. THE VERTICAL PLANE (See Fig. 3)

This consists of vertical lines marking ranges measured on a horizontal line in hundreds of yards from *O,* and radial lines from *O* measuring angles of site in 5-mil intervals above and below the horizontal line 300. The horizontal scale is one inch equal 400 yards; the vertical scale is one inch equal 83⅓ yards. This gives the intentional distortion of the three-inch trajectory plotted on the diagram. Since the trajectory is rigid, the single plotted trajectory is the trajectory for all ranges, the end of any trajectory, 2000, for instance, being the intersection, *E,* of the vertical line through 2000 with the trajectory. For this 2000-yard trajectory the radial line marked 340 would be remarked 300 in considering a problem relating to the use of this trajectory on the horizontal. The diagram is used for two purposes: (1) to graphically transform angles of site of mask, obstacle, or target, as read from an observing station to the angles of site to be considered at the guns; (2) by the use of the plotted trajectory (ordinates are differences of angles of departures), to solve, by inspection, problems involving characteristics of the trajectory, such as shooting over masks or obstacles at either end of the trajectory, angle of slope, interval of burst, etc. An illustration will explain the construction of the chart. The vertical distance 2000-*E* is contained between the radial lines 300 and 340, that is, 2000-*E* is 40 mils high, which at 2000 yards range is equal to 40 × 2 equal 80 yards, which gives the scale of yards drawn at the left of the diagram through *O*. This chart is engraved *in full* on the back of the opaque (Fig. 4) celluloid sheet, see Fig. 6 (photograph).

PROBLEM 1 (Fig. 3).—The angle of site of Gun *G,* 1000 yards from observer *O,* reads 275; the angle of site of target *T′* 2700 yards from observer *O,* reads 320. Plot both as shown; with dividers take the sum *N G*+*n′ T′* and apply it at range 2450 yards from *O* (now used as position of gun)—the assumed distance of gun from target, and plot T'_1. Read transformed angle of site as about half way between radial lines 330 and 335, say 332½. Calculated by the usual formula the value is 332.2.

Similarly for cases with gun and target both below or both above the 300 line, taking the *difference in level* on the dividers in any case. In the same way the height of a mask or obstacle above a gun may be determined from data measured at any observing station *O,* not at the gun. An enlisted man, without knowledge of arithmetic, formulæ, signs or trigonometrical relations, may make these transformations after a few minutes instruction, as it is purely graphical. The difference in level between gun and target may be *seen,* so there is no mistake in signs.

PROBLEM 2.—T_1' is 2450 yards from Gun *A,* and 32½ mils above that gun as just shown. At what range will the trajectory through this target pierce the horizontal plane through Gun *A?* Plot *T* on the trajectory at 2450 yards. Measure by inspection 32½ mils *down* to *H*. The radial line *O-H* intersects the trajectory at *K,* the point required, which is at range *about* 3225 yards.

PROBLEM 3.—There is a mask, *M',* 1100 yards from Gun *A,* whose top is 60 mils above the gun, and an obstacle *M'',* 2200 yards from Gun *A,* whose top is 40 mils above. By inspection the trajectory through *T* clears both, in the first case by about 18½ mils, in the second by about 2½ mils. Remember to measure the mils from the 300 line for the trajectory in question—in this case the line *O-K*.

PROBLEM 4.—What is the minimum range *A.S.* 300, for the obstacle *M''?* Measure down by inspection 40 mils from the trajectory itself to *M'''*. The corresponding minimum range, found by the intersection of the radial line *O-M'''* with the trajectory at *S,* gives about 3150 yards. Similarly the minimum range for the mask *M'* is about 2800 yards.

PROBLEM 5.—By inspection the maximum ordinate for

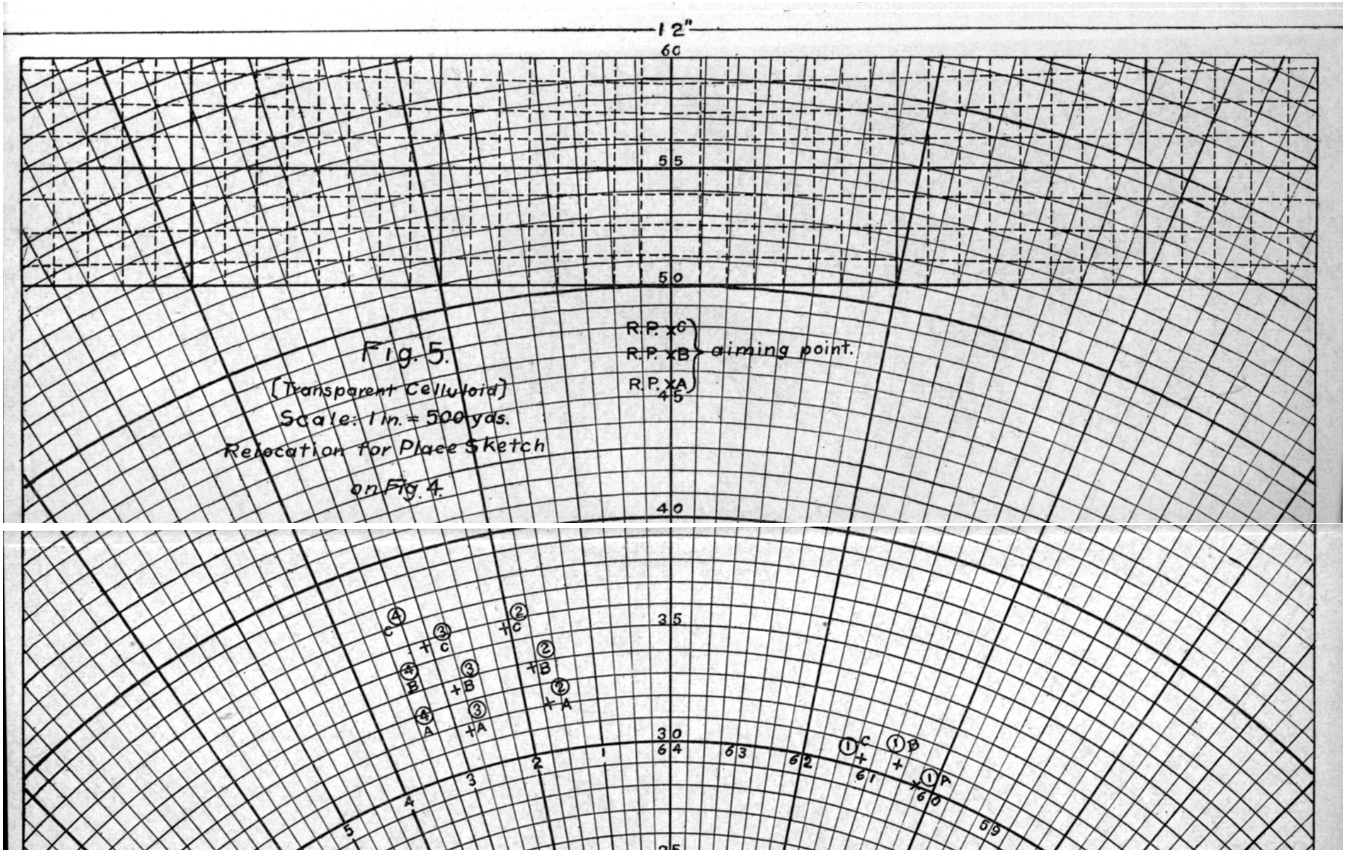
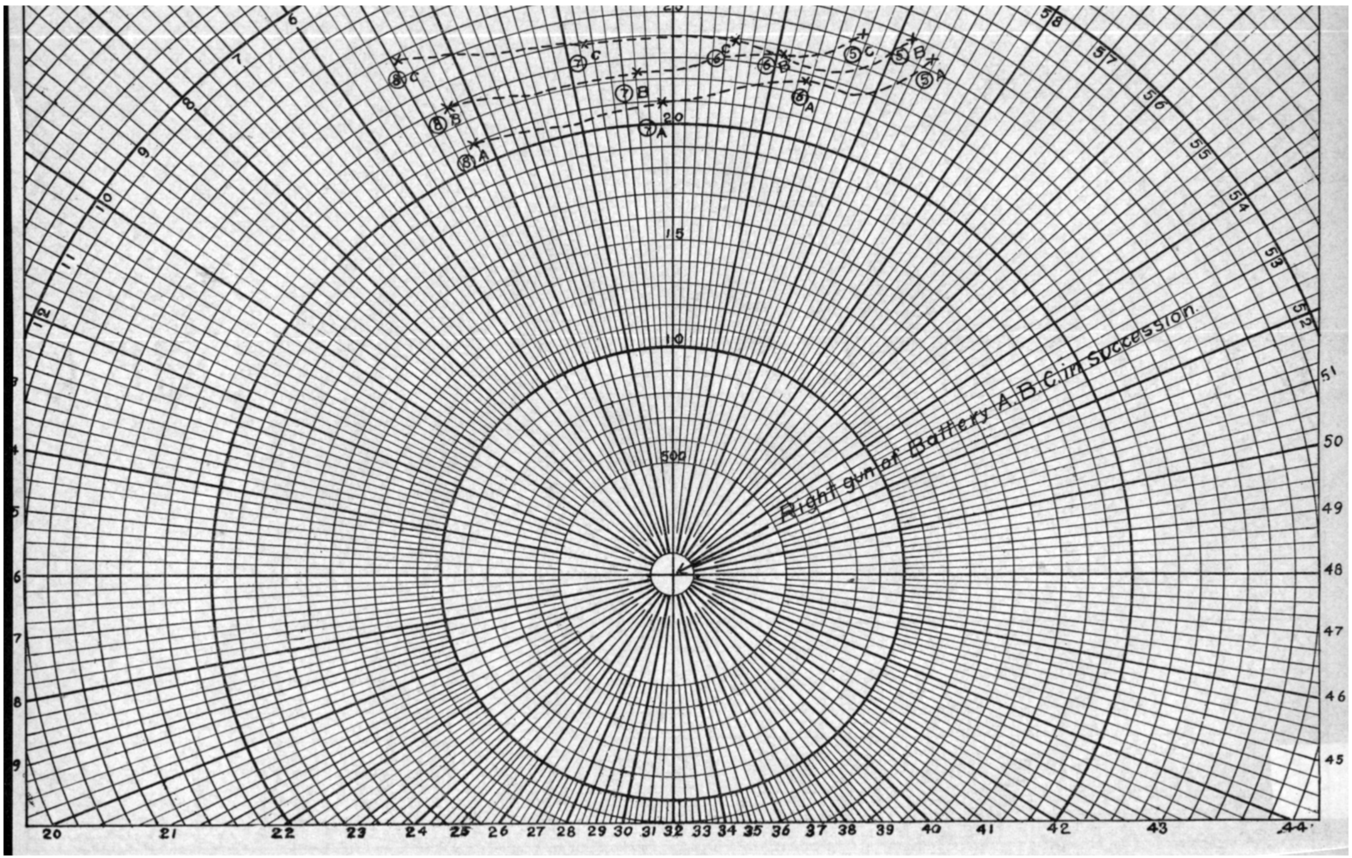


Fig. 5.
(Transparent Celluloid)
Scale: 1 in. = 500 yds.
Relocation for Place Sketch
on Fig. 4.


Right gun of Battery A. B. C. in Succession.

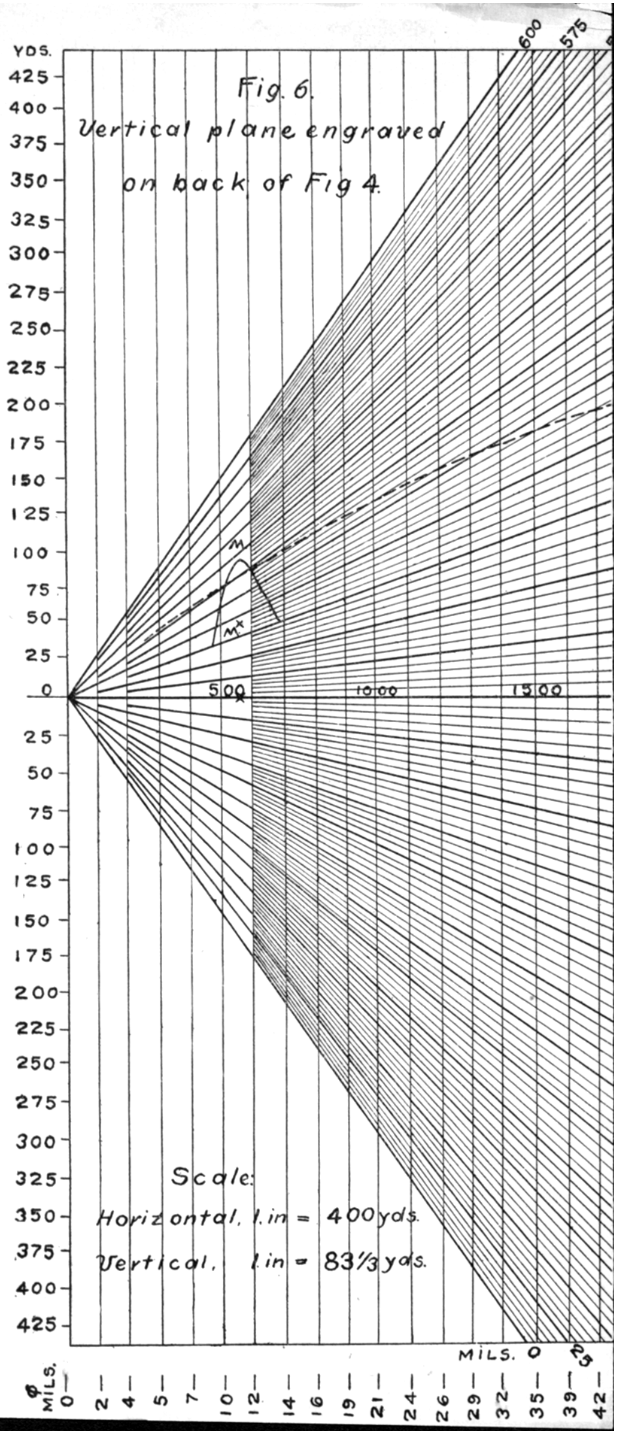
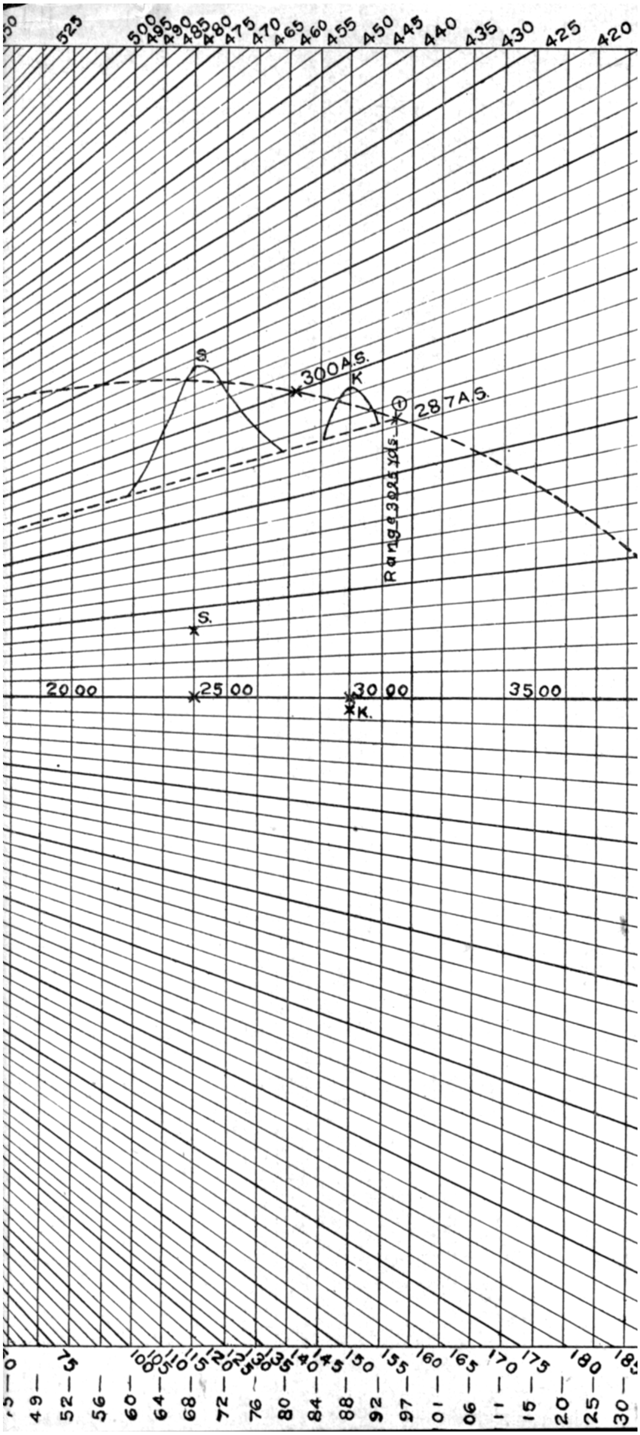


Fig. 6.
Vertical plane engraved on back of Fig 4.
Scale:
Horizontal, 1. in = 400 yds.
Vertical, 1. in = 83 1/3 yds.
YDS.
MILS.
500
1000
1500
600
575
M
M¹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430
425
420
S.
300 A.S.
K
287 A.S.
Range 3025 yds.
S.
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25 00
30 00
35 00
K.
75
100
105
110
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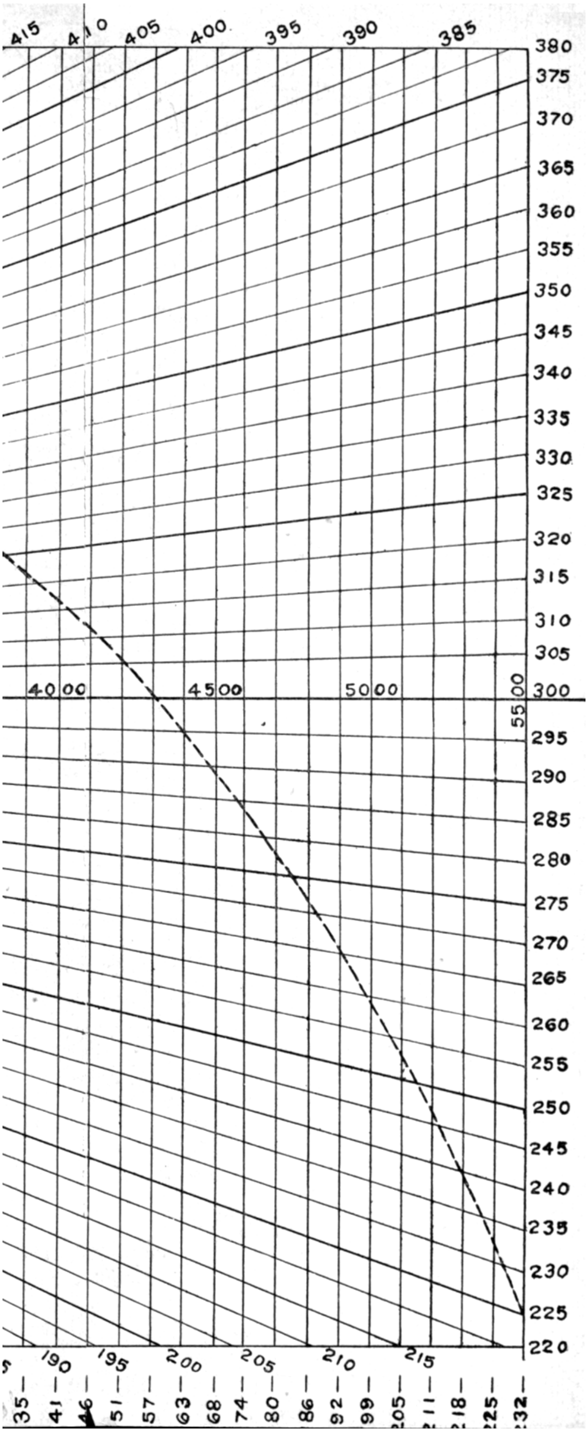

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3000 yards is *about* 85 yards; for 3525 yards, *about* 130 yards, etc.

PROBLEM 6.—Our infantry line is entrenched on the edge *d* of a horizontal plateau 2450 yards from, and 25 mils above, the guns *A,* located in a valley. On account of defective ammunition it is considered necessary that the trajectory pass at least 7½ mils (about 18 yards), above this trench. What is the minimum range and angle of site for the guns? Plot *d* 7½ mils from *T* to *d*. Through *d* draw *d-f* parallel to *H-K,* the horizontal plane. By inspection the minimum range is about 2675 yards, and the angle of site about 323. That is, our artillery firing must stop at (2675–2450) 225 yards in front of our trenches.

PROBLEM 7.—What is the average slope of the trajectory (not the angle of fall), from above the infantry trench *d,* to the plateau? Answer, 18/225 equal 1/125, say, or the projectile falls vertically 1 yard in every 12½ yards range.

PROBLEM 8.—An impact burst at *f* cannot be seen from Gun *A*. If at *A,* how high above Gun *A* should the Battery Commander be, to see *f?* Answer, about 61 yards.

PROBLEM 9.—Firing at a target with angle of site 300 and range 2400, what interval of burst are you getting with a height of burst of 15 mils? Answer, by inspection, about 400 yards.

From the above simple examples of problems it is seen that all problems in the vertical plane can be solved by inspection with sufficient accuracy for all practical firing.

It can also be assumed that the vertical plane chart would find more useful application in the curved and high angle of fire of heavy mortars and howitzers. Several trajectories for each calibre of such cannon would be necessary, the number to be determined by the limits of elevation within which a particular trajectory could be assumed rigid.

COMMENT.—None of these charts are presented with a view to replacing, but to supplement, the use of formulæ in cases:

where time is available; when the problem is difficult, due to distance of fire conductor from guns; to more readily indicate targets and to control and direct the fire of dispersed units; to save ammunition by affording a simple graphical means of securing more accurate initial data; to use the place sketch we are required to make as the basis of data for the direction of fire and also to secure battery firing data in certain difficult cases. In practice, no matter what the theory, a large amount of ammunition is expended in determining the correct deflection. When time presses, such a system may be justified. When time is available it is inexcusable. More than once it has been observed that three salvos of 4 rounds each, total cost about $100.00, have been expended in obtaining a deflection. A short time given to calculation, instead of to excited estimates, might have reduced the expense. This occurred in cases when the tactical situation did not require immediate fire.

It is also believed that, by the use of these simpler graphical methods, some of the duties now necessarily performed by officers, may be delegated to enlisted men during the organization and preparation of an artillery position.

It is also hoped that by their use, either in the present form, or enlarged and thrown on screens, indoor classes of enlisted men, militia and volunteers, may more quickly grasp the problems of relocation and the characteristics of the trajectory. Trigonometrical and geometrical relations are more quickly understood when actually seen that when imagined from algebraic formulæ.

Figs. 4 and 5 (photographs), show the set of two charts engraved on ⅛-inch thick celluloid with prepared surface for the use of pencil, the marks of which are readily removed with rubber. They may be used in rain and wind. Fig. 4 is opaque white celluloid; Fig. 5 transparent. On the back of Fig. 4 is engraved the "vertical plane" shown in Fig. 6.

On the top of Fig. 4 is shown a panorama of the enemy situation as seen from *O*. It will be noticed that the panoramic features are drawn in the proper deflection limits with respect to the corresponding features in the horizontal sketch and that a vertical scale is used in the panorama. Fig. 4 is the original sketch, Fig. 5 is the relocated record of the features of Fig. 4, showing by inspection the ranges and deflections for each of three batteries, A, B, and C, for 8 different targets, or 24 relocations in deflection and 24 relocations in range, or 48 in all, using reference point (*R.P.*) in front, as an aiming point. Fig. 6 is the complete vertical plane chart. The profile from Battery C to Target 1 thereon shows that it would be impossible for Battery C, if a three-inch battery, in its present position, to attack Target 1. On the left edge of Fig. 6 is a vertical scale in yards from which height of ordinates are read in yards. On the bottom of Fig. 6 a table of angles of departure, in mils, for each 100 yards, is set opposite the corresponding ranges.

The weight of each celluloid sheet is as follows: Yellow transparent, 15 oz.; white opaque, 1 lb. 6 oz.; leather case, 2 lb. 15 oz. Total weight 5 lb. 4 oz. The device is conveniently carried, in the field, under the arm, by a strap over the shoulder.

Field Artillery Fire

BY MAJOR E. D. SCOTT, FIELD ARTILLERY

(*Abstracted from a series of lectures given while instructor at the Army Service Schools*)

THE fire of field artillery is dangerous against any troops in any formation, anywhere within the range of the gun. A shell or percussion shrapnel or the head of a high explosive shrapnel is just as effective and will do as much damage at 6000 yards as at 1000 yards. A shrapnel bursting at the proper interval from a line of skirmishers 6000 yards from the gun will give the same percentage of hits as one bursting at the proper interval from a similar line 1000 yards from the muzzle.

If the effect of the shell itself is the same at all ranges, why should not shell-fire be equally effective at all ranges? Or shrapnel fire?

If all projectiles were alike in form, in thickness of wall, in balance, in density of metal, in density of bursting charge; of uniform weight; if the propelling charge always gave exactly the same initial velocity; if the projectiles always took the lands alike; if they left the bore with exactly the same components of force operating; if the atmosphere remained unchanged through the firing—it might be possible. But if all these conditions were fulfilled, it is certain that the human element, be it never so well trained, would cause error. In test firings, which are conducted under the most favorable conditions as to stability of mount, perfection of ammunition, good weather, painstaking care on the part of the personnel, it is found that the hits form a group to the right of the bull's eye. The centre of this group is called the centre of impact, and its distance from the centre of the target is the drift for that range. In some guns the sight is so constructed as to automatically correct for this. The mean of the deviations of the other shots from the centre of impact gives the mean error, which is used in determining the accuracy of the gun.

For discussion of artillery fire, two so-called "targets" are considered, the horizontal and the vertical. For any range, the horizontal target is the horizontal rectangle containing all the points of fall of a great number of shots fired at that range. Similarly the vertical target is the vertical rectangle pierced by all the trajectories. The centre of each is the "centre of impact."

Fire is adjusted for range when the centre of impact, the point of piercing of the mean trajectory, is at the centre of the material target. In either target the shots are grouped most thickly towards its centre, and for purposes of consideration and calculation, the length of the centre strip of each rectangle that contains 50 per cent, of all shots, is computed and tabulated.

These strips are called the "50 per cent. zone for length, for width, for height." The 100 per cent. zone, that is, the one containing all the shots, is taken as 4 times the 50 per cent. zone.

There is also a variation in the burning of the fuze in time fire, resulting in bursts short of and beyond the mean point of burst. Values of the 50 per cent. zones for time fire are, therefore, computed and tabulated, and the 100 per cent, is similarly taken as 4 times that of the 50 per cent. zone.

The product of the length of the 50 per cent. zone for length by that for width gives the horizontal area within which 25 per cent. of all shots will fall.

The following partial table is taken from the Handbook of 3-inch Field Artillery Matériel, 1912.

The trajectories are, of course, the same for time as for percussion fire, the tabulated zone for time fire relating only to the points of burst.

3-INCH FIELD GUN, SHRAPNEL. (50 PER CENT. ZONES.)

Range	Percussion Fire Length	Percussion Fire Width	Percussion Fire Height	Time Fire Length	Time Fire Width	Time Fire Height	Angle of Cone of Dispersion 11 deg. 00 min.
1000	24.8	.95	.63	....	.....	.....	.....
2000	45.4	2.4	3.28	34.5	1.54	2.45	13.02
3000	61.5	3.96	8.30	39.5	2.54	5.34	14.28
4000	75.2	5.3	16.05	44.1	3.40	8.92	15.22
5000	85.8	8.45	26.94	48.3	5.42	15.09	16.12
6000	92.4	13.7	40.52	51.7	8.78	22.67	16.48
000	97.2	21.9	58.20	55.1	14.00	34.44	17.20
000	101.0	33.2	82.60	57.8	23.40	52.55	17.50

From these data many problems may be worked out having to do with the probable effect of fire on targets of varying kinds.

From the table it will be noted (using the factor 4) that the dispersion in range varies from 99.2 yards at 1000 yards to 369.6 yards at 6000 yards. Ranges above that need not be considered, since the present type of carriage will not permit of fire above 6500 yards.

This means that, in the first case, if fire be delivered at a range of 1000 yards, the shots will be scattered along the ground from 50 yards short of the target to 50 yards beyond, and that in the second case they will be scattered from 184.8 yards short to 184.8 yards beyond the target. The dispersion for intermediate ranges may be similarly determined.

The corresponding lateral dispersions are 3.8 and 54.8 yards, that is, the shots will be scattered to 1.9 and 27.4 yards on either side of the centre of the target.

The corresponding vertical dispersions are 2.5 and 160 yards.

The centre of the hypothetical "vertical target," being at the ground, it is evident that one-half the shots—those that would pass through the lower half of it—are practically lost, since they strike the ground short of the target. The remainder pass through the upper half of the target, scattered in a vertical area 80 yards high by 54.8 yards wide. The low percentage of probable hits at such a range may be imagined.

A rough illustration will serve to show how important to the artilleryman is a knowledge of the principles of dispersion and probability of hitting.

A gun and caisson in firing position present a vertical target about 2 × 4 yards. At 1000 yards the 50 per cent. zones for height and width are .63 yards and .95 yards, the 100 per cent. zones are 2.5 and 3.8 yards, therefore nearly all shots should be hits.

At 2000 yards these zones are 3.28 and 2.4 yards respectively. The product of these is 7.87 square yards, is slightly less than that of the material target, and is an area containing 25 per cent. of all shots. Therefore slightly more than ¼ of all shots might be expected to hit.

At 3000 yards these zones are 8.30 and 3.96 yards, giving an area 4 times that of the material target. But as explained, this area contains but ¼ of the shots, hence the number of hits to be expected on the material target is much lower than at 2000 yards.

What is the chance of one battery destroying another with shell fire? Assuming the fire to be accurately adjusted, the solution of the problem shows the following:

At 1000 yards 1 shot is required for each hit.
At 2000 yards 4 shots are required for each hit.
At 3000 yards 15 shots are required for each hit.
At 4000 yards 40 shots are required for each hit.
At 5000 yards 100 shots are required for each hit.
At 6000 yards 263 shots are required for each hit.

In the School of Fire computations a factor of error is introduced for field conditions, which largely increases the number of shots necessary to a hit. In the school firing in the spring term 1912 the percentage of hits obtained was higher than that calculated.

If we assume that one high explosive shell striking a gun or cassion will put the gun out of commission—not at all a certainty—a battery would require 73 per cent. of the shell it would ordinarily have with it to account for one hostile gun at 6000 yards, or all for three guns at 5000 yards.

What is the chance of hitting a trench with shell?

Consider the trench shown in Fig. 4, Ap. 2, F. S. R. 1914. It may be assumed that, for the 3-inch guns, shots striking within one yard of the front edge or one foot of the rear edge (outside) will be effective. Such a trench presents a vertical target of from .08 of a yard at 1000 yards to 1.4 yards at 6000 yards, a horizontal target of 9 yards.

Lateral dispersion need not be considered. Calculations show the following expectancy of hits:

At 1000 yards 1 hit per 14 rounds.
At 2000 yards 1 hit per 50 rounds.
At 3000 yards 1 hit per 50 rounds.
At 4000 yards 1 hit per 50 rounds.
At 5000 yards 1 hit per 50 rounds.
At 6000 yards 1 hit per 55 rounds.

Above 2000 yards the increase in vertical dispersion is practically compensated for by the greater height of target, due to the increased angle of fall.

In howitzer fire such a trench presents a vulnerable horizontal target about 6 yards in length, and the vertical target it presents is from 2 to 6 yards, depending on the range and zone charge used. Great effect may, therefore, be expected from this cause as well as from the greater weight of metal.

Assuming (in the absence of proper tables of dispersion), that the 4.7″ howitzer is as accurate as the 3-inch gun, and it seems to be, the expectancy of hits for its fire is as follows:

At 1000 yards 1 hit per 6 rounds.
At 2000 yards 1 hit per 17 rounds.
At 3000 yards 1 hit per 20 rounds.
At 4000 rounds 1 hit per 22 rounds.
At 5000 yards 1 hit per 26 rounds.
At 6000 yards 1 hit per 24 rounds.

In other words, the howitzer gives more than double the number of hits. If the charge for zone 2 be used (up to 3500 yards) the greater angle of fall should give a higher percentage of hits, and that for zone 1 (up to 2000 yards) one still higher.

Aside from the greater apparent accuracy, the burrowing effect of the howitzer projectile is greater than that of the gun projectile, and it is always a much heavier and more powerful projectile in every way, and vastly more destructive.

The howitzer projectile is, however, moving very slowly at the summit of its trajectory, hence is much affected by atmospheric conditions. Some authorities claim that it is always very inaccurate on that account.

Suppose now, the trench to be dug at right angles in the face of a very steep cliff. The target it presents approaches the full width of the trench as taken above, or roughly 3 yards, and the percentage of hits at all ranges will be greatly increased. At 2000 yards, for example, it is just about the length of the 50 per cent. zone for height, hence about 50 per cent. of the shots would be hits.

From the above it is evident that *the nearer the site of a trench approaches a level plane, the more nearly safe is that trench* from shell fire and the same is true of shrapnel fire. Blind adherence to the book rule of putting trenches on the military crest results in presenting the most favorable targets possible to hostile artillery.

The dispersion of shrapnel is practically the same whether fired for percussion or time, but in the latter case the error of the fuze is added, affecting the action of the bullets.

A normal burst is one at such a distance from the target that at the latter the density of bullets in the cone of dispersion is one square yard. In other words, for the 3-inch gun, the area of cross section of the cone of dispersion at the target is 252 square yards. Practically the density of bullets increases from the perimeter towards the centre. The diameter of the cone of dispersion for such an area is 18 yards. The effective sweep of the shrapnel is 20 yards, and this determines the interval of 20 yards between guns, in universal use.

The pattern is elliptical in form and varies from 350 yards (effective depth), at the gun, to 40 yards at 6000 yards.

The target will be in the first third of this pattern, and consequently in the first third of the beaten zone of a number of shots fired with the same data.

The beaten zone for the 3-inch gun may be taken as 400 yards at all ranges.

It is considered that an average height of burst of 3 mils gives the greatest percentage of normal bursts at all ranges. This is not strictly correct, a height of burst of 4 mils being necessary or above 4000 yards.

A calculation of shrapnel patterns shows that they decrease slowly in length from 350 yards at the muzzle to 200 yards at 3000 yards range. At 4000 yards the length is only 100 yards and it drops to about 40 yards at 6000.

No better argument could be desired for using the 3-inch gun, whenever possible, at ranges of less than 4000 yards.

The velocity of the shrapnel bullet is that of the projectile at the moment of bursting, plus an additional velocity imparted by the bursting charge. For the 3-inch gun this additional velocity is taken as 275 f. s.

At 3000 yards the upper element of the cone of dispersion is just below horizontal, at ranges below that it is inclined upward, reaching a maximum at 6 degrees in fire at will. The farther ranging of these bullets are likely to be ineffective. Above 3000 yards the upper element of the cone of dispersion is inclined downward, and all bullets from a majority of the shrapnel will still be effective when they reach the ground.

A few very high bursts, the number increasing with the range, will be ineffective in part, the bullets in the upper part of the cone of dispersion falling below the required 400 foot seconds velocity before they reach the ground.

The effect, then, is largely measured by the area swept, and as shown above, this diminishes rapidly with the range after 3000 yards is passed.

If we consider the target to be a line at right angles to the line of fire it will be included in the sweep of all shrapnel bursting in it at the shorter ranges in that of a majority of those at mid ranges, and in that of only a few at long ranges.

Perhaps this idea may be more readily grasped by a comparison of the relative lengths of the 100 per cent. zones for dispersion in range, and the patterns. At 2000 yards the dispersion in range is about half the length of the pattern; at 4000 yards it is about 3 times, and at 6000 yards about 10 times the length of the pattern. It is evident that at the last range many patterns may be wholly short of or beyond the target.

The above discussion relates in general to normal bursts, as a majority of bursts will be of that character.

High bursts are those caused by the fuze burning too quickly, by the trajectory being too high, or by both. Effect is lost by the greater dispersion of the bullets by the time they reach the ground, by their loss of velocity, and by the whole cone passing, perhaps, above the target.

Low bursts are caused by the fuze burning too slowly, by the trajectory being too low, or by both. Effect is increased by the greater density of the bullets, but lost by the smaller pattern, and in fire for effect a large proportion of them are certain to be outside the target.

The angle of fall, plus one-half the angle of opening of the cone of dispersion, determines the slope that can be swept by shrapnel bursting at the crest. The following table gives the slopes that would be swept by 3-inch shrapnel:

1000 yards, 7 degrees, a slope of 1 on 8.
2000 yards, 10 degrees, a slope of 1 on 6.
3000 yards, 15 degrees, a slope of 1 on 3.8.
4000 yards, 20 degrees, a slope of 1 on 2.8.
5000 yards, 25 degrees, a slope of 1 on 2.
6000 yards, 32 degrees, a slope of 1 on 1.7.

It is evident that what are considered "practicable" slopes, are not safe from shrapnel fire. Howitzer fire will sweep slopes relatively twice as steep.

INFANTRY UNDER ARTILLERY FIRE

Par. 212-219, Inf. D.R., 1911, discuss the advantage of infantry under artillery fire. The formations advocated are, platoon or squad columns, and a succession of thin lines. The first is a column of men 2 abreast and 14 deep, the second a column of 8 men in single file, the last (ordinarily) lines of men at 8 yards interval, with from 100 to 250 yards distance between lines. The idea in any case is to present as small a target as possible to the effect of a single shrapnel.

An average man presents vertical area of about .6 of a square yard. The normal burst giving 1 bullet per square yard at target, and the width of the zone of dispersion at target being 18 yards, it follows that each of the men in the front line has .6 of a chance of being hit by such a burst. Men covering them run little risk, since the shrapnel bullet, unlike that of the rifle, has little effect after passing through the body or pack of a man.

At medium and short ranges the vertical target presented by the squad column is .7 of a yard, the platoon column 1.45 yards, the thin line described above 1.2 yards plus an equal area presented by the two men in the next line, where the density of bullets is very slight. A skirmish line of one man per yard presents a vulnerable area of 10.8 square yards. These figures, then, show the number of hits to be expected.

Passing a given point in these formations under shrapnel fire, a platoon of 32 men might expect the following losses, assuming the hostile battery to be using parallel fire:

In platoon column	1.45
In squad column	2.8
In skirmish line	19.2
In thin lines	19.2

The argument seems to be all in favor of the small column. But it must be remembered that the thin lines, say at 150 yards distance, will require 12 minutes to pass the danger point, the movement is likely to attract little attention and if it does, an abnormal amount of hostile ammunition must be expended in meeting it. On the other hand, it is certain to be very productive of loss of time and control, and of straggling. Like most other matters in the field, local conditions will determine which method of advance is preferable in a given situation.

Experiment has shown that dummy prone figures, under shrapnel fire, receive 60 per cent. of hits in the back, and 40 per cent. in front, when packs were not worn, and just the reverse when packs were worn. The American pack is not such an effective protection as is that of the French (who made these experiments) and it seems probable that with it the hits will be distributed about equally.

Against 18 silhouettes prone 2.7 hits may be expected from a normal burst. But normal bursts are infrequent, and an analysis of fire for effect against such a target at the Field Artillery School of Fire shows about 2.7 per cent. of figures hit per shrapnel. Assuming that an equal number of hits would be made on the back, the average per shrapnel is .97 or 1 figure.

It is not uncommon for a single shrapnel to wipe out such a target as the one under discussion, but the greater the number fired the more closely will the percentage of hits approximate the figure given.

This corresponds with similar calculations made by various authorities. It seems small, but given the opportunity of firing against prone figures only in skirmish line, a single battery with its normal supply of ammunition, would at this rate inflict a loss of 27.6 per cent. on a brigade of infantry, in fire of an hour's duration.

A column of squads presents a front of five men, or 3 square yards. If we consider such a column advancing in the plane of fire, the target it furnishes is as wide as the column, while its depth is determined by the slope of all of the upper clement of the cone of dispersion. The projection of this target on the cross section of the cone of dispersion at the head of the column will contain all the bullets that can effect the column. Assuming the mean trajectory to be at the centre of the front of the column, this projection is roughly 5 yards by 10, hence 50 bullets will strike within the column and all may find separate billets, though the chances are very much against it.

If the burst occurs at or close to the head of the column, the number of possible hits is increased. If in a defile, as a street or bridge, such a target would be attacked by concentrated fire, quadrupling the effect. If not confined by some such obstacle, the column would deploy at once and distributed fire would be in order.

The effect of a single shrapnel, at normal burst, is practically independent of the range.

Against mobile cavalry and artillery, led horses, limbers, trains, etc., shrapnel is very effective.

Against shielded artillery a great deal is necessary to produce effect. The cases and heads merely punch holes through the shields, but would damage other material. The bullets will not pierce the shields, but some will find their way through ports in them, under them, and between them and the wheels, and between carriages. Low bursts, increasing the density of bullets, increase these chances of reaching the personnel.

Against overhead cover it is of little effect. Against troops in trenches it is effective, inflicting casualties, shaking the nerves of the defenders, interfering with their aim by its smoke balls, etc.

In an attack the artillery fire is quite likely to be much dispersed; directed against hostile works, batteries, infantry lines, possible positions of supports and reserves, lines of approach, etc., keeping the enemy busy on his entire front.

The infantry attack advances irregularly, some parts finding better cover or less resistance, or having more vigor.

The artillery fire is shifted as necessary to enable the advance where hostile opposition is strongest. Finally the time arrives when some portion of the line is in position to drive home its attack, and then batteries are designated to concentrate their fire on the front that portion is attacking. Under a heavy storm of projectiles the attack endeavors to carry the hostile position. The supporting artillery sweeps the ground beyond and to the flank of the position carried, to beat off possible counter attacks and give the successful infantry time to establish themselves in the position.

Victory is usually attained by the capture of one or more strong points in the hostile line, which renders other positions of the line untenable. Rarely does it happen that a whole position is carried at once, and it could probably never be done except by overwhelming superiority of numbers, and at heavy cost.

In defense the same general methods are employed to beat off the hostile attack, and if it gains a footing in our lines, to render that footing untenable, to prevent hostile supports reaching it, to prevent further advance through it, to help our infantry retake it.

The Employment of Artillery in the Present European War

BY WALTER W. MERRILL, FIRST LIEUTENANT, 4TH FIELD ARTILLERY

MATÉRIEL

ALL nations in the present European war are armed with a modern quick-firing field gun of approximately 3″ calibre. The Russians are equipped partly with this gun and partly with a semi-quick firing gun of an older pattern. Russian officers, however, speak well of the latter weapon. It has given good service.

In other words, at the outset of this war all nations had thoroughly developed the 3″ light field gun. Heavy artillery had by no means been so thoroughly developed. In this field Germany led the world. Other nations lagged far behind, hardly suspecting the possibilities of those giant types of ordnance, which are now so familiar. The French were hypnotized by their 75 mm. field gun. They thought it was a well-nigh universal weapon. They had a few guns of heavy types—as had the English—but their heavy artillery was a relatively small factor. Russia had more heavy guns than either of her allies, but she too was much behind Germany.

Germany's full equipment in guns of all types is as follows:

77 mm. (3.03″)	field gun
	mountain gun
10 cm. (4″)	field gun
13 cm. (5.2″)	field gun
30.5 cm. (12″)	gun (Austrian)
38.1 cm. (15″)	gun
15 cm. (6″)	howitzer
21 cm. (8.4″)	howitzer
28 cm. (11″)	howitzer
30.5 cm. (11.2″)	mortar (Austrian)
42 cm. (16.5″)	mortar

As soon as the French saw that heavy calibres were so badly needed, they made strenuous efforts to provide them. France now has the following equipment in guns of all types:

75 mm. (2.95″).......field gun
65 mm. (2.56″).......mountain gun
90 mm. (3.54″).......old model field piece
105 mm. (4.1″).........the new heavy field piece adopted shortly before the war
120 mm. (4.7″).........long and short—old model
150 mm. (5.9″).........long and short—old model
155 mm. (6″)...........Remaihlo R. F. howitzer
210 mm. (8.25″).......mortar, old model
260 mm. (10.25″).....howitzer on wheels; a late gun manufactured since the war began
270 mm. (11″)..........mortar, old model, mounted on platform
305 mm. (12″)..........gun mounted on special railroad carriage
340 mm. (13.8″).......gun—also mounted on special railroad carriage

The French now have a 370 mm. (14.6″) howitzer. Six or eight of these guns have been completed and are to be sent into the field immedaitely. This is a motley array of all classes, old and new, but they answer the purpose. The old types are supplied with modern ammunition.

The first British Expeditionary Force was equipped with 4.5″ field howitzers and 5″ field guns.

As the English have since worked feverishly to increase their heavy artillery, they have doubtless done so. Exact data is lacking.

About six months after the war commenced, Russia had the following types and calibres:

3″ light field gun
3″ mountain gun
4.2″ gun
6″ gun
4.8″ field howitzer
6″ field howitzer

There are many old slow fire 4.2″ and 6″ guns, which date from the Japanese war period, and are generally used as fortress or siege artillery.

Russia's present strength in heavy artillery is not known.

ANTI-AIRCRAFT GUNS

Anti-aircraft guns are still in a process of development. They follow the general lines of the 3″ quick-firing field gun, have high muzzle velocities, pivot mountings, a very high elevation, and an all-around field of fire. They are often mounted on motor wagon bodies.

The latest type of German gun for firing at aircraft has a calibre of 4.1″, fires a projectile weighing about 34 pounds, and has a muzzle velocity of 2625 feet per second. It has a range of about 13,000 feet and can be fired at the rate of 15 rounds per minute. The shrapnel shell which it fires is said to burst into 625 fragments.

French anti-aircraft guns follow the same general lines as the German. They have also made extensive use of their 75 mm. (2.95″) field gun, for firing at aircarft. This has been done by using a very high carriage which gives the gun an elevation of about seventy degrees.

Since the war began there has been a remarkable increase in the range of anti-aircraft artillery. The first guns built had a range of less than 5000 feet, The present guns have a range of more than 10,000 feet; a fact which makes it now more difficult to conduct aeroplane reconnaissance. Yet, in spite of developments in anti-aircraft artillery, aeroplane reconnaissance has not been seriously affected. Aviators are sometimes forced to use high altitudes, when crossing the line at points which are strong in anti-aircraft guns; at other times they fly lower. At any rate we are told that while hundreds of projectiles are fired at aeroplanes every day, a machine is seldom crippled or brought down.

ARTILLERY HARNESS AND WHEELS

It is interesting to note that English officers are unanimous in condemning the collar for artillery harness, whether it be that of light or heavy artillery. Heavy horses which were used in transport wagons were first worked with their civilian collars. When they grew thin from hard work many of them had to be given breast harness, to avoid shoulder galls from the bottom of the collar.

English officers have also recommended that their rope traces be abandoned, and wire wound traces with leather covers substituted.

It is interesting to note, also, that the wheels have proved to be a weak element of every mobile gun and howitzer. The breakage and destruction of wheels has caused the capture of many field pieces. Many efforts have been made to remedy this weakness. Wheel shields have been tried. Wheels have even been made of plate. These remedies, however, have not been found practical.

TRANSPORTATION OF HEAVY ARTILLERY

The use of motor traction has rendered heavy artillery mobile where good roads exist. These guns are so arranged that they can be fired from their own carriages. The use of belted wheels overcomes many difficulties of bad grounds. All types of heavy artillery use the same general system of transportation. The necessary number of traction engines are provided—each with a number of trailers. The pieces and carriage may be drawn separately. With some types even the carriage comprises two vehicles. The barrel is drawn on one carriage and the mounting on another.

This system of dividing various parts of the mechanism for transportation has been so ingeniously developed that even the 42 cm. motor is now moved entirely by tractor.

ESCORTS

As might be expected, field artillery has frequently been without escort. When every rifle was needed in the firing line, the field artillery had to depend on the nearest troops or rely upon itself for protection. It may be noted at this point that many of the personnel of German batteries are armed with rifle or carbine.

The German heavy artillery, however, is carefully escorted. A 42 cm. mortar is accompanied by a brigade of infantry with many machine guns. Their trenches and machine gun positions are placed to cover the emplacement of the mortar.

In the Russian army, field artillery is always provided with escort, both on the march and in position. The usual escort is about sixty men per battery. On the other hand, they rarely assign escorts to their heavy batteries.

COMMUNICATIONS

Communication in this war—between artillery units or between artillery and the infantry lines is always by telephone or buzzer. Visual signalling has been used but rarely. It can seldom be done except as a link and is of no use on a big battle front. The buzzer is by far the most important means of communication; it can be used many times when the use of a telephone is impossible. It is often necessary to establish communication for a distance as great as two miles. Artillery officers of experience in the war have recommended a complete equipment for each section as single guns are often detached to fire on separate targets—under the direction of observing officers in advanced positions. The time necessary to run telephone lines made them unavailable in the early stages of field battles. It is known that in the early stages of the war neither the French nor German field telephones were entirely satisfactory. The French have since installed commercial telephones in their trenches with great success. The lines are usually laid in duplicate. Forward observers prepare two positions each with complete equipment to guard against being cut off from their batteries. These precautions are the result of bitter experience. On more than one occasion, when telephone wires were destroyed, serious trouble has arisen, because infantry and artillery were no longer coördinated.

Panoramic Sketches

Panoramic sketches have been extensively used. They are usually called "fire sketches." These sketches are made by reconnaissance details for the use of all units—batteries, battalions, and larger forces. On one occasion German officers found in a captured Russian position a panoramic sketch, complete in every detail. Every stretch of woods, every small knob, every little point, which stood out prominently, was fixed. Even the avenues in rear of the sector were not forgotten. One small sector contained 48 points accurately located in range and deflection.

Positions

Because of aeroplane observation, positions are selected and concealed with the greatest care. Laxity in this respect leads to destruction. To place a battery behind cover and concealed from view is not enough. It must be concealed from overhead view. Positions are usually occupied at night. Batteries are placed in belts or trees, edges of woods or well into a fence—one containing trees, if possible. Small trees are felled and placed not only around the guns, but also in the intervals. The object is to make what looks like a natural belt of trees. Limbers are similarly hidden in woods. The following method of concealment has met with remarkably good results. A large net—a fish net for instance—has been supported by poles and covered with grass leaves or twigs from neighboring trees. This covering must harmonize with the surrounding country.

Guns and even horses have been painted to match their surroundings. Mottled effects are especially effective. Shelter pits are dug and roofed over to protect the men from shell fire.

As for high power field howitzers, they are so destructive that there is no protection against them. Concealment is everything; protection is impossible. The moment a battery is accurately located all personnel is withdrawn. The guns are moved to a new position; at the first opportunity usually under cover of night and to a position already prepared. A battery not located can fire for weeks without hindrance. When its exact location is known the enemy's artillery destroy it with ease and certainty.

Guns have been placed in dwelling houses, barns, chicken houses, even in the kitchen of a cafe. Caissons and limbers are concealed in haystacks, barns, sheds, covered with hay or surrounded by transplanted trees. When an artillery commander has hidden his guns he has his own aeroplane fly over him many times, to tell him if they can be seen. When a hostile aeroplane appears, the personnel of artillery invariably stand stock still; otherwise the aerial observer would discover men moving about and surmise the presence of artillery.

This art of concealment has been developed to such a high degree that airmen now suspect every protuberance, every hump on the otherwise level surface below them. Almost without exception, field batteries in direct fire positions have suffered heavily.

Early in the war German batteries frequently used sight defilade and suffered serious losses. This method was soon discarded; maximum cover was sought; the guns were protected by field fortification and bomb proofs built for the detachments.

Dummy positions are frequently used to draw fire. The Russians are fond of using false or quaker batteries to draw German fire. They are made of old cart wheels, logs, boxes, pieces of tin to represent shields, etc. They always have some arrangement for imitating the flash of a gun. One ingenious battery commander, when he had deceived the Germans into firing on a quaker battery, exploded a bomb under an old box. The enemy thought he had found a battery and fired furiously. Another Russian officer, after a heavy bombardment, withdrew his battery under cover of darkness. He carefully left all the old screens and evergreen branches in place, with hastily arranged dummies to represent the guns. A German aero, which had previously discovered the battery, returned the next morning, and thinking the battery was still in position, directed fire on it for some time.

TARGETS

When troops are in rapid movement, as in an advance or retirement, the artillery doubtless finds many good targets. In the position warfare which is now the rule on European battle fields good targets are extremely rare. Artillery rarely see anything to fire at. They depend on aerial reconnaissance, and the correction of fire by aeroplanes; upon observers in advanced positions; upon spies; or else they resort to searching and sweeping fire.

FIRE CONTROL

The general rule is that all tactical handling of field artillery is by battalion. The battery is the technical unit. Upon assignment to position each battery is given a sector for purposes of observation and fire. Battalion commanders maintain fire direction, as far as practicable; for the purpose of concentrating or distributing the fire of their batteries.

CONDUCT OF FIRE

Observation ladders were used a few times at the beginning of the war, but they quickly disappeared. They are regarded as shell traps. In the battle of the Marne, observation stations were mere holes dug in the ground. An ideal observation station is a very narrow seven foot trench with a two foot periscope—located on a slight rise of ground. In the field battles the battery commander has generally been near his battery and controlled it. In position warfare the use of forward observing stations has become general. The forward observing officer, who is generally in the infantry trenches is connected with his battery by telephone. He conducts the fire of his unit on any objective by simply indicating so many mils right or left of an already understood reference point. As already noted both observation posts and telephone lines are usually in duplicate.

Although rough methods for obtaining preliminary data were used in the earlier field battles, in the present trench warfare all data is carefully obtained and verified. In many positions the artillery has become so familiar with the ranges and deflections to different points that their firing is almost an exact science. High places in the terrain, towers, church steeples, etc., have repeately been occupied as observation stations. Hostile Artillery have invariably fired on these points. Both German and Russian telescopes have a device for fastening the observing instruments to the side of a tree or other vertical support.

The ground over which the Russian army has operated is so flat, that they have had difficulty in finding suitable observing stations. Frequently they have occupied observing stations which were almost three miles from the batteries. They have light and practical reel carts which carry a large supply of telephone wire.

Not only is observation of fire most important but observation of every description. Great efforts are made by all armies to methodically observe every part of the battle field; aeroplanes, ballons, and auxiliary observers in every direction are employed—frequently at great distances.

The location of targets and the correction of fire by aeroplanes is an art that has been greatly improved and developed as the war progressed. Various systems are used. Communication between aeroplanes and battery may be established by wireless, visual or sound signals. The English aeroplanes are equipped with wireless. If this fails them, they resort to the use of a flash bomb (Very's light) in red, white and green colors, which can be seen in daylight at a height of 3000 feet and for a distance of 3500 yards. These lights are exposed singly or in combination in accordance with an elaborate code. A Klaxon horn is used to warn the battery that signals will be displayed. This horn cannot be heard at a greater distance than 1800 yards and from a height of 2000 feet.

For long distance signalling the French use the wireless. For short distances they use a system of smoke signals. Smoke puffs from the engine exhaust in large and small clouds represent the dots and dashes of the Morse alphabet. These signals can be read at a distance of 16 miles.

In the German army the aviator uses a smoke bomb which he drops when over the target; this gives the deflection and range to observers at the battery. The fire is said to be corrected by long streamers of colored paper, which flutter slowly to the ground, their color indicating short or over, right or left, or target.

Communication from battery to aeroplane is usually by white signal flags spread on the ground in rear of the battery to form letters or code signals.

During the last few months of the war drachens or sausage shaped ballons have been relied on more and more as a means of observation. They are often used to direct the fire of the heavy artillery. Because of their peculiar shape they are very steady, even in strong winds. The observer in one of these ballons has telephonic communication and powerful glasses. These observers are always on the alert and nothing escapes their observation.

Artillery in this war has done much night firing. Incidentally, this night firing reveals artillery positions to the enemy. The illumination from the flash cannot be concealed. The direction of the flash is noted and accurate maps consulted.

If a wood or other cover is discovered in the line of the flash, that point is covered with searching fire which may continue for days.

AMMUNITION

All available data seem to indicate that shrapnel is nearly as effective against troops in the open as it was supposed to be, and not at all effective against troops under cover. Troops in well constructed trenches, suffer little from shrapnel fire.

Shell is superior to shrapnel in stopping an Infantry attack though shrapnel has greater killing effect and puts more men out of action. High explosive shell has a great effect on advancing troops. The sheets of flame; the clouds of dust and dirt thrown up in their front, and above all the shock effect caused by the explosion of the high explosive charge, cause advancing lines to waver and even stop. A stunning effect is produced on the troops, which throws an attack out of coördination.

Against troops in the open, an extremely sensitive fuze is desired which bursts the shell as near the surface of the ground as possible, distributing the fragments in every direction, especially parallel to the surface of the ground. For the demolition of matériel and the attack of intrenchments, delay action fuzes are preferred; as the shell must penetrate before bursting.

Shell is the only projectile at all effective against troops under cover.

At the present time, excepting the attack of aircraft, high explosive shell seems to be universally used for all purposes.

It is a matter of common knowledge that the expenditure of ammunition in this war has been enormous. A few figures may be of interest. At the battle of the Marne, many French batteries fired over 600 rounds per gun, per day. One regiment fired 62,000 rounds during three days of battle. In Champagne alone during four or five days fighting the French directed 1,000,000 projectiles on the works of the enemy.

THE EFFECT OF ARTILLERY FIRE UPON ARTILLERY

Even well directed artillery fire inflicts very little damage on shielded batteries if they are well defiladed, and provided with splinter proofs. What is so often called a destroyed battery is usually one which has adopted the wise policy of silence. There have been cases where batteries with the customary protection were under artillery fire all day. The ground was literally torn up with shell holes, and guns were even put out of action; but as the men took refuge in dug out splinter proofs the losses to the personnel were slight. It is a different story when batteries are caught in the open; even though shielded they suffer heavy losses. Experience has shown that shell fire is much more deadly to the Artillery than that of shrapnel. Batteries—well dug in and shielded—are almost invulnerable to shrapnel fire.

ARTILLERY IN TRENCH WARFARE

In trench warfare, Artillery is of primary importance. The heavier types, are especially useful. Heavy howitzers as well as field guns have been used for the destruction by shell fire of wire entanglements and kindred obstacles. Occasionally, they have been successful in such destruction.

Cannon, howitzers and mortars of many calibres—are used. The most effective types of cannon are the 75 mm. (2.95 inch) and the 105 mm. (4.5 inch); of howitzers the 150 mm. (5.9 inch); of mortars the 210 mm. (8.25 inch) and the 270 mm. (11 inch). In some combats, the assaulting troops, by massing heavy guns, have practically destroyed the trenches and either killed their occupants or stunned them into a helpless and non-resisting state.

Although the opposing trenches are separated by only 50 or 60 yards the artillery has not hesitated to adjust on the enemy's trench and shell it, even at distances as great as five or six thousand yards. The projectiles, however, are sorted, and every possible mechanical error is eliminated. Complete lots are always sent to the same battery. The firing begins at ranges several hundred yards beyond the point of final adjustment. Then by methodical reduction of the range, the required point is exactly reached.

Firing on trenches by Artillery at considerable distances, has now been replaced to a certain extent, by the use of bomb throwers and hand grenades.

Preparations for an attack on the opposing trenches are most elaborate. The preliminary phases of the infantry attack do not exist in trench warfare. The Infantry attack commences with the assault. The artillery clears the way for the infantry by destroying the enemy's accessory works, first line trenches and shelters in the rear; together with the second line trenches and their communications. When the preliminary bombardment has been completed there comes a final bombardment which consists of bursts of rapid fire. At this time, by signal or at a prearranged time, the infantry is launched to the assault. At the moment of assault the artillery increases the elevation and creates a curtain of fire, 300 yards beyond the assaulting troops. When the first trenches are carried, the curtain of fire is moved 300 yards beyond, to cover the attack of the second line. At this stage of the attack, guns are brought forward to destroy any accessory works which have been previously undiscovered. Artillery Officers observing in the front trenches go forward with the Infantry, striving by every means, to keep their communications intact. The artillery must know where the infantry is.

VARIOUS USES OF HEAVY ARTILLERY

The largest types of heavy artillery such as the famous 42 cm. (16.5 inch) and 30.5 cm. (11.2 inch) mortars and the 28 cm. (11 inch) howitzer were primarily designed to reduce the great fortresses which defend the French and Belgian frontiers. How successfully these pieces destroyed the Belgian forts is a matter of history. The forts surrounding Liege and Namur were all of the same type namely: a heavy concrete mass from which rose five or six small cupola turrets containing the guns. The giant projectiles launched against these concrete walls reduced them to bits. The detonation of these great projectiles had a most terrible effect upon personnel. They suffered from severe toothache; their cars rang; after every shot they gasped for air. Men subjected to this fire for several hours were driven almost crazy.

The 15 cm. (6 inch) and 21 cm. (8.4 inch) howitzers have been used primarily for the reduction of field fortifications and fortified villages. They have also been used—especially the 15 cm. (6 inch) piece—in field battles against both artillery and infantry. Shells from these heavy howitzers, when used against infantry, have a great moral effect. The howitzers usually fired at ranges of about 6000 yards, and were placed in rear of the line of light field guns, though sometimes the 15 cm. howitzers were placed on that line.

The German light field gun appears to have been overmatched by that of the French, but this disadvantage was more than offset by the German heavy howitzers. At the outbreak of the war, France had very few of these heavy field pieces. Reports indicate that these howitzers were brought into action after the divisional artillery became engaged and used against a part of the line in which it was intended to break.

In trench warfare the heavier types of ordnance heve been relied on. Their use for this purpose has been described.

Heavy artillery fire has been used at great distances. The Germans are reported to have bombarded certain places at a range of nineteen miles.

Main roads in close country, roads which are necessary for transportation purposes are often completely destroyed by four or five shots so placed as to form huge craters directly in the middle of the road. Flying grounds for aeroplane squadrons are ruined by the same method. Towns which are useful for the billeting of troops are shelled at irregular intervals—simply for the moral effect. The same procedure is applied to important cross roads and railway centres.

It is a daily practice for both sides to shell the roads leading into the first line trenches. Aeroplane scouts inform the commander, of the roads used for bringing up supplies. Towards evening the re-supply of the trenches commences, and at this hour, a continuous bombardment takes place, which usually continues throughout the night.

Nature of Fortifications Which May Be Encountered in Field Warfare and Artillery Means and Methods of Attacking Such Works

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IT is not considered within the scope of this paper to describe and discuss the various more or less standard types of field and permanent fortifications. The details of these works are given in the various manuals, textbooks, etc., not only of this country, but of all other countries making any pretense of having a considerable military establishment. What will be discussed is the artillery means of attacking the well-known types, the general considerations involved in the types recently developed or in process of development, and the artillery means and methods of attacking such newly-developed types.

Fortification is a very old art, but fortification as we know it today has had its development since the introduction of firearms. However, for a long period preceding the invention of rifled guns and cannon little advance had been made either in the development of firearms or in the science of fortifications. Since the invention of rifled guns and cannon the power and effectiveness of fire-arms have increased enormously, not only through vast improvements in the weapons themselves, but also through tremendous improvements in propelling charges, projectiles, and for cannon, improved means of transportation. These improvements have rendered necessary vast changes and improvements in fortifications and their employment on a scale hitherto undreamed of. The contest between fortifications and weapons continues unabated and what is up-to-date today may be obsolete tomorrow.

The U. S. Army Field Engineer Manual gives the following definition of fortification:

"Fortification is the art of increasing by engineering devices the fighting power of troops occupying a position. These devices have for their object to increase the effect of the fire action of troops protected by the fortifications and their mobility on the field, or to diminish the effect of the fire action of the assailant and his mobility."

Fortification may be divided into two general classes, viz., Permanent Fortifications, and Field Fortifications.

PERMANENT FORTIFICATIONS

Permanent fortifications may be further subdivided into two general classes, seacoast fortifications and land fortifications. The former is not within the scope of this paper.

LAND FORTRESSES

Professor Engman gives the following definition of a land fortress:

"The purpose of a fortress is to defend a given strategic point with the smallest possible garrison for the longest possible period against numerically superior forces of the enemy."

Land fortresses have ever played a prominent part in field warfare and there seems to be no reason to believe that this state of affairs will be altered as a result of the experiences of the present war in Europe. The fortresses of Liége, Namur and Antwerp were reduced after a few hours' bombardment by the German 30.2 and 42 centimeter howitzers. Every German Artillery Officer knew that this would happen, but the rest of the world was amazed. Many persons appear to have concluded that these events spelt the passing of the land fortress as a factor in field warfare. Such conclusions seem to be entirely unwarranted. The forts just referred to were largely armed with the revolving Gruson cupola turrets and the heaviest armament they were designed to withstand were the 7 and

9-inch siege howitzers. Against such artillery as these forts were designed to withstand they stood the test well, and it was only when the huge 42 centimeter shells, with their monstrous bursting charges fell upon them that they crumbled and failed to take a strain for which they were never designed. Contrary to general opinion these events did not prove that land fortresses, or even Gruson forts, are obsolete. They merely proved that forts, like all other products of engineering skill, cannot be expected to perform service out of all proportion to that for which they were designed.

The German coast defense forts are largely armed with Gruson turrets—not the Gruson turrets of Antwerp and Namur, but Gruson turrets armed with rifles ranging in calibre up to 17.7 inches and designed to withstand the shock of impact of armor-piercing projectiles fired from 13-inch naval guns. Admiral Beresford has remarked that only madness could move a naval commander to oppose works of this type and calibre. The total weight of the heaviest of this type of turret is 2300 tons, the greatest bulk that has ever been moved with mathematical precision for any purpose. In the Spezzia tests three 2,200-pound projectiles were fired from a 100-ton Armstrong gun against a Gruson plate of German manufacture. Though the shots were all fired at close range and at the same plate, the plate was not perforated or broken. Had the Belgian forts been half so strong the story would have been very different.

It is highly improbable that the German 42s came as a complete surprise to the Belgian and French Artillery Officers and Engineers. When Antwerp were built they were the last word in the science of the construction of land fortresses. But known heavy siege armament had advanced greatly since the construction of these forts. It is to be recalled that the Japanese used 11-inch howitzers in reducing Port Arthur. Moreover, the air had been filled for years with the rumors of the great siege guns which the Germans were constructing. The Germans themselves had boasted that they would upset everything with their new armament. It seems highly probable that had the Belgians and French been given a few more years before war broke upon them they would have met Germany with an entirely reorganized and remodelled system of barrier forts.

It would seem that the present war, far from spelling the doom of land fortresses, will mark the beginning of the construction of barrier forts and land fortresses of tremendous powers of resistance, designed to withstand not only 42 centimeter howitzers, but also designed to meet further improvements in heavy siege ordnance. Such forts may not be turret forts. They may be only of earth and heavily reinforced concrete. They may be only of earth. In this connection a few of the facts connected with the siege of Port Arthur should be pertinent. The concrete walls of the casemated buildings of Port Arthur were 3 feet thick. They were designed to resist 6-inch howitzer shells and successfully withstood the fire for which they were designed. In most cases where a 6-inch shell hit a wall and exploded it made a depression 3 or 4 inches deep and about 1½ feet in diameter. In striking upon a roof it made a funnel shaped hole of about the same diameter and about 4 or 5 inches deep. There were cases where several of these projectiles hit in the same place. Each time the damage increased and after several hits cracks appeared on the inside. A layer of from 4½ to 5 feet of earth entirely secured concrete structures from injuries from these shells. The result was entirely different when 11-inch howitzers were brought upon the scene. The projectiles from these howitzers easily penetrated the 3-feet concrete roofs, even when they did not explode. In some cases these projectiles fell upon roofs having a thickness of 5 feet of concrete. Even where two shells fell upon the same place the roof was not perforated. The influence of covering the concrete with a layer of a few feet of earth was very great. One 5-foot concrete roof was observed covered with a layer of earth 3½ feet thick, over which was placed a layer of gravel and cobblestones 1½ feet thick. This roof was frequently struck by 11-inch projectiles which made funnel-shaped holes in the top layer only.

The concrete remained intact to the end of the siege. The experiences gained at Port Arthur demonstrated clearly that a layer of earth absorbs the force of impact of the projectile and also weakens the effect of the explosion.

We thus see that it ought to be quite practicable to construct works that will successfully resist the 42s and even more powerful weapons, using for such purpose only earth and concrete.

Whatever type of work predominates we may expect to see, in all first-class fortresses of the future, the present system of fort construction fundamentally altered. An incomparably greater amount of attention and expense will be devoted to making the elements of the fortress inconspicuous if not altogether invisible at any except very short ranges. As for the individual forts and other works, geometrical outlines will entirely disappear; a most irregular trace will be adopted; parapets, traverses, etc., will have a wavy shape corresponding to the relief of the site. Mounds and depressions will be joined; artificial terrain will be constructed; great quantities of trees, shrubs, and vines will be grown; the whole fortress will conform so closely to the terrain and such extreme measures for concealment will be resorted to that the elements of the defense will be most difficult of detection and ranging will be most difficult.

In the attack of a fortress the many advantages possessed by the defense are offset to a considerable degree by the advantage which the attack possesses in having the initiative, especially in being able to select the point of attack. In the attack of such a fortress as has been described, siege operations will necessarily have to be undertaken. During the earlier stages of the siege the artillery will be well occupied with doing as much damage as possible to various parts of the fortress, especially to such defensive works as can be accurately located, including central storehouses, shops, power plants, etc., and with frustrating attempts of the enemy to impede the work on the siege approaches. During this stage it may be expected that large quantities of ammunition, both shrapnel and shell, will be expended. During this period, too, all batteries should register accurately on all defensive works within their sector and the position of which has been determined. Registration on invisible works will have to be accomplished through the co-operation of aeroplanes or captive balloons.

During the later stages of the siege carefully planned attacks on specially selected points will be made. Upon the artillery will devolve the duty of preparing for these attacks by hurling into the works selected for assault a hurricane of high explosive shell for many hours or even days. During the assault it will be the duty of the artillery to keep down the fire of the defenders by subjecting the works selected for assault and all other works that are so placed that they are able to fire upon the assaulting bodies, to a smothering fire of shrapnel and high explosive shell. The most intense fire, which should include both shrapnel and shell, should be directed upon the actual point of attack. The fire directed upon the other works should be chiefly shrapnel fire. The fire upon the point of attack must be kept up until just before the attackers actually reach the objective. The fire should then be continued at a slightly increased range in order to cover the rear part of the work and to prevent reserves from coming up. Even during the first stages of the assault certain batteries should be designated to cover the rear approaches to the works. The fire on the adjacent works should be kept up even after the assault has reached the works, in order that the attackers may secure their position and be reinforced if successful, and to cover their withdrawal if they are defeated.

The reduction of a first-class fortress of the future, stubbornly and skilfully defended, will be a very difficult undertaking.

Our present field artillery armament would be unequal to the task. The artillery attack on such a fortress will require, in addition to the types of guns and mortars we now possess, many howitzers or mortars of very large calibre with an efficient high explosive shell and ammunition in tremendous quantities.

To co-operate with the artillery in such an undertaking a large and efficient aerial service will be essential.

It may be contended with reference to the foregoing discussion of fortresses that there are not in the countries adjoining the United States, nor even in the Americas, any strong land fortresses. In reply to this contention it may be said that this country no longer enjoys the splendid isolation which we for so long felt was ours. We are now a world power and are taking our part in the world's events. We can never be sure that tomorrow we will not be involved with a first-class power and we should be prepared for such a contingency. Moreover, we may not have to cross the seas for an occasion to engage in fortress warfare. A first-class power effecting a lodgment on our shores could and probably would, in a very short time, construct exceedingly strong works for defending his holdings. This he could do in the time that would be required for us to create and train an effective army of any great size to oppose him.

FIELD FORTIFICATIONS

The following are the classes of field fortifications with which this paper is concerned:

1. Shields or shelters which protect the defenders from the fire of the assailants, such as trenches, redoubts, etc.

2. Obstacles, by which the advance of the assailant is stopped or retarded, such as wire entanglements, abatis, etc.

3. Masks, by means of which troops, guns, and other elements of an army are screened from view of an enemy.

4. Communication facilities, such as roads, bridges, etc.

There are other classes of military works that are usually classed as field fortifications, such as demolitions and clearings, that do not concern us in the present discussion.

A special phase of field warfare is encountered in what is commonly known as "trench warfare." Soon after the Battle of the Marne the armies of the allied British, French and Belgians deadlocked with the German armies and both sides hastily intrenched themselves. These intrenchments have been steadily extended and improved until today operations along the Western Front resemble siege operations more closely, perhaps, than they do the operations of armies maneuvering and fighting over an ever shifting battleground. Still, most of the phases of purely field operations, so far as the fortification aspect of such operations are concerned, are encountered in this warfare. Hence, by a study of the fortification problems involved in this trench warfare we can get a grasp of the field fortification problems of the present war and the means and methods that are being used to solve them. Trench warfare is the logical sequence of the struggle of huge and nearly evenly matched armies, both equipped with the highly destructive weapons of today. This is especially true when either side, wishing or forced to take the defensive, is able to rest its flanks on positions secure from the flanking operations of the enemy. This condition prevails on the Western Front where both armies are resting one flank on neutral Switzerland and the other on the sea. After a long series of great battles and movements of armies of unprecedented size over an immense area, the struggle on the Russian Front also seems to have reached the trench warfare stage, the Southern flank of both armies resting on the frontier of neutral Roumania and the Northern flank of both on the Baltic Sea.

It is probable that this is a form of warfare that is very apt to confront us if a strong military power succeeds in establishing a foothold in this country. The seizing and holding of any considerable portion of this country by a foe from across the sea seems highly improbable, but once such an enemy has siezed a vital point or section he will doubtless proceed with all possible speed to heavily intrench himself in an effort to deny to us the recovery of such point or section and thereby force us to make peace on terms of his own making.

While to date much less information is available concerning the mobile operations in the Russian theatre than is available concerning the operations on the Western Front, such information as is available seems to indicate that there have been no startling developments in the way of field fortifications or the manner of their attack. The facts that stand out most conspicuously are the greatly increased importance of the part played by the artillery and the enormous consumption of artillery amunition, especially of high explosive shell. A vast amount of shrapnel is still required, but the proportion of shell used has greatly increased. In this same connection it will be recalled that in the Russo-Japanese War the Russian Field armies were usually not provided with shell for their artillery and that they felt the need for it very sorely. It is of record that the Russian artillery in this war hurled thousands of shrapnel into such places as the squatty but substantially constructed Manchurian villages almost entirely without effect, while a fraction of this number of high explosive shell would have had the desired effect. Shrapnel will continue to be used in great quantities, for it is still the most desirable for firing not only on troops deployed for combat, but also on massed formations and on troops under cover of hasty intrenchments. It is, of course, quite impossible to foretell, even approximately, what proportion of shrapnel or shell will be required in a war. The proportions will be determined in general by the character of the fighting and on particular occasions by the particular object in view. There are conceivable conditions where all, or practically all, of the ammunition needed for a battle or a particular phase of a battle will be shrapnel. On the other hand, occasions will arise when the artillery will require nothing but high explosive shell, more high explosive shell, and still more high explosive shell.

Through the improvement in the mechanism of guns, the great increase in the range of guns, and the improvement in sights and range-finding apparatus, it has become possible to deliver fire rapidly and accurately at very long ranges. On the other hand, through the introduction of aerial observation and the marked improvement in observing instruments, batteries are in danger of discovery and destruction at distances that only a few years past were absolutely safe.

These developments have rendered necessary the utmost ingenuity and care in providing cover and especially concealment when within firing ranges of the enemy. This will in the future be true, to a certain extent, of all kinds of combat, but applies particularly to combat where both sides are stationary, as in trench warfare. In trench warfare officers can hope to see but rarely the hostile artillery matériel against which they are conducting fire. The position of such targets will have to be determined as closely as possible by such indications as flashes at night or even at dawn or twilight, location of approximate position by aerial observers, direction from which hostile artillery fire is being received, and by the dust raised by the blast of discharge. To deny the enemy the use of these aids in locating the positions, guns and other elements various expedients have been resorted to. The ground in front of the muzzles is watered or treated with crude oil; paulins or brush mats of a color that blends with the ground are staked down in front of the guns; trees are transplanted so as to conceal the batteries; nets are stretched over the batteries and covered with grass, branches or twigs; dummy batteries are constructed to draw the opponent's fire. Emplacements are usually prepared for batteries in advance and they are moved into them under cover of darkness. In all cases concealment is provided for; in many cases protection against shrapnel fire is provided for; and in some cases protection against shell fire is provided for.

Protection against shell fire is provided for in various ways. In some cases howitzers are placed in deep pits, and in others a high parapet is constructed in front and rear and on both flanks of each section. In most cases where only concealment or shrapnel protection are provided for the guns, heavy bomb proofs are constructed near at hand in which the cannoneers can take refuge if the battery comes under a destructive fire.

The first line, communicating, cover, and other trenches of the system on the Western Front are very narrow and have been so skilfully located and concealed that it is exceedingly difficult to locate them or spot the fall of shots fired at them unless the observer is very close to them. For the attack of these trenches by artillery fire the observer is often in the first or second line trench and connected with the firing units by telephone. For this work several lines of telephone should be provided, for the lines are very apt to be cut and it has been found that visual signalling is often impracticable for work of this kind.

All of the machine gun positions and most of the infantry positions are provided with overhead cover of such character that only the largest calibre of high explosive shell is able to make much impression on them, and even these only when falling directly upon them, or within a very few feet of them. For most of the machine gun and infantry positions deep bombproofs that are proof against even the heaviest high explosive shell are provided in which the defenders can take shelter when a bombardment with shell of this kind commences in earnest. The opposing trenches are at all places close together, being in some places less than 50 yards apart. Due to the proximity of friendly and hostile trenches, bracketing is rarely resorted to in firing on the hostile first line trenches. Firing commences with ranges safely over and the ranges are gradually reduced. Even after adjustment a large proportion of the shots are over the first line trench when the trenches of the opponents are very close together. This is not particularly objectionable, as the communicating, cover, second line and other trenches and works must in any case receive their share of attention. The artillery frequently fires under these conditions at ranges of 5000 or 6000 yards. In such cases every possible care is taken to eliminate errors, even to the extent of sorting and grouping projectiles according to their weight and measurement. In such firing too the individual characteristics of the guns must be considered in laying, as it is well known that different guns shoot on the average to different ranges, even when laid to exactly the same elevation and using the same lot of ammunition, etc.

Trench attacks usually begin with an intense artillery bombardment of the enemy's trenches for the purpose of causing him losses, destroying his trenches and other defensive works and especially obstacles in front of his works. After a breach has been made in the obstacles the infantry rushes into the breach and the artillery, at a prearranged signal, increases its range sufficiently to avoid firing into its own infantry. If the infantry succeeds in making a lodgment in the hostile works the artillery observers must hasten forward and seek new stations. From these more advanced stations they will probably be able to see many good targets, including some of the hostile batteries that were not visible to them from their former stations further to the rear. Communication between such observers and the firing units will become exceedingly difficult and special preparation for such communication will have to be very carefully arranged in advance. Visual signals under such conditions cannot be relied upon. Aeroplanes equipped with wireless and carrying trained artillery observers should be of very great value under these conditions, as well as under a great many others. On these occasions, if by day, as well as during other operations by day the Drachen, or sausage-shaped captive balloon with smaller balloons attached as air anchors, has proven of great assistance. They are used by both sides in great numbers. They are sent up at daybreak and remain up until night. They are sent up a few hundred yards and far enough to the rear to render them immune from the fire of the hostile artillery. The observer in this balloon is equipped with powerful glasses and a telephone.

For destroying barbed wire entanglements both shrapnel and shell fire are used, though the latter is now much more used than the former. It has been found that the same amount of destruction can be accomplished with a much smaller number of shell than of shrapnel. For such purpose a large number of guns are concentrated on the objective. As a matter of fact, a large part of the firing, particularly during attacks in force, is done by large masses of artillery. A large number of guns is frequently grouped under a single officer for the purpose of the conduct of fire. This is especially true of the French who have great faith in the moral effect of a vast burst of fire.

The same general method as is used in attacking barbed wire entanglements is applicable to the attack of many other forms of obstacles such as abatis, palisades, military pits, etc., except that only high explosive shell should be fired into them.

The artillery is playing an extremely important part in trench warfare. Each side is provided with a very large amount of artillery and the amount of ammunition fired is almost beyond belief. The French factories turn out upward of 100,000 rounds of artillery ammunition per day. In some of the great offensives the number of artillery projectiles fired by both sides had run into the millions.

There is in use on the Western Front a very large number of calibers and kinds of guns, howitzers, and mortars in use. This has resulted not from the necessity or desirability of so many kinds and calibers but from the necessity for the use of every available gun both modern and obsolete. This applies especially to the French who have seemingly mobilized everything that can hurl a projectile. Many guns firing spherical projectiles, and even catapults, have been seen in action.

Except against aircraft, practically all projectiles fired in this trench warfare are high explosive shell. Even against troops in the open high explosive shell is coming to be largely used. The effect of even the larger caliber shell is very much localized. Little damage is done unless they happen to strike right on the bombproofs and even then the effect extends for only a few feet. The 150 m/m howitzer and the 210 m/m mortar are the principal and most effective fortification destroying weapons in use by the French. The Germans have a 42 centimeter howitzer but the only use to which this howitzer has been successfully put has been the attack of fortresses. It has not been a success in trench warfare. Mortars or howitzers of such large caliber are even less successful in strictly field warfare. The Japanese tried their 11-inch howitzer in the field operations around Mukden. There were no strongly centralized works there like those against which these howitzers had been used with such success at Port Arthur, and the big projectiles fell among the scattered field works, doing very little damage. Moreover, such heavy ordnance cannot be moved forward promptly in a pursuit nor saved in case of defeat.

Mortars and howitzers of calibers up to 276 m/m are, however, in very great demand on the Western Front.

Both the Allies and the Germans have developed a type of so-called Trench Mortar for throwing for short distances large charges of high explosives enclosed in thin walled projectiles. This weapon is usually placed in the first or second line trenches, sometimes being placed less than 100 yards from the enemy's trenches. It can be fired up to ranges of six or seven hundred yards. These weapons have proven extremely valuable. As a result of the very large charge carried in the projectile the effect is exceedingly destructive. In fact, the effect is so great that the detonations of these projectiles have often been erroneously reported as the detonations of the German 42 centimeter projectile. In the French service the trench mortars are served by artillerymen but the infantry decide where they are to be placed, when fired, etc.

General

Armored automobiles and railway cars, especially the former, have played an important part in the operations of the present war. These cars usually carry both high power artillery and machine guns. Many of the autos also carry antiaircraft guns. The railway cars played a more important part in the earlier operations of the war than they do at present. The armored autos, however, seem to have gained in importance as the war has progressed. On account of their great mobility they are very useful in repelling aeroplanes and in quickly strengthening a point threatened with an attack. Naturally shrapnel is of little or no use against either the autos or the railway cars. The successful attack of either with shell fire presents great difficulties owing to their mobility. Of the two the attack of armored railway cars is by far the simpler, as they are constrained to move over the established railways. The simplest method of attacking them is to register fire on the railway track and then await the appearance of the armored car or cars. Such registration should, when possible, be made on a section of the track which is in prolongation of the line of fire delivered on the registration point. It will be possible to demolish the track at various points by means of artillery fire, but this damage will always be easily repaired under cover of darkness.

The same general method of attack will usually be employed against armored autos, with the difference that it will be much more difficult to damage roads to the extent of rendering them impassable for autos than it will be to damage railroads to the extent of rendering them impassable for trains, and that the road repairs will be much more quickly and easily made in the case of autos. Furthermore it will generally be possible for the autos to avoid exposed sections of the road by making a detour.

The use of ordinary roads may be denied to troops by the liberal use of shrapnel and they may of course be temporarily disabled by shell fire, particularly by the shell fire of large caliber howitzers and mortars. In general the permanent disablement of roads by such means is not possible unless the roads are of some special construction, as in a mountainous country where their maintenance is dependent on retaining walls, shoring, etc.

The use of bridges may be denied to troops by the use of shrapnel, and they may be disabled or destroyed by shell fire, particularly by the shell fire of large caliber howitzers and mortars.

For the destruction of blockhouses, storehouses, magazines, etc., high explosive shell will be required.

PROJECTILES

The selection and development of the proper types of projectiles is an important consideration. The shrapnel of the various countries seem to be of the same general type, and all of them seem to be very efficient. The so-called universal projectile has been used to a considerable extent in the present war but from such information as I have been able to obtain this projectile does not seem to be meeting with high favor.

The shell of the various countries at war seem to differ considerably. Two general types of projectiles seem to prevail, (a) those having heavy walls, carrying a comparatively small bursting charge, and equipped with a delayed action fuze. They are intended to penetrate deeply and then detonate. (b) Those having thin walls, carrying a large bursting charge, and equipped with either ordinary non-delay fuzes, or with instantaneous fuzes. Those equipped with ordinary non-delay fuzes are expected to make a slight penetration before detonating, while those equipped with instantaneous fuzes are expected to detonate on the very instant of impact and give a large super-surface area of destruction. So far the British appear not to have used the delay action fuze.

The French use a thinner walled shell than do the other powers, and consequently, for the same caliber, their bursting charge is larger than that of the other powers.

It is in the kind and amount of high explosive used that the greatest difference is to be found in the shell of the different powers. As just stated the largest bursting charge for a particular caliber is used by the French. Moreover, the French use melenite, the Germans use trinitrotoluene and lyddite, while the Belgians use macarite. The French explosive, melenite, being a picric acid derivative readily forms metallic picrates when in contact with the walls of the projectile or other metal parts. Since the beginning of the war the French have had an enormous number of guns destroyed through premature bursts in the bore. This has probably been due to the formation of sensitive metallic picrates in the projectiles with resultant premature detonation on shock of discharge. Ordinarily the interior of all projectiles to be filled with a picric acid derivative are coated with a non-metallic paint before they are loaded; but in the haste to supply the enormous quantity of projectiles required in the present war, this coating has probably not been done as carefully as in peace time. Even leaving aside the consideration of the possibility of formation of metallic picrates these premature explosions may be accounted for in another way. Since the war started an increased tolerance has been allowed on French projectiles. The theory has been advanced that due to this increased tolerance many projectiles have been fired that were so much under the proper dimensions that they have pounded in the bore; that melenite, being a very sensitive compound, has been detonated by this pounding.

The question of a suitable bursting for shell is one of such importance to field artillerymen that it is believed that a statement of the requirements for a high explosive for use as a bursting charge for field artillery shell should not be out of place in a discussion of the subject in hand.

These requirements are:

1. Must have sufficient power to produce proper fragmentation of the projectile.
2. Must be safe to manufacture and handle.
3. Must be sufficiently insensitive to withstand the shock of discharge with a considerable margin of safety.
4. For projectiles equipped with delayed action fuzes and intended to penetrate concrete, brick, stone, or steel before detonating, explosive must be able to withstand the shock of impact.
5. Must be completely and uniformly detonated by the service fuze.
6. Must not form sensitive compounds when in contact with metals.
7. Must not deteriorate in storage or when loaded in projectiles.
8. Cost must be reasonable.
9. Ingredients for manufacture readily obtainable in large quantities.
10. Must be non-hygroscopic.
11. Quickly manufactured.
12. Force must not be affected by freezing.
13. Safely and easily loaded and unloaded.

Of the various explosives that have been used as bursting charges the only one that completely fulfils all of the foregoing requirements is trinitrotoluene.

It fulfils these requirements so completely that there can hardly be a doubt but that it will be quickly adopted as a shell filler by practically all of the powers. It is produced in this country for 25 cents per pound and can be manufactured in a day. Commercially it is obtained from the distillation of coal tar. It will be found mentioned in various publications under the following names: Trinitrotoluene, T.N.T., trotyl, trotol, trytil, trinitrotoluol, trinitromethylbenzine, tolite, trilite, trinol, tritone, and possibly others.

In conclusion it is desired to lay particular emphasis on the following points:

1. To meet successfully the problems of modern war artillery requires long, intense, and careful training.

2. Land fortresses are by no means a thing of the past.

3. The relative importance of field artillery has advanced enormously as a result of the experiences gained in the present war.

4. As a result of the extensive scale on which fortification is now practised, and other causes, the field artillery must be prepared to expend enormous quantities of ammunition if involved in war with a strong power.

5. High explosive shell have gained greatly in importance at the expense of shrapnel, particularly in certain forms of warfare.

6. Several calibers of guns, howitzers, and mortars are required to meet the various problems of modern warfare. We are deficient in the matter of very large caliber howitzers and mortars and steps should be taken to remedy this deficiency.

7. We should develop a suitable type of Trench Mortar.

8. For use as a busting charge for shell, trinitrotoluene is the most suitable high explosive so far developed and tested.

Searchlights and Other Night Illuminants Applicable for Use by the Field Artillery

BY E. J. DAWLEY, SECOND LIEUTENANT, 6TH FIELD ARTILLERY

THE sole reason for the existence of Field Artillery is its ability to assist the other arms, especially the Infantry, upon the field of battle.

To enable it to render effective assistance upon the battlefield, artillery must be able, first, to march rapidly and in good order and to establish itself, promptly and without confusion, in such positions as will best utilize the available terrain; second, to deliver an effective and overpowering fire upon any designated part of the enemy's position.

Fire to be effective must be attended by careful, correct and efficient observation of fire. The function of night illuminants for Field Artillery is to make observation by night possible, and *per se* effective fire probable.

The war in Europe to-day, and as regards the Western Front, has been since the late months of 1914 practically the attack and defense not of single fortified places, but of fortified lines extending for hundreds of miles the length of frontiers. Mobile units, while they have not lost their mobility, seem to have lost the occasion for it. Campaigns have become struggles not for miles but for a few hundred yards of enemy trench.

With the advent of this so-called trench warfare has come unprecedented use of the night attack and night fighting. The attack and defense have kept fairly abreast and with the necessity for night operations has come the necessity of making these night operations as nearly impossible of achievement and as costly as may be.

Various methods for securing night illumination are used: searchlights, parachute rockets, rocket shell, star shell, shell tracers and searchlight projectiles and all in a great diversity of size design and *modus operandi*.

This paper will attempt in a general way the description of these different illuminants, having particular attention to the practicability of their use in connection with Field Artillery, their importance as adjuncts to Field Artillery and their tactical employment and operation as such.

THE SEMPLE TRACER.—Our 3-inch Handbook gives us a description of this tracer. Its use as a night illuminant is certainly contemplated but as to results to be expected from its use and of the practicability of its employment little is known.

SEARCHLIGHT PROJECTILES.—Among recent patents in the United States along this line is one assigned to Fried. Krupp Aktiengesellschaft. This projectile is arranged to burst in air, throwing out a number of candles or luminous bodies that light up the surrounding country for a considerable area and reveal the movements of the enemy. Each candle is provided with a parachute that unfolds as soon as it has been discharged from the cell, so that the candle will drop very slowly and will burn for a long time before striking the earth. The arrangement of such a projectile is shown in the accompanying cut and plate.

* * * *

It is similar in design to a base chamber shrapnel and is provided with the usual time fuze A, and bursting charge B. The interior of the shell is provided with a number of candles each pitted in a casing C. The fuze is set to burst in air and as soon as the candles are disengaged from the shell the caps D are thrown off by a spring which releases the parachute F, while at the same instant the candle is ignited by the match G. After their ejection the candles fall slowly to the ground while the light material H burns brightly.

Nothing is known as to the practical war uses of this projectile. It is thought that our Ordnance Department has made tests of these or similar illuminating projectiles but the results of these tests and the reports on their operation are not available.

PARACHUTE ROCKETS.—The parachute rocket hereinafter described was developed and patented by a German firm, has been thoroughly tested by some foreign armies, and in a slightly different form by our Ordnance Department. However, official reports and records do not but mention its use in this war.

The starting point in its development was the ordinary rocket, which is driven into the air by means of its lighted gas expanding, the wooden staff, or tail serving as a rudder or steering gear. Its use in war as an engine of destruction and as a means of communication or signalling dates back for centuries.

The parachute rocket as perfected by the German, Müller, is fired from a pistol or short rifle. It can be fired at any angle or from any position. Manifestly the best position in any case is that which secures to the firer or to his comrades the maximum illumination of the object or area of observation. A certain skill then in operation is requisite and can only be had as a result of practice and study.

These rockets burn on the average for about 40 seconds, the parachute to which the illuminating body is attached opening at the instant of explosion of the rocket. The parachute serves as a reflector. The intensity of the illumination is such as will enable features of the terrain to be rendered quite distinct and moving objects as men and animals greatly so. The light is projected from the reflector in a cone. The lighted zone at the most effective height of explosion is about 500 yards. The effective range is about 1,200-1,500 yards. The rocket complete weighs about .35 lbs. A haversack will easily contain a large number. The pistol or rifle for firing them is considerably lighter than our magazine rifle, weighing about 4 lbs.

In Western Europe mobile artillery has become largely artillery of position. Batteries and more often larger units occupy single positions for almost unlimited periods. Fire is conducted and observed in various ways, by flank observers, aerial observers and observers well to the front, often times in very close proximity to the hostile lines. In the cases of these batteries the data for firing at any target in any direction is known to the greatest precision and is kept tabulated and recorded, available for instant use; it may almost be said that every square foot of terrain is known and registered, the elements of firing data for it having neither been computed, or actually determined by adjustment.

It is possible therefore for an advanced observer with facilities to light up and reveal terrain in his front, to turn the fire of his guns upon any spot or area, always supposing, of course, that he is in communication by wire or phone with his battery and has control of its fire. The lightness, small size, cheapness and ease of replenishing renders this adjunct to fire control at once very effective as compared to that obtained by heavy, costly and cumbersome projectors or searchlights.

An accompanying cut shows photographically what may be expected of this method of night illumination.

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THE 10-INCH PORTABLE SEARCHLIGHT.—Another aid to the advanced observer might be the small portable searchlight. An example of this is the 10-inch Zeiss A O projector.

The apparatus with all of its appurtenances and a supply of material for two working hours can easily be carried by the operator and readily served by him. Material for twenty working hours is carried by an assistant. The optical portion consist of a glass mirror 10 inches in diameter, silvered at the back. The radiant is furnished by the incandescence of a glow in an oxyacetylene burner. The whole of the material required for the working of the apparatus, calcium carbide for the generation of acetylene and oxygen generating material, glowns, and water may be kept at a depot or storage place for any length of time without risk of deterioration. The dispersion attained in operation varies from 3-90 so as to cover from 56–170 yards at 1,000 yards distance. Under ordinary and average atmospheric conditions and with the minimum dispersion this projector will light up well at ranges up to 550 yards.

Accompanying cuts show the outfit in detail and illustrate the methods of transportation.

THE SEARCHLIGHT.—The searchlight has now attained to a very high state of technical perfection and great progress has been made in the methods of utilization.

In the course of the Franco-Prussian War several projectors were mounted at Paris but without great success. It was at about this time that the use of the electric dynamo for such lights became feasible. The first apparatus had from its very crudity but little mobility. The tactical handling seemed scarcely to be of any importance. Units were often located in sites just the reverse of which might have been used with great profit. Troops were little, if any, acquainted with their operation and tactical advantages, and by many leaders their use was not thought to be important or to be relied upon. It is, however, wth the advent and perfection of rapid fire guns and the attendant great use of the night attack that the real development of the tactical field use of projectors begins. In the Russo-Japanese War for the first time searchlights were used in the field to light up and sweep the surrounding country. The illumination of the terrain assumed a new and great importance. Projectors of many sizes and design were employed on both sides. In general it may be said that in point of design the projector itself was nearly perfected but much was left to be desired in its disposition, its mobility and its tactical employment.

PARTS

The parts of a projector are: a reflector, a barrel, a glass front door, arms for supporting the barrel, a turn-table to enable the barrel to be revolved in azimuth, a training mechanism to allow the beam to be changed in direction of altitude, a lamp for supplying the light, a generator for supplying the power for the light and a truck or wagon to transport the same in the case of the portable light.

As regards reflectors which are the great important features, there are the parabolic glass silver-backed mirrors, one piece and segmental; the metallic mirror, gold, silver and nickel plated, and those of monel metal. The first mentioned has come into large favor.

The barrel is a metallic cylinder carrying on the back the reflector, on the front a glass door to close the front at the drum, at the bottom a lamp box to house and support the lamp, and underneath a rack and pinion, by means of which the beam may be moved in a vertical are. The lamp is essentially a pair of carbon holders, a mechanism for starting the are and a feeding apparatus. The latter operation may be accomplished either by hand or automatically by the use of electro-magnets.

Projectors are built in many sizes; those best adapted to military uses being the 24, 30, 36 and 60-inch projectors. For obvious reasons lights 36-inch and under are the better adapted to use as portable lights.

The qualifications of searchlights necessary to insure successful and continued use under the rough conditions of field service may be summed up as:

1. Good illuminating power: (a) Adaptability to high polish; (b) absence of light absorptive qualities.
2. Permanence of reflecting surface.
3. Ruggedness against shock in handling and transportation.
4. Continuance in service even when struck by missiles.

5. Ease of cleaning, handling and general control and operation.

6. Lightness of weight.

As regards the illuminating power, glass silver-backed mirrors are thought to be the best, the glass lending itself more readily than any other substance that might be used, to a high polish. It has tested out that a 24-inch glass mirror projector, though old and greatly worn was the superior in reflecting power to a 30-inch monel metal projector.

As regards quality of light in color, the gold backed mirror seems to be the best. While the silvering on the back of glass mirrors is not at all permanent, when it has become speckled or worn it may be easily resilvered, the repolishing or regrinding so necessary to refit the metal reflectors being in no wise required. Again little damage can be done to the glass while removing dirt and dust while the same operation on metal is productive of scratches and marks. Furthermore, corrosion is not a factor as it is with the metallic reflectors. The metal mirrors are superior as regards weight and their liability to damage through shock of transportation or being struck by missiles.

To remedy this there has been designed a segmental glass mirror which is the most generally accepted type of reflector.

It consists of four or more segments which are held in place by metal bands across the surface. A damaged segment can be replaced quickly and easily. The metal bands do not appreciably diminish the reflecting area nor as they are of reflecting metal the reflecting power of the mirror.

Extensive tests have demonstrated that the glass mirror is by far the superior to any other in definition and regularity of beam form.

The latter is accounted for by the fact that the glass lends itself readily to a very high polish and consequently a truer surface.

New segmental mirrors are generally finished as one piece and thereafter cut into segments. It has also been found practicable, having damaged mirrors of approximately the same profile to make segments of the clear parts which work very well when placed together. Regrinding is sometimes necessary but has been found practicable. This is done by a large firm which has in the past supplied to a great extent the projectors for the French Navy. This firm claims that the objection made to the segmental mirror that the beam from such a reflector will not be as homogenuous as that from a one-piece mirror, has been fully refuted by actual tests made for the French War Office, proving that the beam form of a segmental mirror was in nearly all respects identical with that of the single glass mirror.

As regards the action of heat on the mirror from the are lamp it has been found that a small central hole in the mirror renders the glass much less likely to damage. This hole being in the blind spot, *i. e.,* directly behind the carbons, it does not materially alter the intensity of the beam. Still another advantage of this central opening is that it allows an equalization of pressure on the glass following the atmospheric disturbances attendant upon cannon fire and makes far less probable, damage from this source.

Design of Units

As to design of units, the projector itself has been perfected together with control apparatus. The greatest advancement of recent years has been in the line of designing suitable mountings and generators at once highly efficient and possessing a large degree of power and mobility. The use and perfection of the internal combustion engine has gone a long way toward solving both the problem of the generator and that of transportation.

The first units consisted of a horse drawn carriage mounting the projector, and a second carriage mounting the generator, control apparatus, etc. In some instances the first carriage carried a platform or ladder which might be erected to give to the light a greater command. While these animal drawn units are by no means obsolete and are still preferred in some services, the late tendency has been toward motor traction.

A recent design of portable projectors by the General Electric Company for field uses consists of a light mounted on a motor truck, the motor funishing the power for the generator. This type will be more fully described later.

The problem of mobility is in general very much that of traction for field artillery material. As special cars and trucks must be designed to meet the demands of motor traction of artillery so must the same questions be met in developing a suitable type of car or truck to transport the auxiliary projector with the additional problem of requiring a motor generator that is capable of standing up under sustained and constant load at constant speed.

Motorization of Field Artillery is receiving a great deal of study and consideration both here and abroad. Transportation of search light equipment is so nearly allied to it that we will not consider it here further.

CONTROL

Portable searchlights of the type most favored by the military, are equipped with two methods of control, electric and hand. The former is accomplished by electro-magnets. The movements of the beam in both horizontal and vertical planes follow the movements of the controller hand wheel. A release clutch serves to throw out of gear the electric control and the horizontal and vertical motion can be given by operating small handwheels much the same in principle of operation as the method of elevating and traversing the field piece.

An improvement on this control system has been the graduation of the horizontal and vertical ares in mils. This system, with a zero line established by two sighting lugs enables the direction and elevation to be directed as precisely as can be the fire of a gun. The advantages of this to an observer are very apparent.

VISIBILITY AFFORDED

It must be borne in mind that, in the use of projectors, all the light affording observation emanates from the projector itself and is reflected back from the objects illuminated to the eye of the observer. From this it is apparent that the degree of visibility depends not only on the distance of the light from the objective, in range of beam, but also and in a greater degree upon the proximity of the observer to the objective. Tests made by our Engineer Corps establish that with the 36-inch light the effective maximum beam range is from 4,000 to 6,000 yards.

This long range enables projectors of this size and even those of 30 and 24-inch diameter placed at artillery ranges to secure to the advanced observers sufficient visibility for fair observation.

Diameter of mirror. C. M. S.	Normal current amps	Relative distances of illumination. Meters[1]	Radius of action for small objects. Meters[2]					
			With concentrated Beam Meters	With angles of dispersion of				
				10°	20°	30°	45°	
35	20	860	1530	1000	850	770	690	Visibility 3
40	30	1050	1680	1080	910	825	740	
45	40	1250	1830	1200	1010	920	825	
60	60	1710	2550	1400	1180	1060	960	
60	70	1740	2170	1410	1190	1070	970	
75	80	2200	2430	1590	1340	1200	1090	
90	100	2700	2700	1750	1470	1330	1200	
90	120	2700	2700	1750	1470	1330	1200	
110	150	3300	3000	1910	1610	1440	1310	

[1]The distances at which searchlights of the respective diameter must be placed in order to render objects just visible when the observers distance from the object is 2700 meters.

[2]The distances at which it is possible to see whether artillery fire is too high or too low and to clearly distinguish sappers working on entrenchments.

Nerz in his text on searchlights, their theory, construction and application gives us some very interesting data on the performance of searchlights. This data is based on tests made with projectors having parabolic glass mirrors.

VULNERABILITY

We have spoken elsewhere of the ruggedness of the projector to withstand the shocks of transportation and of being struck by missiles. Let us consider now the kind of target a light in action makes, the probability of its being struck and the difficulty which may be expected in firing upon it.

The Dutch Engineer School supplies a report on the test firing on Electrical Searchlights at Karkamp in September, 1904.

The searchlights serving as targets were placed behind an earthen breastwork with but the electric are lamp and the mirror wholly exposed. The dynamo carts were placed 500 meters to the flank and covered. Two projectors are used, the one a parabolic glass segmental mirror and the second an old condemned noval metal mirror searchlight of 90 and 60 c.m. diameter respectively; the light produced being in each case equivalent to that of a 40 ampere, 60 c.m. Schuckert projector.

The firing line was made up in part of officers and noncommissioned officers from the normal Firing School, some stationed within and others without the beam of light.

It appeared that for those who did not know the exact location of the light it was simply impossible to estimate the range. The human eye, affected by the blinding light, and deprived of the opportunity of comparison with protrusions of earth of known distance as these remained in darkness, seems to have lost all ability to estimate ranges. For instance the range of 1,500 meters was variously estimated at 1,000, 700 and 500 meters. Firing tests were held at this range notwithstanding the small probability of hitting the target as this was conforming to the condition that the firing section should as far as possible remain at such a distance from the light that observers at the light would be unable to clearly identify them.

The firing as a rule lasted but one or two minutes at a time, under the assumption that in actual service the searchlight whenever fired upon could always in a short time be extinguished.

With the detailed and tabulated results of this firing we are not especially interested; suffice it to say that out of over 1,600 rounds fired but eleven hits were made, six of these only being direct, one bullet striking the carbon holder and breaking it. A new holder was immediately set in and the firing resumed. From the position of the riflemen no decrease in the reflecting power was noticeable after hits.

The board before whom this test was made was conclusively of the opinion that it was extremely difficult especially at ranges of 800–1,500 meters to hit searchlights in action, even though the true range was known to the marksmen, and considering the range of the light that there need be but little apprehension as to the danger to searchlights from rifle fire. Moreover, a firing enemy has no way of knowing when his fire is effective, for except a carbon or holder is struck the light continues to operate even though the mirrors have been struck.

This test of rifle firing is of importance to us only as it shows the difficulty of observation in attacking such a target. It might be very interesting to know just how vulnerable lights are as used on the Western Front in Europe, how they stand up under heavy machine guns' fire and how they are affected by shrapnel.

The Japanese display with great pride projectors used in the Manchurian War and of which they claim that they were never incapacitated by shrapnel fire. Just how much of this is boast and how much of it is fact it is difficult to say.

So far as is known we have in our service but one instance of artillery fire on a searchlight or stimulated light. One of the maneuver problems of the Philippine Department in February and March, 1914, was the attack and defense of Corregidor from the land side.

One feature of the regulations as prepared by the umpires for the conduct of the solution was the provision that a light which had been under artillery fire from the mainland for a half hour was considered incapacitated and out of action.

Battery E of the Second Field Artillery—Mountain—was a part of the attacking detachment and for the greater part of the maneuver period was located at Alasasin Point directly north across the channel from Corregidor. A good part of each night was spent as we termed it "potting lights" with the result that all of the lights on the one—the north side of Corregidor were ruled out of action.

To determine the validity of this special provision which caused some considerable comment among officers of the Coast Artillery and defending garrison, the Department Commander ordered that the test firing be held upon a searchlight from the Marivales side. A stationary light on North Point, operated from a bombproof was chosen as the target. A 60-inch metal reflector—tin—was set up at the outside of the covered way in such a position that the light could be operated from the bombproof and the beam being thrown on the reflector made to simulate an actual light in operation. The very pertinent reason was to avoid all chance of injury to the expensive plant of the light itself. The beam as thrown off the reflector was not nearly as strong as that emerging from the projector, but it served well the purpose intended. Some 50 rounds were fired at a range of about 4,200 yards, time fire.

The position of the light was about 100 feet above the water with a rocky cliff for a background. Observation of overs and shorts was almost impossible and no effect could be noticed from the position of the battery. The writer who was the battery reconnaissance officer and was a flank observer, was able positively to sense one short only.

The light was hit, several fragments and about a dozen pellets having struck the reflector ineffectively.

The firing while it clearly demonstrated that a light could be struck by artillery fire, nevertheless showed how difficult it is to bring effective fire to bear on an exposed light. The firing was, in most regards, done under most favorable circumstances. All the elements of the firing data were most carefully computed. The large Marine light on "Topside" made a most excellent aiming point. The range was determined by scale from a reliable map and by triangulation. The firing was by piece and extremely deliberate, every effort being made in laying and firing to minimize the errors in range, deflection and burst interval.

It is impossible, of course, to say what effect the intermittent use of the light might have had on the firing or how seriously the real light might have been injured under the same circumstances. Again, while results showed that the light could be hit it demonstrated how extremely difficult it was to secure an adjustment upon a searchlight in action even under the most favorable circumstances. Conclusive deductions as to the vulnerability can scarcely be drawn from this test. It is related here partly because in itself the whole procedure was so unique and partly for the item of interest that it may contain.

It might be added that so well were the guns masked that with all the available projector equipment of the island searching to locate the battery, with officers observing, the position of the firing battery was never revealed by flash or smoke or in any other way.

Description of Type

As a representative type of late construction of portable projector is taken an auto-searchlight set designed especially for and tested by the Engineer Corps to determine its adaptability for field service. Elsewhere will be found the results of the tactical test given similar reflector equipment by the Field Artillery Board. The auto-searchlight set consists of two units, the automobile, hereafter designated the car, and the searchlight trailer.

The car was a couple gear truck upon which was mounted a 15 kilowatt gasolene generator set. The trailer consisted of a standard artillery caisson upon which was mounted a spring supported platform carrying a 30-inch General Electric metal mirror, electric control searchlight, with 500 feet each of supply and controller cable. The weight complete of the trailer was 4,400 pounds.

The car was originally designed to carry in addition a 24-inch projector mounted on its rear platform. After considerable test this was removed and extra gas storage tanks substituted to increase the radius of action of the unit.

The gasolene generating set consisted of a semi-automobile type 5 cylinder, 4 cycle, 5 × 6-inch Dock, enclosed type gas engine, direct connected to a 15 kilowatt, Sprague, 6 pole, 85 volt interpole direct current compound generator. The usual automobile type of engine is not satisfactory as it will not stand up to generating service, because the design of the cooling water jacket is not liberal enough to allow carrying a continuous load at constant speed.

The generator was of special light design of the interpole type. It was direct connected to the engine by a flange coupling and supported on a cast aluminum sub-base integral with the engine base. The interpole feature made possible carrying for short periods, as high as 75 per cent. overload, thus increasing the power of the car as a tractor.

The weight of the car complete was 10,400 pounds with the second projector, without, 9,800 pounds.

TACTICAL EMPLOYMENT OF SEARCHLIGHTS

The uses of searchlights on the defensive may be:

1. To illuminate points over which the attackers must advance as through defiles, so as to bring them under fire at the earliest possible moment.

2. By lighting distance areas or sectors to disclose the movements or dispositions of hostile troops and with the aid of this illumination establish a fire swept zone, retarding or making impossible further advance of the enemy or his establishment in closer lines of investment.

FOR THE OFFENSIVE

1. To prevent the enemy from improving his position with entrenchments or obstacles under the cover of darkness.

2. To light up definite targets for the artillery such as batteries, redoubts, trenches, moving columns, lines or supplies.

As to actual methods of employment in the present war to accomplish these aims we know but little. We do know, however, that they are being extensively employed by the warring nations and that previous to the war England, France, Russia and Germany had given considerable thought and attention to the organization and training of searchlight units and to the perfection of mobile searchlight material.

Except that full advantage is taken of the illumination afforded by projectors, we may say they have failed in their function. Ground presents a very different aspect when lighted by the electric are to that which it presents by daylight. Daylight illumines all folds in the terrain, which is not the case with light from a projector. The source of light in the latter case is always at a relatively small height above the ground. A certain amount of command is therefore not only desirable but necessary. This may be had by posting the light on eminences or as is provided in some designs by hoisting the light on a specially constructed tower. The generator set must of course be masked as also the controller. Again, electric light brings out certain color contrasts, some colors being far more visible in its light than others. Thus objects that have relatively the same visibility by daylight may be far separated in points of discernment at night. To a degree the sense of proportion of size of objects is lost by are illumination. These and many other reasons show how requisite is a well trained observer and especially a good eye.

Observers must as a rule remain on the ground in front of the light as long as the enemy will allow. They must be connected with their light by telephone and to their commander, their battery or artillery unit. Complete control of the light must be vested in the observer to enable the greatest results to be obtained from its use.

In addition to telephonic control of the light the observer should by means of the electric button control the occulting shutter. The graduated vertical and horizontal scales—in mils—on the late design furnish the means whereby a searchlight may be trained on any desired point much as our indirect laying methods permit of our training the field piece.

It will greatly facilitate and for the safety and security of the light it will be mandatory that the observers have made during the day a most thorough and complete reconnaissance of the terrain by day. The light, in position by day, the observer can by means of the sighting vanes, or, in the case of some designs with the sighting telescope, accurately train the light on any desired point, in short, register accurately by means of readings on the horizontal and vertical scales his sector of observation. The more time given to this, the greater the efficiency of registration. With this registered data tabulated and recorded the observer can quickly train his occulted light on any point he may desire and when so trained open the shutter with his occulter switch, occulting the light immediately he has made the observation he sought.

The French estimate that it takes but about twenty shrapnel well directed and observed to destroy a light. To secure the best use then its light must be hoarded and used only when its use will warrant returns.

To show the entire practicability of the use of searchlights as an adjunct to field artillery fire and control, and without considering the great use they are being put to in this regard to-day in Europe I quote the résumé of the conclusions of tests made by our own Field Artillery Board to determine the feasibility of night firing by artillery with the aid of searchlights.

The problems were fired at Fort Riley by the Board by bright moonlight September 5, 1911. The ranging was completed by daylight and the targets were fired upon at night; ranges 3,150 and 2,650. In 1, all the firing was done at night, bracket 2,600–2,650. Although the beam could not be sufficiently concentrated nor brought to parallelism, the Board concluded:

1. That it is entirely practicable to bracket at night a target representing a surface as great as that of a line of kneeling men.

2. That if the target contains prominent features the bracket may be reduced to 100 or 50 yards.

3. That to secure good results there must be auxiliary observers to the front and flanks of the battery and within at least 1,500 yards of the target.

Two problems were fired on a very dark night, September 13. In one the bracket 3,200—3,400 was established by daylight, in the other all firing was done at night. Better focus was secured at this test.

The Board concluded that:

1. It is entirely practicable to fire at night; all or part of the adjustment being done at night.

2. Auxiliary observers advanced toward the target are necessary.

3. Indirect laying must be used.

4. At medium ranges prominent targets may be ranged on by observation from near the firing point but advanced observers are necessary to determine the height of burst.

Of the importance of the searchlight to the other arms there can be no doubt, its necessity to the artillery to aid it in night firing cannot be questioned. It is, however, a costly, elaborate and highly technical service. What its organization shall be and under what corps or arm of the service it shall properly belong are questions that must be answered practically. European nations are making of it almost a separate arm of the service and their searchlight units or sections are integral parts of large organizations.

Special schools and courses of instruction are employed to train mechanicians, operators and observers; it is being made a specialists' vocation. With us the light as a mobile unit is only experimental.

When their use with our army becomes settled it would seem that they must come as auxiliary divisional troops, searchlight companies or sections that will be available for troops of all arms and for all uses.

Notes on Observation of Fire from a Station Off the Line of Fire.

BY CAPTAIN A. U. FAULKNER, 4TH FIELD ARTILLERY

THE subject of observation of fire from a point considerably to a flank of the firing battery is discussed in S. F. pamphlet No. 20 g, but from that discussion a practical rule for use in firing can hardly be drawn.

I have worked out a method of determining the approximate location of shots and making desired corrections during actual firing.

The method will at least give an officer firing from a flank observation station some idea of where he is in deflection.

Assuming that a shot must ordinarily be in line with the observation station and target in order to be sensed for range, the method may be explained as follows:

With change of range of 100 yds. and a station 100 mils from the line of fire, a change of deflection to put the second shot in line with the first and the observation point is 10 yds.; with change of range of 400 yds. and a station 800 mils from the line of fire, a change of deflection to put a second shot in line with the first and the observation point is 400 yds.

This statement holds for practical purposes if the gun is laid within 100 mils of the target.

For changes of range and stations between the extremes mentioned the following table is approximately correct:

Angular distance of line OT from line of fire.	Range changes.	Corresponding change of deflection to put 2nd shot in line with first.
100 mils	100 yds.	10 yds.
	200 yds.	20 yds.
	400 yds.	40 yds.
200 mils	100 yds.	20 yds.
	200 yds.	40 yds.
	400 yds.	80 yds.

Angular distance of line OT from line of fire.	Range changes.	Corresponding change of deflection to put 2nd shot in line with first.
300 mils	100 yds.	30 yds.
	200 yds.	60 yds.
	400 yds.	120 yds.
400 mils	100 yds.	40 yds.
	200 yds.	80 yds.
	400 yds.	160 yds.
500 mils	100 yds.	55 yds.
	200 yds.	110 yds.
	400 yds.	220 yds.
600 mils	100 yds.	70 yds.
	200 yds.	140 yds.
	400 yds.	280 yds.
700 mils	100 yds.	85 yds.
	200 yds.	170 yds.
	400 yds.	340 yds.
800 mils	100 yds.	100 yds.
	200 yds.	200 yds.
	400 yds.	400 yds.

The foregoing table may be kept in mind by what I call the 10 yds.-400 yds. rule.

By remembering that the deflection changes for 100 mils off the line of fire begin with 10 yds. for 100 yd. jump, the approximate values of the deflections up to and including 400 mils from the line of fire are by regular increments.

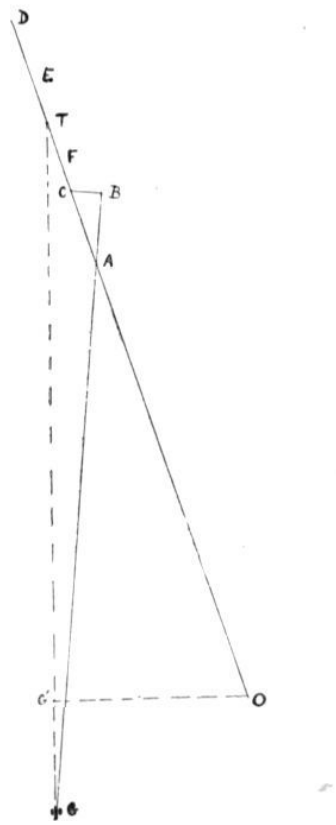
By bearing in mind that 800 mils from the line of fire the deflection change is 400 yds. for a 400 yd. jump, the approximate values of the deflections down to and including 500 mils from the line of fire decrease regularly.

As an aid in estimating the angle the line O-T makes with the line of fire G-T, it may be observed that when the distance O-G′, from the observing point to the line G-T is equal to the distance G′-T, the angle O-T-G is 800 mils; when O-G′ is ½ the distance G′-T the angle is about 500 mils (470 mils). To estimate the latter and smaller angles the mil system is sufficiently accurate.

It follows that when the observation station is directly on flank of the battery (on a line normal to the line of fire through the firing point G) and the distance from O to G is equal to the range, the angle is 800 mils; if O to G is ½ the range the angle is about 500 mils.

The method can be worked out roughly as follows:

Gun laid within 100 mils of target. If the observation station (0 in figure) is 100 mils from the line G-T and a shot falls in line with the target and observation station, a change of range of 100 yds. without change in direction of the piece will place shot 10 yds. to the right or left of the line O-T.



In figure, A is shot observed in line O-T; B is second shot range 100 yds. more and C is point on line O-T where a line C-B from point of fall of second shot and approximately normal to the line of fire intersects line O-T. The length of C-B is 10 yds. This is arrived at approximately by the mil system. Angle GAO and hence CAB being about 100 mils, line AB about 100 yds., line B-C at 100 yds. from A, is approximately $100/1000 \times 10 = 10$ yds. Hence to put the second shot, range 100 more, in line with the target, a change at Range 2000 of "Add 5 mils" must be made in order to observe the second shot.

A method of applying the rule in ranging is: B. C. at O, 500 mils from line of fire; target is visible carriage of battery at T. Range 2000. First shot at A short in line O-T. Next command "add 100 (200 yds. from table ÷ Rn/1000); Range 400 more." The second shot falls at D in line O-T and is observed over. Next command "Subtract 50-Range 200 less." Shot falls at E in line O-T and is observed over. Next command: "Subtract 25, 100 less." Shot falls at F in line O-T and is observed short. This gives 100 yd. bracket, but deflection is not yet adjusted, as line of fire G-F is to right of T. The most probable position of the T is midway between shots E & F, so that the most probable position of E is 50 yds. short; at any rate the B. C. knows about where he is. By making a correction for 50 yds. short or about 25 yds. in deflection, the fire for effect will be approximately on the target. The next command then is: "Add 10 or 15" (25 yds. ÷ 2 = 12½ mils) Range same."

If a ranging shot does not fall in line (O-T), that range should be fired again with correction the number of mils right or left that shot appears with multiplier of from 1.1 to 2.5 according to angle (O-T-O) off line of fire as stated in S. F. pamphlet subject No. 20g; except that the relative lengths of the lines O-T and G-T must be considered. At 800 mils from the line of fire with observing station on a flank on a line through the gun and normal to the line of fire the multiplier will be nearer 2 and 1.4. A station 1200 mils from the line of fire will probably be in front of the gun and it may be so near the target that 2.5 will be too great a multiplier.

The 10-400 yd. rule also enables corrections to be made for adjusting the final deflection error if the visible target is so wide that the rule is not needed in ranging.

B. C. 200 mils from line of fire.

Say the 200 yd. bracket is secured at 3000-3200. The right of last salvo which was fired at 3000 was 20 mils to left of right of target. If it was approximately 100 yds. short it should appear 20 yds. ÷ 3 = 7 mils to left of right element. The B. C. subtracts 10 and goes to effect.

The same principle may be used for observing point 1200 mils from line of fire, which is about the limit at which observation for range can be made, but the correction for 100 yds. change in range is about 250 yds.

In ranging with flank observation I venture to suggest:

1. Get initial deflection and deflection difference as near correct as possible.

2. Fire the first salvo with sheaf well opened.

3. If the first salvo is sensed for range either from a shot in line or from the terrain, close to parallel fire on shot nearest in line with its place on T., change deflection by method just described and fire second salvo for bracket, continuing until desired bracket ise secured.

4. If first salvo is not sensed for range, close to parallel fire on shot nearest in line with its place on the T.; change deflection by rule in S. F. pamphlet No. 20g and repeat range.

5. When desired bracket is secured correct deflection by 10-400 yd. rule for distance of half the bracket and go to effect.

6. As the probable range and fuze errors are sufficient to make considerable difference in the apparent relative deflection of the shots of a salvo as sensed from a flank station, it is not desirable to make individual corrections for relative deflection of the pieces when the angle from the line of fire is more than 300 mils. For instance, with observing station 500 mils from the flank at Rn. 2500 yds. the bursts from the first and second pieces may appear in same line through a difference in range of burst of 40 yds. (I. E. 20 yds. ÷ 2500/1000 = 8 mils) when the guns are correctly laid for parallel fire.

CURRENT FIELD ARTILLERY NOTES

Our Ammunition Supply in War

TRANSLATION OF AN ARTICLE BY CAPT. OEFELE, RETIRED, IN PERIODICAL "PROMETHEUS," JAN. 15, 1916.

AMMUNITION plays a specially important role in war. It is one of the most important requisites for the fighting efficiency of the troops and decisive for success. There are, indeed, other equally important factors necessary to maintain the preparedness and efficiency of the troops. Reference is made here only to supplies and medical assistance both of which share this in common with the ammunition supply, namely, that they do not reach the troops too late. But in view of its far-reaching importance, the ammunition question demands special consideration, and the supply of ammunition, therefore, takes precedence over all other branches of army supplies.

The ammunition question is a matter of fore-sight and money. This saying of a well-known French military writer is undoubtedly justified. Only fore-sight is more important than money. The Russo-Japanese War has already indicated this clearly and the present World War shows it even more clearly. Accordingly the supply of ammunition requires on the one hand the most careful preparation in peace, and on the other hand far-sighted and thorough preparation, as well as untiring and systematic work, in war itself.

Due to progress in the technique of arms and the tactical changes involved therewith, the consumption of ammunition has now become considerably greater than in former wars. In order to satisfy the materially increased demand for ammunition the ammunition equipment of the troops has been increased to the utmost limit on the one hand, and on the other, fore-thought taken for a timely and ample replenishment of the same. This is possible only while already in peace the required supply of ammunition was held ready regardless of the cost and preparation made for its expedition. But the further indispensable reserve supply of ammunition demands that during war also its production shall be maintained without cessation and with increased energy and that its transportation shall be insured. The production of ammunition during war is liable to experience difficulties because the industries may not be able to meet demands due to lack of workmen. Therefore the security of production requires the adoption of far-seeing measures and a united co-operation of all circles concerned with mustering of all available resources. The transportation of the ammunition is then only guaranteed with the necessary certainty when it is regulated by a well thought out and good working organization perfected to the smallest details. This requires a well considered and far-seeing utilization of the available means of transportation as well as a strict carrying out of standing regulations covering re-enforcements in ammunition.

The consumption of ammunition has increased enormously of late years both with the infantry and in the artillery. This is evidenced by characteristic instances from the Franco-German War 1870-71 and the Russo-Japanese War 1904-5. Thus in the Manchurian Campaign in the Battle of Liaoyang, the Russians consumed more than half the weight in artillery ammunition than the German Army used in the entire war of 1870-71, and over one-third the infantry ammunition. According to the Russian General Staff account, in the Battle of the Schaho, each Russian infantry rifle shot on the average 195 cartridges and in the Battle of Mukden 196. Individual regiments engaged in specially stubborn defensive fights reached as high as 400 cartridges per gun per fighting day. In the War of 1870-71, on the other hand, the average consumption per rifle on the German side was only 56 cartridges, and the maximum on any one fighting day was only 200. The Russian artillery fired from each gun at Liaoyang 240 shots, at Schaho 170, and at Mukden 480. What a difference, if one considers that in 1870-71 the German Artillery only very seldom fired more than 200 shots on one fighting day and that the average for single fighting days was much less; for example at Wörth 40, St. Privat 53, Sedan 37 shots. In the Battle of Mukden, the Russian Field Artillery fired approximately 487,200 shots; in the War of 1870-71, on the other hand, the German Artillery consumed in the open field during the entire war only about 338,000 shots, of which a tenth part was fired at the Battle of St. Privat (which as is known consumed the most ammunition) or abuot 33,800 shots.

The colossal increase of ammunition consumption is still better illustrated by the quantities used in the present war. Exact figures are naturally for the present unavailable, but from reports which have been published it is clear that the consumption of ammunition has far exceeded that heretofore to an incredible degree. According to a report in the French Army publication, "Bulletin des Armées," one of the contending parties fired 100,000 shots in a single day on a front of 8 km., and with this it is maintained that the number of hits per meter of front was six times greater than in the hottest day of the War '70-'71. According to official report of the French Army Headquarters dated June 17, 1915, the French artillery north of Arras fired 300,000 shots within 24 hours, the total weight of which can be estimated at 4,500,000 Kg. (8,901,000 lbs). It may be concluded from the Russian reports that the Germans fired 700,000 projectiles in the great battle in Galicia. According to statements in the "Neuen Züricher Nachrichten" during the great French Offensive, September 22-25, 1915, in the Champagne the French fired at the rate of 900,000 shots per hour against the principal front of attack of 25 Km., making a total of over 50 million shots in three days on this 25 Km. front. If it is considered that the attacks extended over the entire front, one can imagine what an enormous quantity of ammunition was expended throughout the whole offensive. And one will also appreciate the enormous quantity of ammunition which was necessary to enable the French to again resume a drum fire of 43 hours duration on the occasion of their attempt to break through the German lines on October 24.

The reason for this colossal increase in expenditure of ammunition lies in the tremendous capacity of modern fire arms and the great demands of modern fighting methods. The modern quick firing arms (repeating rifles), machine-guns, and quick fire guns, in consequence of their construction and rapidity of fire require in themselves considerable more ammunition. The greater ranges make it possible to begin battle from greater distances, which again requires larger expenditure of ammunition for carrying out this fire fight. Further, the character of the targets, the great difficulty of recognizing them, their form, the effort to seek cover, the increased skillfulness in employment of covers and strengthening the terrain, all require greater expenditures of ammunition if decisive results are to be obtained, in spite of the increased effectiveness of weapons. In addition to the above must be considered that the now universal efforts to secure fire superiority as well as local and timely concentration of effect and for decisive fire effect all of which considerably increase the expenditure of ammunition even for single decisive actions. It is therefore obvious that enormous quantities of ammunition are required by the size of modern armies and the long duration of modern fighting methods, as well for field battles as for position warfare. Above all position warfare has developed into pronounced battle of ammunition. An adequate ammunition supply is, however, an indispensable requisite for the fighting efficiency of troops in all fighting situations. For it is essential in the attack in order to combine time and place effect at the decisive point, in defense in order to compensate for its weakness, in the pursuit of the enemy in order to push his defeat into a complete dissolution and in the retreat in order to make it possible to break away from the enemy. The first demands of the necessary ammunition supply is carried by the troops themselves.

This equipment of troop ammunition is suitably distributed among the troops themselves and in the columns following them. Each German infantryman carries 150 cartridges with him, divided between his knapsack and cartridge pouch. An additional 70-80 cartridges per man is carried in the company ammunition wagon, which belongs to the combat baggage, and follows the troops everywhere; in difficult terrain where the ammunition wagon can no longer follow, pack animals are substituted. A further supply is carried in the infantry ammunition wagons. The machine-guns, which use same ammunition as the infantry, likewise carry their first supply on their own ammunition wagons, but unlike the infantry their cartridges are attached to bands each containing 250 rounds packed in individual cases. The further supply is here likewise carried by the infantry ammunition column. The ammunition equipment in the case of artillery varies according to type of gun and its calibre. In the field artillery there is an ammunition wagon to each gun, the body of which stands in the immediate vicinity of the gun in the firing position. There are 138 rounds for each gun; 90 rounds for each light field howitzer in the combat battery, i. e. in the gun-limber and ammunition wagons. In the light ammunition column belonging to each Battalion is a further supply for each gun of 120 rounds or 70. Finally, further supplies are found in the artillery ammunition column of the Army Corps. The ammunition equipments for heavy artillery, heavy field howitzer and mortar battalions are carried in a similar manner; here also the ammunition supply is distributed among ammunition wagons, light ammunition columns and foot artillery ammunition columns.

Re-enforcements of ammunition supplies for the troops are furnished by the home depots. This is only possible if sufficient quantities are on hand. For this reason ample supplies of ammunition for infantry, field and foot artillery were kept in stock in the artillery depots during peace—for the emergency of war. Through the war organization the artillery depots with their ammunition stocks are assigned to the various armies, so that each army relies upon its own special depot for its supply of ammunition. At the outbreak of war the troops receive their first equipment of ammunition and the troop ammunition columns are loaded. The reserve ammunition is likewise taken from these depots, during first period of war, from stocks laid in during peace, and sent to the troops regularly by means of the Etappe. But as the available supplies are only sufficient for a very limited period, the production of new ammunition was immediately taken in hand after the beginning of the war. These new supplies are likewise stored in artillery depots and held in readiness to be forwarded to the troops. In order that the necessary amount of reserve ammunition may also be available at all times during war, it is necessary to enlist not only all reserve resources and a steady busy work of the government arsenals and factories, but also of the private industries, manufacturies and trades. For in the manufacture of ammunition we are solely dependent upon our own resources, because all importation is cut off. Therefore we must exploit to our utmost not only the resources of the home land but those of the occupied hostile territory which have already been placed under German administration. This requires above all adoption of strict measures to insure for the production of ammunition all available raw stuffs and materials and prevent them from being used for other purposes. In view of the enormous consumption of ammunition, it is impossible for the state factories alone to satisfy the demands. Therefore in addition to the military technical institutions and government factories, numerous private undertakings are continuously occupied at high pressure with the production of ammunition. Among the latter are not only meant the private concerns occupied with ammunition production during peace, but many others whose peace activities covered quite different branches of manufacture and which have now gone into the business of making ammunition or parts thereof. Not only regular factories assist in this work, but also the smaller machine- and work-shops, for the army administration as well as the private industries are obliged to enlist the co-operation of the smaller factories in order to fill orders. Only in this way is it possible for the German Army authorities to keep abreast with the extremely great requirement of ammunition. That they have far exceeded all expectations in providing ammunition without disturbances in operation is unmistakable evidence of the will-power and singleness of aim of the military administration and the efficiency of our military institutions and private industries.

The supply of ammunition not only embraces manufacture and laying in necessary stocks at home, but also includes its transportation to the theatre of operations, for the troops are only able to make use of ammunition reserves when the latter is delivered in time.

This re-enforcement of ammunition is a function of the Etappe and is under the Etappe Inspector of each army. It is the latter's duty to see that there is sufficient quantity of reserve ammunition in his Etappe District at all times and that the troop supply of the field army is replenished on time. For the solution of this problem the Etappe inspector has at his disposal the ammunition supplies lying in readiness in the home territory which are brought to the Etappe District as required and from there to the toops as it is needed. The transportation into the Etappe district is performed by special ammunition trains or ships which are loaded from the stock of the home territory artillery depots. The unloading takes place in Etappe ammunition depots, especially erected for this purpose and resembling the home artillery depots in arrangement. With the progress of operations these ammunition depots are constantly moved forward in order to keep them at not too great a distance from the troops. The moving of depots is facilitated by use of railroads or waterways when possible and, under certain conditions, by laying field railways. Should such means not be available or inadquate then Etappe ammunition columns are employed. They consist partly of horse drawn and partly motor truck columns, which latter can cover great distances quickly and have considerable more capacity. They are therefore especially employed in cases of unexpected urgent need and by advancing as far as possible into the theatre of operations; their carrying capacity makes them useful in transportation of heavy ammunition of large calibre. The ammunition columns of the Army Corps load up at the foremost Etappe ammunition depots and supply the fighting troops at the front. If the distance is too great for the troop ammunition columns to cover, or an unusually great consumption of ammunition is foreseen, then the Etappe ammunition column carries ammunition from the depots to the special ammunition delivery points, which have been established by the Etappe as close as possible to the rear of the army, keeps these constantly filled up and in the course of further operations either changes them into Etappe ammunition depots or abolishes them. At these delivery points the infantry and artillery ammunition columns receive their supply from which again are filled the cartridge and ammunition wagons of the combat troops.

The smooth working of the ammunition supply imposes a tremendous demand on the Etappe. Above all it demands a far-seeing control, but notwithstanding this also a great adaptability to the varying relations of the war. For the ammunition supply proceeds quite differently in a rapid maneuvre war from that of the monotonous position war, differently in good passable flat country from difficult mountain terrain. And again, the ammunition supply is different during an advance from what it is in battle, different during quieter periods of fighting from the time preceeding a decisive engagement. In every case it is, however, a question for the Etappe to insure the ammunition Ersatz in the most suitable manner.

The following brief indications show how variously the ammunition supply may shape itself. For example, in position warfare it is a question of providing continuously great masses of ammunition. But here the ammunition re-enforcement is easier and simpler than in a smoothly advancing maneuvre warfare. For here the long stay of the troops in the same area permits of the installation of permanent ammunition depots, and, above all, to build out the railway system in the most complete manner. Through this it is under circumstances possible to bring forward ammunition trains and motor truck columns to the fighting troops and to effect an immediate delivery of ammunition to them without unloading. In mountain warfare the conditions require a radical departure from customary methods. Here wagon trains with teams and motor truck columns can be employed only to a very limited extent, because they cannot get forward. Here the further despatch of ammunition must be accomplished by pack train columns, not only by the fighting troops themselves but also in the Etappe. In position warfare in mountainous country, cable ways and lifts sometimes make the transportation of ammunition possible, even in very difficult terrain, so that here also a regulated and ample ammunition supply is effected. When a decisive action is imminent it is a question of having in readiness the greatest possible ammunition supply close behind the army. In this case not only the ammunition trains will be brought to the front as for the ammunition supply. By a steady shuttle service they carry the far as possible but all available Etappe columns will be put in service ammunition from trains and boats to delivery points. During the fighting the ammunition supply proceeds without interruption. In certain cases the ammunition trains proceed so close to the army that the Corps columns can be filled directly from them. But often also the Etappe columns proceed to the field of battle and deliver their ammunition to the troop wagons. Here the high capacity of the Etappe motor truck columns can be especially well utilized. After the battle, especially in a pursuit after victory, a rapid and increased ammunition supply is demanded, here also motor trucks may become decisively important.

The ammunition supply by the troops proceeds as follows: In the infantry, the contents of the cartridge wagons are wholly or partly distributed among the men before going into action. The empty wagons obtain fresh ammunition from the infantry ammunition columns halted farther in rear. Ammunition for the fighting troops is carried forward from refilled wagons by the re-enforcements pushed into the fire position. Any threatened shortage of ammunition is reported to the rear by signals. Ammunition is taken from the dead and wounded and further utilized. In the field artillery, where each gun has its caisson body standing alongside, the ammunition is taken from the gun and caisson limbers and laid down at the gun. Empty caissons of the fighting battery are exchanged with full caissons from the light ammunition columns. The empty wagons of the latter are refilled from the artillery ammunition columns farther in rear. In the heavy artillery the same principles apply. With the heavy calibres it however, often happens that ammunition motor truck columns advance to the guns themselves and bring up ammunition without reloadng, as is seen, the ammunition supply of the troops consists in a constant back and forth movement of cartridge and ammunition wagons, empty wagons being sent always farther back while full wagons are brought from the rear forward, in part on the field of battle.

The entire ammunition supply as it takes place between the artillery depots of the home territory up to the foremost line of the fighting troops requires a correct working together of all parts of the ammunition service. The fact that until now all demands on the ammunition supply have been met in every particular, speaks for the high degree of working together which exists in the German Army. It is also an unmistakable sign of the organizing talent of our military officials and the excellence of the organization of our ammunition service.

To Determine the Deflection D of the Directing Gun, or to Relocate the Position of any Objective, by Means of the "Parallel Method," Referred to in D. R.

BY LIEUTENANT-COLONEL BROOKE PAYNE, FIELD ARTILLERY

1—THE distance from the Observing Station, B, to the directing gun, G, called the Base, is estimated, paced, or determined by stadia. The last method is the best; a rod or wire of fixed length is held horizontally at G, and the length in mils is read from the instrument at B. A table of distances corresponding to these readings should be prepared and entered in a note-book. The signalling flag-staff is 65.5 inches long—six mils corresponds to 303 yards, etc.

2—The distance to the Aiming Point, P, and to the target, T, are measured with the R.F., or taken from a map. It is no longer satisfactory to estimate these distances if prompt adjustment is necessary.

3—The deflection of T is accurately measured with the instrument; it is recorded as A, and for convenience is called the "Red Angle;" it is always measured counter-clockwise.

4—The angle between P and G, and the angle between T and G, are measured and recorded. They are necessary in order to determine the obliquity correction to the parallax.

This obliquity angle corresponding to T is always the difference between the "Red Angle" A, and the obliquity angle for P. Consequently it is not necessary to change the setting of the instrument after the Zero has been set on P.

5—So far, 3 distances and 3 angles have been determined; they are the same six quantities that must be known to use the plotter.

6—It is next necessary to have already prepared and entered in the note-book a special obliquity table, corresponding in general to the table on the reverse side of the metal B.C. Ruler. This table gives the factor—a decimal fraction—by which the parallax must be multiplied, corresponding to every one hundred mils.

7—Multiply the base by the obliquity factor corresponding to P and divide by the range to same; apply the result to A. Do the same thing corresponding to T. The final result is D, the desired deflection.

To determine whether to add or subtract these last two corrections, follow this "Rule of Thumb." Standing at B, extend the arm towards P and move it away from the guns, G; if it passes out of the "Red Angle" the correction is added; if it passes into the "Red Angle" the correction is subtracted. The same rule applies to the correction corresponding to T. This rule holds good whether P is in front or rear, and whether B is to right or left of G.

8—A very simple way of recording the measurements and operations is shown below. Draw a line down the center of note paper, and on one side write P, T and G as shown; on the other side write A, under it 2 lines, then D. The 3 distances and the 3 angles are entered as determined. The factors for P and T are taken from the obliquity table and the operations prescribed in par. 7 are quickly performed.

9—This method is as accurate and speedy as the Plotter.

10.	P 5000,	1170	A 1920
	T 2700,	750	45
	G 250	250	1965
	.9	.7	
			65
	5)225	2.7)175(65	
		162	D 2030
	45	130	
		135	

11—The obliquity factors are as follows:

100 m, .1-200 m, .2-300 m, .3-400 m, .4-500 to 600 m, .5-600 to 700 m, .6-700 to 900 m, .7-900 to 1000 m, .8-1000 to 1300 m, .9-1300 to 1600 m, 1. and so on up to 6400 m.

The table should be arranged in columns and lines for convenience; thus the factor for 100, 3100, 3300 and 6300 is the same, namely, one-tenth, (.1), and so forth.

Emergency Use of Motor Transport.

Two very interesting and important experiments have recently been made in the matter of transportation of infantry units by automobile, one under the direction of General Funston and the other under General Sibert.

General Funston made use of one of our motor truck companies of twenty-eight three-ton trucks and moved a thousand fully armed and equipped officers and men, including a machine gun company and its equipment and the attached sanitary troops. The exercise consisted of loading about thirty-five men standing on each truck, moving out seven miles through San Antonio to a point where the regiment was unloaded and deployed at once in an attack formation at a distance of several hundred yards from the trucks. Fifty seconds were required to load the regiment. The time required to pass a given point while running slowly through the city was three minutes and fifty seconds.

For General Sibert's exercise, the transportation was furnished by the 1st Company, Automobile Reserve Corps of San Francisco, and consisted of twenty-one five-passenger cars, five seven-passenger cars, two three-quarter ton trucks and one five-ton truck. The full field equipment was taken and in addition a seven-inch howitzer was mounted on the five-ton truck. The truck with the howitzer and six men in a passenger automobile left Fort Miley at eight a.m., and the remainder of the expedition at nine-seventeen a.m., all bound for Half Moon Bay thirty-four miles away. The passenger cars made the outward bound trip in one hour and forty-seven minutes and the return trip, thirty-six miles, in one hour and fifty-nine minutes. The howitzer made the trips in three hours and seventeen minutes and four and a quarter hours respectively. The troops went into camp for their stay at Half Moon Bay.

General Sibert's object in conducting the experiment was to determine how easily and quickly men with full field equipment could be transported to a point on the shore line where the landing of an enemy might be reasonably expected, and to devise a method of transporting a seven-inch howitzer or a five inch rifle to the same place without loss of time. A cradle of four by four-inch timber, constructed so that it would securely fit the frame of the truck, was arranged so that by removing the wheels the howitzer carriage would rest on the cradle and could be securely bolted through the cradle to the truck frame. Using the experimental cradle, a seven-inch howitzer or a five-inch rifle can be loaded on a truck in from one-half to three-quarters of an hour and can be removed and made ready for action in from twenty to twenty-five minutes.

The two experiments above described are of particular interest at this time as one demonstrated the practicability of rapidly moving large bodies of infantry to protect against border raids, while the other proved that infantry, supported by medium calibre guns, can be moved rapidly to oppose hostile landings on our seacoast.

The Chief of Staff has directed the General Staff to make further study of the problem of rapid movement of infantry by automobile and experiments will undoubtedly be made during the summer.

EDITORIAL DEPARTMENT

Some Praise and a Plea

IT is with a great deal of pleasure that the JOURNAL publishes a number of articles prepared as theses by the student officers at the School of Fire, and recommended for publication by the Field Artillery Board.

These articles show a great deal of research work on the part of their authors, and include material which is of undoubted value to the Field Artillery service. The editorial staff is confident that they will be critically read and fully appreciated by the service at large. They are all worthy of commendation and some of them merit special praise.

The experience of the Field Artillery in the present war is such that its future status may be that of a co-ordinate arm instead of the secondary role of an auxiliary, in which it has hitherto played its humble part. Artillery fire has grown more and more important in the great battles of Europe; in the trench battles it takes a place of equal importance with the infantry. From one point of view, the infantry is utilized to seize and fortify ground from which the enemy has been driven by the fire of the artillery.

The field of Field Artillery literature is at the present time a very wide one. More and more information of value is being obtained from authentic sources concerning matériel and methods, and it is extremely desirable that such information should be imparted to the service through timely articles on Field Artillery topics.

Contributions are, therefore, invited on any topic pertaining to our service, and it is hoped that the response may be such as to fill the pages of the JOURNAL with original articles by our own officers, rather than to oblige the editor to have recourse to reprints and translations, which, however good they be, do not indicate as healthy a state of thought and professional activity as do original studies.

The War College Division of the General Staff publishes a monthly list of military information carded from books, periodicals, and other sources, and this information is obtainable on call by any officer of the Army. We have availed ourselves of this list and publish in each number of the JOURNAL an index to current Field Artillery literature abstracted from the general list. It is hoped that this index will not be neglected, and that in response to this call many officers may make use of it in obtaining data for future articles.

Field Artillery Firing in Trench Warfare

IN this issue is presented an article by Major LeRoy S. Lyon, 4th Field Artillery, on "The Graphics of an Artillery Position."

The subject suggests to Field Artillery officers a system of firing to which as yet little attention has been paid in our service, the pamphlet on "The Use of the Compass and Map in Laying for Direction" (Subject No. 37, School of Fire for Field Artillery, January, 1916) being the only authoritative publication thus far issued which treats of this important matter.

Firing by map is not new. It was practised to some extent by both sides in the Russo-Japanese War, and is believed to have been suggested considerably prior to that time.

However, on our adoption of what is practically the French system of fire, we accepted their doctrines that future wars would be decided by the open field battle, and that the rôle of Field Artillery in such wars would be to obtain fire effect in the minimum of time, a proceeding which precluded the use of any but extremely rapid and approximate methods of adjustment. For the time being, position warfare and the use of deliberate and accurate methods of determining firing data were lost sight of.

The present situation in western Europe confirms what was fully proved in the Russo-Japanese War and pointedly reminds us that such methods should not be allowed to fall into disuse, but should form an important part of our Field Artillery training.

The moment two armies reach an impassé in their operations, and liberty of maneuver is lost, even over a comparatively limited sector, the Field Artillery must immediately resort to careful and elaborate methods of laying, involving the use of accurate maps, and the maximum employment of distant observing stations and complete systems of communication.

The occasions will be numerous in which the batteries must fire upon targets which cannot be seen by the battery commanders and in which complete dependence must be placed upon observers placed in heavily fortified observing stations in or near the infantry trenches. It is possible, even probable, that this will be the general rule, and is therefore incumbent upon us to train our personnel to meet such situations.

The method suggested by Major Lyon appears to be too complicated, as it involves the use of specially prepared celluloid charts and employs polar coördinates, which, while they are especially adaptable to the case of a single battery, are not so for a group of firing units. The transfer of coördinates is too complex, and is subject to error in all cases in which an observer is at a material distance from the guns, which, as shown above, is likely to be the general case. Moreover, it requires the preparation of a special position sketch on the celluloid chart and disregards that most valuable auxiliary, an accurate map.

Furthermore, the necessity for the use of such an elaborate method is not apparent in a system of Field Artillery in which each gun is provided with a panoramic sight, and it is regarded as doubtful whether its use in ordinary field firing would produce an increase in efficiency over the methods now employed.

The system of rectangular coördinates, or "square" system, is suggested in its stead, and a short sketch is given, to show its simplicity and general applicability, as well as to contrast it with the method proposed by Major Lyon.

An accurate map of the locality on a scale of at least three inches to the mile (1000 yards 1.7 inches) is prepared and is divided into numbered or lettered squares of suitable size. All features on the terrain are accurately located and noted on the map. Where there are no such features, points in any square may be easily determined by their rectangular coördinates from any corner, say the lower left hand.

Each Battery Commander, or observer, on receipt of his map, carefully locates thereon the position of his guns, or observing station, with an orienting line drawn through the aiming point or other reference point.

The method of using the map is extremely simple. The observer, stationed far to the front in or near the infantry trenches, sees a possible target in his sector. He immediately locates it with respect to the position of some known object on the ground and telephones the information to the proper commander or commanders. If there be no known object in the vicinity with which to compare it, he determines its coördinates on the corresponding square and transmits them instead.

Each Battery Commander, on receipt of the information, locates the position of the target on his map, determines the range and direction for his guns by means of a scale of ranges and a protractor, computes the angle of site from the difference of level as shown by the contours of the map, and is at once ready to fire. The firing will frequently be without adjustment, the whole area containing the target being swept by a rapid fire from all the guns. Where time permits, adjustment may be made through information sent back by the observer.

The simplicity of the system is admirable. The data obtained by a single observer may be used by any number of batteries, thus enabling a commander to immediately concentrate the fire of a large number of guns upon a single objective. Moreover, it requires no complicated or elaborate apparatus or charts, the only material needed, in addition to the usual Field Artillery equipment, being an accurate map (a *sine qua non* in any case), a scale of ranges, and a protractor, or substitute therefor.

Comparison seems to favor this system as against that proposed by Major Lyon, but the comment is principally intended to awaken interest in the subject on the part of all Field Artillery officers.

We should immediately make the training necessary to meet such conditions a part of our regular instruction and practice, lest we find ourselves confronted by the emergency and unprepared.

New Members

WITHIN the next few months a large number of young officers will be added to the Field Artillery, a few of them from the Military Academy, but most of them fresh from civil life.

It is extremely desirable that these young officers should be brought up in the way they should go, and should, therefore, be imbued with the *esprit de corps* of the arm in its highest sense. It would seem that this can best be given them by inculcating the spirit of organization and solidarity in our arm of the service.

The Field Artillery is now organized, and, it may be said, well organized. Little by little our membership has increased until at the present time it includes about ninety per cent, of our commissioned personnel, with a large and growing membership in the National Guard.

The addition of the names of the majority of the new officers to our roll will be a material assistance to the Field Artillery Association and will greatly help in accomplishing its mission of raising the efficiency of the Field Artillery service.

At the same time, the financial advantage of a large increase in membership is far from negligible. The Association is solvent, and the JOURNAL, while not on a money-making basis, has paid all expenses and is able to keep a small balance laid by for a rainy day. The influx of new members will increase the income, extend the circulation, with a consequent increase in advertising rates, and will aid in putting the JOURNAL into such a self-supporting state that it may in the future have its own offices, pay adequate clerk hire, and widen its activities.

It is to be hoped that every member will influence the new officers to become members at the earliest practicable moment.

BOOK REVIEWS

THE ENGINEER IN WAR, with special reference to the training of the engineer to meet the military obligations of citizenship. By Major P. S. Bond, Corps of Engineers, U. S. Army. McGraw-Hill Book Company, Inc., New York, 1916. Price, $1.50.

The purpose of this handy volume is to present a brief outline of the relation of engineering to the conduct of war and the adaptation of the principles and practices of civil engineering to military requirements with the hope of arousing the interest of the engineering and contracting professions in this important question of national defense.

The preface states that "engineering plays so important a part in all the operations of warfare that it is perhaps no exaggeration to say that modern war is an application of engineering science to the armed conflicts of states."

The book does not claim to be a manual or treatise on military field engineering, but after preliminary chapters on the military policy of the United States and the general duties of the military engineer and the economics of military engineering, it contains about one hundred pages in more or less detail of the work to be done by the military engineer in the field with a number of excellent and well reproduced illustrations, from drawings and photographs relating to military bridges, field fortification and military reconnaissance, the chapters on these subjects being the most complete in the book.

The ideal military engineer, in the author's opinion, is the "all around" man who can turn his hand to anything. On such a man the nation relies and specialists become tools in his hands. The conditions which govern the military pioneer result in work of a very simple nature and the highest expression of the skill of the military engineer is this very simplicity and the rapid adaptation of his designs to the tactical requirements of the situation and to the resources of men, tools and materials at his command.

An interesting chapter on the mobilization of material resources and one on how engineers and contractors may prepare to meet the military obligations of citizenship complete the book.

All out-door men, from the boy on the farm to the builders of our great bridges and dams and the pioneers in road, railroad, stream and seacoast work, are in training as military engineers and will read this book with interest. The clear type of the volume is an added attraction.

H. J.

THE MOUNTED RIFLEMAN. By Brigadier General James Parker, U. S. Army. Size 6 × 9—164 pages. George Banta Publishing Company, Menasha, Wisconsin.

This volume is a treatise on the training and employment of cavalry, by one of the most prominent officers of that arm. The opinions expressed and the suggestions made by the author have additional weight since he writes after forty years of commissioned service, a large percentage of which has been spent with troops, and much of it in the field.

After explaining how the invention of the aeroplane and the wireless has increased the value of cavalry, General Parker calls attention to the weak points in our system of training. The fact is emphasized that cavalry, to be efficient, must have trained mounts, ridden by men who can shoot, use the saber, ride and ride boldly. Then follows a scheme of Garrison and Field Training, undertaken in compliance with General Orders No. 17, War Department, 1913, and of Combat Exercises for Troop, Squadron, and Regimental units that he has found valuable in the training of his Brigade. These chapters are mostly in the form of General Orders and comments from time to time. The results obtained are recorded.

There is much other valuable matter in the book. The chapter devoted to "Cavalry in the Attack" leaves nothing to be desired and those on Training and Field Instruction are excellent. The chapter beaded "Hasty Training of Recruits for War" is very interesting. In it, General Parker describes the intensive training of 429 recruits sent to the 11th Cavalry in 1911. After three weeks of this training, General Parker says, "These recruits lacked the discipline and much of the training of the old soldier. Nevertheless, they were fairly well-fitted for the march, and should have given a good account of themselves on the firing line, merged with the old soldiers of the Regiment."

The chapter entitled "Hasty Training of Volunteer Cavalry" describes how Volunteer Cavalry units may be fairly well trained in four months' time.

The appearance of this book is timely. On July 1st, the majority of our Cavalry officers took increased rank and the increased responsibilities incident thereto. This book will be a great help to them in whipping new units into shape and in standardizing the instruction of old units.

It is hoped that the War Department will think enough of this work to place a copy in the orderly room of every troop in our service.

SMALL PROBLEMS FOR INFANTRY. By Captain A. W. Bjornstad, 16th Infantry. Book Department, Army Service Schools, Fort Leavenworth, Kansas. Size 6 × 9 inches—191 pages and a large map. Price $0.75, postpaid.

This volume is so attractively gotten up that one is almost prejudiced in its favor before beginning to read. The paper used is good and the type large and clear. An excellent map of terrain in the vicinity of Gettysburg, Pennsylvania, accompanies the book.

After a plate of Conventional Signs, the Problems begin and the duties of An Advance Guard Point, A Connecting File, A Flank Patrol, An Advance Party, A Combat Patrol, A Picket, A Cossack Post, A Sentry Squad, Different Classes of Patrols, A Requisitioning Detachment and an Outguard are taught, in turn, by the applicatory method. The last chapter is devoted to Combat Instruction and contains many valuable suggestions.

These problems are admirably adapted for the instruction and training of the Infantry noncommissioned officers of the Regular Army and of the National Guard. Their order is logical and the situations and solutions are so clearly and simply stated that few of the enlisted personnel will be unable to grasp the lesson to be taught. With these as samples, any enterprising Company Commander can construct any number of additional problems for the use of his organization.

This book fills a much needed want and it has only to be seen to be appreciated.

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.

Officers requesting information will please give the number of the entry and the date of the list. For officers on duty in Washington, D. C., a formal call is not necessary; a telephone call will be sufficient. When a book is called for, the title and author will be given in the language in which it is printed. The material here listed is not available for general loan outside of the U.S. Army.

Aerial guns—Great Britain—European war.—Illustrated description of the Davis nonrecoil gun, a U. S. patent made for British government. (Memorial Del Ejercito de Chile, March, 1916, pp. 208–212).

Aerial navigation—Great Britain—General principles controlling aircraft in action.—War Manual. By Lt. Col. C. C. Anderson, London, 1916, p. 238. (U102 A54, Vol. II, 1916).

Aerial navigation—European war.—The air kinema. Aeroplane scouting with a film. (Clipping from Japan Advertiser, February 12, 1916. Filed envelope case—Aerial navigation—European war).

Aerial navigation—Great Britain—European war.—Photo of a Leyland field repair shop, (motor equipment). (Illustrated London News, March 11, 1916, p. 342).

Aerial navigation—Great Britain.—Centralization vs. individual effort. Insufficiency of mere organization. British experience. (Engineering, March 17, 1916, p. 263).

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* Publication suspended during the war.

Field Artillery Directory

Because of the many changes now being made it is impossible to publish an accurate directory of the field artillery of the Regular Army in this issue.

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1st Lieut. Frederick de Figaniers, Battalion Quartermaster and Commissary.
Veterinarian Harry F. Nimphius.
Veterinarian Robt. A. McAuslin.

BATTERY A, BROOKLYN

Capt. Walter P. Fox.
1st Lieut. John D. Butt.
1st Lieut. Roger P. Clark.
2nd Lieut. Henry P. Bristol.
2nd Lieut. Thomas H. S. Andrews.

BATTERY B, BROOKLYN

Capt. Lester C. Fox.
1st Lieut. Horst A. C. Albrecht.
1st Lieut. Harry C. Miller.
2nd Lieut. Edward L. Brennan.
2nd Lieut. Walter H. Hereth.

BATTERY C, BROOKLYN

Capt. Albert S. Hamilton.
1st Lieut. Eugene A. Holmes.
1st Lieut. Edward O. Gilmore.
2nd Lieut. James H. McSweeney.
2nd Lieut. Arthur M. Floor.

It is requested that changes be reported to the Secretary, United States Field Artillery Association, Army War College, Washington, D. C.

FIELD ARTILLERY DIRECTORY—Continued

BATTERY D, NEW YORK CITY

Capt. Howard E. Sullivan.
1st Lieut. Charles J. McGronan.
1st Lieut. Henry G. W. Cox.
2nd Lieut. Charles C. Warren.
2nd Lieut. Theron R. Strong.

BATTERY E, NEW YORK CITY

Capt. Wilbur T. Wright.
1st Lieut. Robert W. Marshall.
1st Lieut. Dean Nelson.
2nd Lieut. Frank A. Spencer, Jr.
2nd Lieut. James H. Davis.

BATTERY F, NEW YORK CITY

Capt. William O. Richardson.
1st Lieut. Samuel E. McRickard.
1st Lieut. Charles H. King.
2nd Lieut. Raymond L. Hoffman.
2nd Lieut. Francis V. Hayes.

THIRD FIELD ARTILLERY
Headquarters, Buffalo

Col. Daniel W. Hand.
Lieut. Col. John D. Howland.
Maj. Louis H. Eller.
Maj. James P. Fowler.
Capt. Charles H. Williams, Quartermaster.
Capt. Christopher A. Dunnigan.
Capt. Thomas Marks.
1st Lieut. Guilford W. Francis, Supply Company
1st Lieut. Miles Merwin, Battalion Quartermaster and Commissary.
Asst. Veterinarian Charles E. Anderson.
Asst. Veterinarian Frank J. Caveney.
Chaplain Walter Fornes.

BATTERY A, BUFFALO

Capt. John S. Doorty.
1st Lieut. John B. Mergler.
1st Lieut. Jacob Brost.
2nd Lieut. Charles E. Kinskey.
2nd Lieut. John D. Webber.

BATTERY D, BUFFALO

Capt. Patrick J. Keeler.
1st Lieut. Henry Hafner.
2nd Lieut. Eugene Warner.
2nd Lieut. Howard K. Parker.

BATTERY C, BUFFALO

Capt. Andrew B. Gilfillan.
1st Lieut. Charles Boyd.
2nd Lieut. John J. Curtin.

BATTERY D, BUFFALO

Capt. Bradley Goodyear.
1st Lieut. Harry L. Gilchriese.
2nd Lieut. Edward L. Williams.
2nd Lieut. Edwin C. Gutelius.

BATTERY E, BUFFALO

Capt. Nelson T. Barrett.
1st Lieut. William T. Doane.
2nd Lieut. Leo Colprice.

BATTERY F, BUFFALO

Capt. William F. Schohl.
1st Lieut. Walter F. Siegmund.
1st Lieut. Chauncey J. Hamlin.
2nd Lieut. Marvin M. Marcus, Jr.

THIRD INSPECTION DISTRICT

Capt. W. F. Morrison, Inspector, Washington, D. C.

District of Columbia

BATTERY A, WASHINGTON, D. C.

Capt. Louis C. Vogt.
1st Lieut. George A. Bonnet.
1st Lieut. Harry E. Shilling.
2nd Lieut. Homer M. Mohr.
2nd Lieut. Milton T. Noyes.

BATTERY B, WASHINGTON, D. C.

Capt. George G. Wilson.
1st Lieut. Ellwood S. Moorhead, Jr.
1st Lieut. John R. Vanderhoof.
2nd Lieut. Charles L. Ladson.
2nd Lieut. Gerald G. McGrath.

Pennsylvania

FIRST FIELD ARTILLERY
Headquarters, Pittsburgh

Col. William S. McKee.
Lieut. Col. Albert V. Crookston.
Maj. Theodore R. McLain.
Maj. William T. Rees.
Capt. Josial L. Reese, Adjutant.
Capt. Edwin L. Brown, Quartermaster.
Capt. Robert W. Cooper, Commissary.
Capt. James B. McCalley, Battalion Adjutant.
Capt. James F. Kratzer, Battalion Adjutant.
1st Lieut. Carl H. Comor, Battalion Quartermaster.
1st Lieut. Edward A. Ohotnicky, Battalion Quartermaster.
Capt. Charles M. Miller, Chaplain.

BATTERY A, SOUTH BETHLEHEM

Capt. Herbert M. Paul.
1st Lieut. George W. Edwards.
1st Lieut. Clarence E. Bradburn.
2nd Lieut. James F. Kratzer
2nd Lieut. Benjamin E. Cole.
2nd Lieut.

BATTERY B, PITTSBURGH

Capt. Clinton T. Bundy.
1st Lieut. Blaine Alken.
1st Lieut. John S. Purucker.
2nd Lieut. Chas. C. Williams.
2nd Lieut. Samuel D. Hollis.

BATTERY C, PHOENIXVILLE

Capt. Samuel A. Whitaker.
1st Lieut. Frederick S. Swier.
1st Lieut. Augustine S. Janeway.
2nd Lieut. John G. Failor.
2nd Lieut. John Nuckel.

BATTERY D, WILLIAMSPORT

Capt. William B. Reilly.
1st Lieut. John D. Andrews.
1st Lieut. Garret Cochran.
2nd Lieut. John H. Ball.
2nd Lieut. Clyde R. Shelly.

BATTERY E, PITTSBURGH

Capt. Robert G. Snyder.
1st Lieut. William G. Fullman.
1st Lieut. Harry Howe.
2nd Lieut. Harry F. Plank.
2nd Lieut. William J. Miller.

BATTERY F, PITTSBURGH

Capt. Samuel R. McKamish.
1st Lieut. Harry L. Probst.
1st Lieut. William K. Weaver, Jr.
2nd Lieut. Peter J. McGurk.
2nd Lieut. John M. Browning.

It is requested that changes be reported to the Secretary, United States Field Artillery Association, Army War College, Washington, D. C.

FIELD ARTILLERY DIRECTORY—Continued

Maryland

BATTERY A, BALTIMORE

Capt. William F. Johnson, Jr.
1st Lieut. James C. McLanahan.
1st Lieut. Gustavus Ober, Jr.
2nd Lieut. John Ridgely, Jr.
2nd Lieut. A. Hunter Boyd, Jr.

Virginia

FIRST BATTALION

Headquarters, Richmond

Major Thomas M. Wortham.
Capt. William W. LaPrade, Adjutant.
1st Lieut. Edward J. Keegan.

BATTERY A, RICHMOND

Capt. William M. Myers.
1st Lieut. Edward C. Rees.
1st Lieut. James C. Pollard.
2nd Lieut. John T. Wood.
2nd Lieut. George H. Myers.

BATTERY B, NORFOLK

Capt. Paul W. Kear.
1st Lieut. McChesney H. Jeffries.
1st Lieut. W. Carleton Jones.
2nd Lieut. John D. Thomas.
2nd Lieut. Cary A. Willcox.

BATTERY C, PORTSMOUTH

Capt. Ira Branch Johnson.
1st Lieut. Walter J. Tennent.
1st Lieut. Lester T. Gayle, Jr.
2nd Lieut. Irving L. Leafe.
2nd Lieut. Calvin Satterfield.

BATTERY D, HAMPTON

Capt. Frank H. Couch.
1st Lieut. Thornton F. Jones.
1st Lieut. Robert G. Sugden.
2nd Lieut. Charles B. Powell.
2nd Lieut. Robert F. Taylor.

FOURTH INSPECTION DISTRICT

Lieut. Charles S. Blakely, Inspector, New Orleans, La.

Alabama.

BATTERY A, BIRMINGHAM

Capt. Leon S. Dorrance.
1st Lieut. Alpha Brumage.
1st Lieut. Robert L. Pittman.
2nd Lieut. Fred N. Feld.
2nd Lieut. Laurence S. Morgan.

BATTERY C, BIRMINGHAM

Capt. C. P. Noland.
1st Lieut. J. M. Fray.
1st Lieut. H. J. Porter.
2nd Lieut. E. S. Jemison.
2nd Lieut. A. A. Adams.

Georgia

FIRST BATTALION

Headquarters, Savannah

Maj. Edward D. Wells.
Capt. Joseph H. Thompson, Adjutant.
1st Lieut. Alan M. McDonnell, Quartermaster and Commissary.

BATTERY A, SAVANNAH

Capt. Edward G. Thomson.
1st Lieut. Alexander R. MacDonell.
1st Lieut. Mathias M. Ray.
2nd Lieut. Joseph B. Buckner.
2nd Lieut. Joseph H. Comer.

BATTERY B, ATLANTA

Capt. Andrew J. McBride, Jr.
1st Lieut. Robert G. Mangum.
1st Lieut. Frank Boynton Tidwell.
2nd Lieut. John W. LeCraw.
2nd Lieut. Sidney F. Dunn.

BATTERY C, SAVANNAH

Capt. Edward G. Butler.
1st Lieut. Joseph E. Inglesby, Jr.
1st Lieut. R. F. Rumph.
2nd Lieut. Lewis H. Harper.
2nd Lieut. Alexander W. Lackey.

Louisiana

FIRST BATTALION

Headquarters, New Orleans

Maj. Allison Owen.
Capt. Stanley M. Lamarie, Adjutant.
1st Lieut. Edward L. Posey, Quartermaster and Commissary.
Veterinarian, Wm. J. Ratigan.

BATTERY A, NEW ORLEANS

Capt. Schaumburg McGehee.
1st Lieut. Willis W. Hobson.
1st Lieut. Arthur C. Ball.
2nd Lieut. Cyril W. Bassich.
2nd Lieut. James S. Mason.

BATTERY B, NEW ORLEANS

Capt. James E. Edmonds.
1st Lieut. Harold P. Nathan.
1st Lieut. Peter Hamilton.
2nd Lieut. Frederick G. Gassaway.
2nd Lieut. Meigs Oliver Frost.

BATTERY C, NEW ORLEANS

Capt. Bryan Black.
1st Lieut. Guy R. Molony.
1st Lieut. Walter J. Stauffer.
2nd Lieut. Louis S. Goldstein.
2nd Lieut. George S. Clarks.

FIFTH INSPECTION DISTRICT

Capt. Clarence Deems, Jr., Inspector, Indianapolis, Indiana

Indiana

FIRST BATTALION

Headquarters, Indianapolis

Major Robert H. Tyndall.
Capt. Thomas S. Wilson, Adjutant.
1st Lieut. Frank W. Buschmann, Quartermaster.
Veterinarian Roy C. Whitesell.

BATTERY A, INDIANAPOLIS

Capt. Gavin L. Payne.
1st Lieut. Marlin A. Prather.
1st Lieut. Sidney S. Miller.
2nd Lieut. Daniel I. Glossbrenner.
2nd Lieut. Mark A. Dawson.

BATTERY B, PURDUE UNIVERSITY, LAFAYETTE

Capt. Harry E. McIvor.
1st Lieut. Harris C. Mahon.
1st Lieut. Frank D. Dexter.
2nd Lieut. Wm. H. E. Holmes.
2nd Lieut. Frank W. Bryant.

It is requested that changes be reported to the Secretary, United States Field Artillery Association, Army War College, Washington, D. C.

FIELD ARTILLERY DIRECTORY—Continued

BATTERY C, LAFAYETTE

Capt. Arthur O. Brokenbrough.
1st Lieut. Rosier W. Levering.
1st Lieut. John C. Doyle.
2nd Lieut. Frank Nisley.
2nd Lieut. Wilmer C. Kashner.

BATTERY D, FORT WAYNE

Capt. John C. Scheffer.
1st Lieut. Henry C. Moriarty.
1st Lieut. Luther H. Mertz.
2nd Lieut. Bertram Lewis.
2nd Lieut. Lee Hensley.

Michigan

BATTERY A, LANSING

Capt. Chester B. McCormick.
1st Lieut. Fred G. Fuller.
1st Lieut. F. G. Chaddock.
2nd Lieut. Earl H. Spencer.
2nd Lieut. Harold H. Beltz.

BATTERY B, LANSING

Capt. Frank P. Dunnebacke.
1st Lieut. Chester E. Boelio.
1st Lieut. Joseph H. Lewis.
2nd Lieut. Edgar J. Learned.
2nd Lieut. Joseph A. Fortin.

Ohio

FIRST BATTALION

Headquarters, Columbus

Maj. H. M. Bush.
Capt. Quida A. Kulish, Adjutant.
2nd Lieut. John B. Morton, Battalion Quartermaster and Commissary.
Veterinarian, Frank R. Lunn.

BATTERY A, CLEYELAND

Capt. Everette C. Williams.
1st Lieut. Robert K. Norton.
1st Lieut. John L. Sullivan.
2nd Lieut. Harold Matthews.
2nd Lieut. Charles S. Bailey.

BATTERY B, AKRON

Capt. Hurl J. Albrecht.
1st Lieut. Joseph J. Johnson.
1st Lieut. John F. Babbit.
2nd Lieut. John R. Taylor.
2nd Lieut. Welton A. Snow.

BATTERY C, BRIGGSDALE (COLUMBUS)

Capt. Rodney E. Pierce.
1st Lieut. George H. Bartholomew.
1st Lieut. Lawrence S. Schlegel.
2nd Lieut. Vincent Welker.
2nd Lieut. William D. Kinsell.

SIXTH INSPECTION DISTRICT

Lieut. Louis R. Dougherty, Inspector, Chicago, Illinois

Illinois

FIRST REGIMENT

Headquarters, Chicago

Col. Charles M. Allen.
Lieut. Col. Louis R. Dougherty.
Capt. Roy B. Staver, Adjutant.
Capt. R. W. Thompson, Quartermaster.
Capt. Harry F. Johnson, Commissary.
1st Lieut. F. C. Armstrong, Chaplain.
Veterinarian, David Smith.
Veterinarian, A. F. McGreevy.
Veterinarian, Frank E. Metcalfe.

FIRST BATTALION

Headquarters, Waukegan

Capt. Jacob McG. Dickinson, Adjutant.
1st Lieut. Benedict L. Maloney, Quartermaster and Commissary.

BATTERY A, DANVILLE

Capt. Curtis G. Redden.
1st Lieut. Lawrence D. Smith.
1st Lieut. Thomas S. Hammond.
2nd Lieut. Fred C. Anderson.
2nd Lieut. R. A. N. Baltz.

BATTERY B, CHICAGO

Capt. Frank M. Course.
1st Lieut. Max E. Payne.
1st Lieut. George H. Gould.
2nd Lieut. Roy F. Riggs.
2nd Lieut. Perry D. Smith.

BATTERY C, FORT SHERIDAN

Capt. Noble B. Judah.
1st Lieut. Bruce D. Smith.
1st Lieut. George Richardson.
2nd Lieut. Joseph Medill Patterson.
2nd Lieut. George Fisher.

SECOND BATTALION

Headquarters, Chicago

Maj. Charles R. Vincent.
Capt. Hugh R. Montgomery, Adjutant.
2nd Lieut. Martin H. Foss, Quartermaster and Commissary.

BATTERY D, CHICAGO

Capt. Edgar A. Ewing.
1st Lieut. R. A. Bokum.
1st Lieut. Arthur W. de Revere
2nd Lieut. H. Lockett.
2nd Lieut. Kenneth Lockett.

BATTERY E, CHICAGO

Capt. Henry J. Reilly.
1st Lieut. Horace R. Denton.
1st Lieut. Irving Odell.
2nd Lieut. D. L. Smth.
2nd Lieut. W. F. Rike.

BATTERY F, UNIVERSITY OF ILLINOIS, URBANA

Capt. Bruce W. Benedict.
1st Lieut. G. H. Dosher.
1st Lieut. W. H. Kasten.
2nd Lieut. Arthur W. Reebie.
2nd Lieut. Edmund Fleming.

Wisconsin

BATTERY A, MILWAUKEE

Capt. Philip C. Westfahl.
1st Lieut. Alonzo J. Comstock.
1st Lieut. John G. Reed.
2nd Lieut. William F. Fraedrich.
2nd Lieut. Alvin A. Kuechenmeister.

BATTERY B, GREEN BAY

Capt.
1st Lieut. Leland Wells.
1st Lieut.
2nd Lieut. Leroy Hoberg.
2nd Lieut.

BATTERY C, RACINE

Capt. George W. Rickeman.
1st Lieut. James W. Gilson.
1st Lieut. Richard Drake.
2nd Lieut. Richard C. Bryant.
2nd Lieut. Harry J. Sanders.

It is requested that changes be reported to the Secretary, United States Field Artillery Association, Army War College, Washington, D. C.

FIELD ARTILLERY DIRECTORY—Continued

Iowa

FIRST BATTALION

Headquarters, Clinton

Maj. Roy S. Whitley.
Capt. James L. Oakes, Adjutant.
1st Lieut. Frank H. Hinricks, Quartermaster and Commissary.

BATTERY A, CLINTON

Capt. Jacob E. Brandt.
1st Lieut. Martin W. Purcell.
1st Lieut. Loren R. Brooks.
2nd Lieut. Frank G. Luth.
2nd Lieut. Oren T. Roberts.

BATTERY E, DAVENPORT

Capt. Arthur M. Compton.
1st Lieut. Harry H. Ward.
1st Lieut. Roland S. Truitt.
2nd Lieut. Edward McCoy.
2nd Lieut. Walter H. Peterson.

BATTERY C, MUSCATINE

Capt. Otto W. Mull.
1st Lieut. Horace L. Husted.
1st Lieut. Edward A. Roach.
2nd Lieut. Edward J. Cox.
2nd Lieut. Ray Norris.

SEVENTH INSPECTION DISTRICT

Lieut. Waldo C. Potter, Inspector, Kansas City, Mo.

Kansas.

BATTERY A, TOPEKA

Capt. John M. Hite.
1st Lieut. William P. MacLean.
1st Lieut. James C. Hughes.
2nd Lieut. Alfred C. Bartel.
2nd Lieut. Richard B. Porter.

Missouri

FIRST BATTALION

Headquarters, Independence

Maj. Edward M. Stayton.
Capt. John H. Thacher, Adjutant.
1st Lieut. Charles C. Bundschu, Quartermaster and Commissary.

BATTERY A, ST. LOUIS

Capt. Frank M. Rumbold.
1st Lieut. Walter J. Warner.
1st Lieut. Robert C. Rutledge.
2nd Lieut. Daniel F. Jones.
2nd Lieut. Leon R. Sanford.

BATTERY B, KANSAS CITY

Capt. Arthur J. Elliott.
1st Lieut. Roy T. Olney.
1st Lieut. Fielding L. D. Carr.
2nd Lieut. Thomas S. McGee.
2nd Lieut. Marvin H. Gates.

BATTERY C, INDEPENDENCE

Capt. John L. Miles.
1st Lieut. Spencer Salisbury.
1st Lieut. Roger T. Sermon.
2nd Lieut. Keneth V. Bostian.
2nd Lieut. Edgar G. Hinde.

Texas.

BATTERY A, DALLAS

Capt. F. A. Logan.
1st Lieut. Fred M. Logan.
1st Lieut. Ward C. Goessling.
2nd Lieut. Arthur H. J. Dumke.
2nd Lieut. Willard J. Stanton.

EIGHTH INSPECTION DISTRICT

Lieut. W. F. Sharp, Inspector, Denver, Colorado

Colorado

FIRST BATTALION

Headquarters, Denver

Maj. Wm. F. Sharp.
Capt. Henry C. Nickerson, Adjutant.
1st Lieut. Lewis G. Carpenter, Quartermaster and Commissary.
2nd Lieut. Thomas N. Slayton, Asst. Veterinarian.

BATTERY A, STATE AGRICULTURAL COLLEGE, FORT COLLINS

Capt. J. A. Rogers (1st Lieut., U. S. A.)
1st Lieut. Roy G. Coffin.
1st Lieut. Artur W. Whitehouse.
1st Lieut. Charles M. Weller.
2nd Lieut. Floyd Cross.
2nd Lieut. Paul G. Putty.

BATTERY B, DENVER

Capt. Guylan A. Blanchard.
1st Lieut. Canton O'Donnell.
1st Lieut. W. H. H. Cranmer
2nd Lieut. Charles W. Comstock.
2nd Lieut. Richard S. Fillius.

BATTERY C, DENVER

Capt. Victor W. Hungerford.
1st Lieut. Daniel W. Knowlton.
1st Lieut. William H. Shade.
2nd Lieut. George B. Thomas, Jr.
2nd Lieut. James H. Gowdy.

New Mexico.

BATTERY A, ROSWELL

Capt. Charles M. de Bremond.
1st Lieut. James C. Hamilton.
1st Lieut. Willard F. Hird.
2nd Lieut. George M. Williams.
2nd Lieut. W. E. Buchly.

Utah

1ST BATTERY, SALT LAKE CITY

Capt. William C. Webb.
1st Lieut. Curtis Y. Clawson.
1st Lieut. Fred T. Gundry.
2nd Lieut. Harold C. Mandell.
2nd Lieut. A. R. Thomas.

NINTH INSPECTION DISTRICT

Lieut. Emery T. Smith, Inspector, San Francisco. Cal.

California.

FIRST BATTALION

Headquarters, Oakland

Maj. Ralph J. Faneuf.
Capt. Frederick W. H. Peterson, Adjutant.
2nd Lieut. James Gleason, Quartermaster.

BATTERY A, LOS ANGELES

Capt. Jesse McComas.
1st Lieut. Harold G. Ferguson.
1st Lieut. Walter Luer.
2nd Lieut. Robert W. Yates.
2nd Lieut. Frederick H. Hover.

It is requested that changes be reported to the Secretary, United States Field Artillery Association, Army War College, Washington, D. C.

FIELD ARTILLERY DIRECTORY—Continued

BATTERY B, OAKLAND

Capt. Harry F. Huber.
1st Lieut. Edward E. Vicary.
1st Lieut. John W. White.
2nd Lieut. Howard W. Enefer.
2nd Lieut. Clyde Alexander.

BATTERY C, STOCKTON

Capt. Edward Van Vranken.
1st Lieut. Otto E. Sandman.
1st Lieut. Charles H. Young.
2nd Lieut. Hunt A. Davidson.
2nd Lieut. Charles A. Reyner.

Oregon

BATTERY A, PORTLAND

Capt. Charles W. Helme.
1st Lieut. Bert V. Clayton.
1st Lieut. Charles L. Johnson.
2nd Lieut. Gilbert W. Stevens.
2nd Lieut. J. Benjamin Hayes.

STATE OF MINNESOTA

Capt. Geo. R. Greene, Inspector, Fort Snelling. Minn.

FIRST FIELD ARTILLERY
Headquarters, St. Paul

Col. George E. Leach.
Lieut. Col. William J. Murphy.
Maj. William H. Donahue.
Maj. George T. Gorham.
Capt. Charles A. Green, Adjutant.
Capt. Fred L. Baker, Quartermaster.
Capt. Erwin H. Sherman, Battalion Adjutant.
Capt. Frederick A. Tiffany, Battalion Adjutant.
2nd Lieut. Holland C. Headley, Battalion Quartermaster and Commissary.
1st Lieut. Lawrence F. Ryan, Chaplain.
1st Lieut. William Hoag, Supply Company.
1st Lieut. Richard Price, Asst. Veterinarian.
2nd Lieut. Anthony J. Matter, Asst. Veterinarian.

BATTERY A, ST. PAUL

Capt. Wallace Cole.
1st Lieut. Fletcher Rockwood.
1st Lieut. John S. Nichols.
2nd Lieut. Charles F. Baird.
2nd Lieut. George N. Bright.

BATTERY B, ST. PAUL

Capt. Charles L. Ames.
1st Lieut. William S. Jenkins.
1st Lieut. James K. Edsall.
2nd Lieut. Clifford C. Hield.
2nd Lieut. Cavour L. Truesdale.

BATTERY C, ST. PAUL

Capt. John H. McDonald.
1st Lieut. Philip J. McCauley.
2nd Lieut. Levens D. Williams.

BATTERY D, MINNEAPOLIS

Capt. Theodore A. Kaldunski.
1st Lieut. Hugh H. Barber.
1st Lieut. Robert W. Grow.
2nd Lieut. Douglas G. Burrill.
2nd Lieut. David C. Schmahl.

BATTERY E, MINNEAPOLIS

Capt. Jerome Jackman.
1st Lieut. William R. Cross.
1st Lieut. Claude H. Helgesen.
2nd Lieut. James G. Cadwell.
Joseph J. McKinney.

BATTERY F, MINNEAPOLIS

Capt. Walter F. Rhinow.
1st Lieut. Edwin Rollmann.
1st Lieut. Harold L. Goss.
2nd Lieut. Jay E. Gillfillan.
2nd Lieut. Oliver M. Michaels.