The New Field Artillery Materiel---*Its Characteristics and Powers*

COURSE IN MILITARY WEAPONS & MUNITIONS OF WAR . . .

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THE NEW FIELD ARTILLERY MATERIEL ❧ ❧ *Its Characteristics and Powers.*

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The present year finds the United States Army in the act of re-arming its Field Artillery with an entirely new type of gun. That is to say, it is new in the sense that it differs in almost every essential feature from that which it supersedes; the type itself, in its general characteristics, is one which is familiar to our Artillery officers, and most of the important foreign nations have already adopted something similar to it.

The Field Artillery materiel which we have finally adopted has been most carefully worked out in every detail, and it is believed that it is at least the equal of that of any foreign power. It is from designs of our own Ordnance Department; but prior to adoption, it was thoroughly tested in competition with the best work of private manufacturers, and selected as the equipment which best fulfilled the requirements. Certain improvements in the design, suggested by the results of the tests, were then made, and manufacture begun. A few changes, making for simplicity and convenience in operation, have been introduced since the completion of the first few guns.

The weapon belongs to the class known as "rapid firers". This term is a convenient designation, but cannot be considered as an accurately descriptive title, since rapidity of fire is not by any means the only distinguishing characteristic of the type.

It is assumed that the members of this class are all more or less familiar with our old 3.2" field gun, now being withdrawn from service; and a rough comparison of the two pieces may be of assistance in obtaining an understanding of the new one.

To open the breech of the old gun, it was necessary to unlock the mechanism by lifting a lever, rotate the breech-block, pull it to the rear, and swing it to one side. All these operations are performed in the new gun by simply moving one lever.

In loading the old gun, the projectile had first to be inserted and rammed home, then the powder charge pushed in. The new ammunition is fixed.

The old gun having been loaded and the breech closed, a primer, to which a lanyard had previously been hooked, was inserted in the vent, and all the cannoneers had to step clear of the piece. With the new gun, the primer is not a separate part, but is fixed in the cartridge case; and it is not necessary for the cannoneers to step clear before firing.

In aiming the old gun, the only way to point it for direction was to move the trail—an essentially slow and inaccurate method; and the sight had to be removed from its socket before firing. The new piece can be traversed on its carriage, by means of gear in the hands of the gunner himself, who remains during the firing with his eye at the sight, keeping the piece continuously trained on the target.

With the old gun, indirect laying, that is, training upon a target invisible to the gunner, was diffi-

cult and inaccurate; with the new one, it is as easy and accurate as direct aiming.

The old gun, with its carriage, recoiled bodily along the ground, and had to be run up by hand and relaid for each shot. The new piece recoils independently of its carriage, which remains motionless, and is returned immediately to firing position by springs.

The new gun throws a projectile 1½ pounds heavier than the old, with a slightly greater muzzle velocity; the number of bullets in each shrapnel is about 50 per cent greater; and the effective range has been increased about 50 per cent.

This outline will serve to show in a general way what advantages have been gained by the re-armament; we will now examine the new materiel itself.

The breech mechanism is of the slotted screw type; the block has two threaded and two slotted sectors, hence requiring ninety degrees rotation to unlock. The breech is opened by a single horizontal motion of the operating lever; the lever latch, which guards against accidental opening of the breech, is released by the grasp of the hand on the lever handle.

Since fixed ammunition is used, no pad or other obturating device on the block is necessary; the cartridge case itself acts as a gas-check.

An extractor is provided, engaging the head of the cartridge case and throwing it clear of the breech when the block is opened.

Percussion primers being used, a firing pin and appropriate mechanism are enclosed in the block. The pin moves eccentrically at the first motion of opening the breech, and does not come in line with the primer again until the block has been closed and locked, premature discharge being thus rendered almost impossible. Another device prevents firing before counter-recoil is complete. The piece is fired by

pulling a trigger-handle on the right hand side of the cradle; a lanyard may be attached to this if it is desired to stand clear of the carriage, as, for example, on a pavement or hard ground where it is feared the trail spade may not take hold.

The gun proper is a nickel-steel, built-up, rifled piece, consisting, essentially, of a tube with jacket shrunk on. The caliber is 3″; length of bore, 28 calibers or 84″; total length of piece, 87.8″; maximum range, 7500 yards. The piece has no trunnions, but is held in what is called a cradle, which forms a part of the carriage, and in which the gun can move longitudinally only.

The recoil of the gun in the cradle is limited and controlled by means of an hydraulic cylinder and piston. The cylinder is attached to the gun, the piston rod to the cradle; the piston fits easily in the cylinder bore, and has notches cut in its circumference, so that liquid may pass from one end of the cylinder to the other. Upon firing, the cylinder recoils with the gun, the piston remaining stationary; the resistance caused by the passage of the liquid in the cylinder through the notches in the piston head controls the recoil, which is limited to 45″.

To check the force of recoil gradually and easily, throttling bars are bolted longitudinally to the cylinder bore, so as to lie in the piston head notches, and gradually close them during recoil.

(Figures:—transverse section through piston head; longitudinal section of throttling bar.)

The total weight of liquid in the cylinder is only eight pounds. A special quality of oil is used, instead of the glycerin and water mixture which is common aboard.

Helical springs are assembled upon the cylinder, which absorb enough of the energy of recoil to return the gun promptly to its firing position. The motion

is very quick; some twenty unaimed shots per minute are possible.

The springs being powerful enough to return the piece thus swiftly, some means must be provided for checking the force of counter-recoil with the least possible shock, so as not to derange the aim unnecessarily. This object is accomplished by fitting a slightly tapered rod to the inside of the rear cylinder head, which fits with very slight clearance into a hole bored in the piston rod. As the piece returns to firing position, liquid is caught in this cup, and can escape only through the small clearance, thus forming a cushion.

(Figure:—counter-recoil buffer.)

To relieve the elevating and traversing gear from strain while travelling, the cradle can be locked to the trail.

The cradle rests upon a platform called the rocker, upon which it is pivotted so as to have a motion in azimuth of about eight degrees,—four degrees on each side of the normal.

These parts complete the upper part of the carriage. The rocker is journalled upon the axle, about which it may be rotated; it thus connects the upper to the lower carriage, which consists of the wheels, axle, trail and elevating device, the last-named part, of course, being connected to the breech end of the rocker.

The energy of recoil, though taken up and distributed in the manner described, must of course come ultimately to the lower carriage, though greatly reduced. To prevent the carriage from being moved out of place by this force, a fixed spade is provided, at the end of the trail, which, on ordinary ground, is buried at the first shot and thereafter holds the carriage stationary. It is necessary to watch this spade during firing on unfavorable ground, to see that it is

holding properly; it was in order to relieve the pressure here, and not on account of possible strain to the parts themselves, that the recoil was made so long; for if only the mechanism proper had to be considered, it might have been limited to a few inches only. The ordinary road brake may be used to lock the wheels and so assist in relieving the pressure on the spade.

For the protection of the personnel against small-arm and shrapnel bullets, a steel shield, 0.2″ thick, is provided, consisting of three parts, apron, main and top shields, which fold together when the piece is limbered. Each shield is tested by firing against it with the service rifle and ammunition at 100 yards range, and must bear this test without penetration or cracking. The scar of this test is visible upon the accepted shield, in the form of a slight indentation.

Seats are attached to the trail, for the gunner and firing number when the piece is unlimbered. Axle seats are also provided, for cannoneers when travelling.

Under each axle seat are two steel tubes, each intended to carry one round of ammunition, for emergency use only.

The laying apparatus consists of two parts,—the sight, mounted on the left side, and the range quadrant, on the right side, of the piece. Both are fixed to non-recoiling parts of the upper carriage.

The sight is telescopic, of peculiar form. Light entering at the objective is reflected directly downward through a tube, and then again reflected directly to the rear to the eye-piece; cross-hairs are provided in the plane of the image, so that the effect is the same as having the distance between front and rear sights equal to the range. The usual devices for giving the sight proper elevation for ranges up to 6500

yards are provided, and also cross-levels, to correct for differences in the level of the wheels when in battery. Ordinary open sights are also attached.

The most noticeable thing about this sight, however, is the arrangement for setting off deflection,—that is, moving the plane of sight out of its normal position parallel to the plane of fire. All previous service sights were arranged on the plan of the rifle sight wind gauge; a very limited motion on each side of the normal was provided, the scale reading zero at normal and being graduated right and left. With such sights, indirect laying was difficult, and even impossible to the extent now contemplated; and mistakes often occurred, even with good gunners, through allowances being set off on the wrong side.

The new sight (called, from this peculiarity, the panorama sight) is so constructed that, while the eye-piece remains fixed, the upper part, containing the objective, can be turned through a whole circle, and an object situated even in the direct rear of the piece may be observed through it. A very ingenious optical contrivance makes the image in the eye-piece erect, in whatever direction the objective points. The value of this arrangement will be seen when the subject of indirect fire is discussed.

The graduation of the sight limb is not in degrees and minutes, but in "points" or "mils", as was the case with most of the old sights. This unit is theoretically that angle, something over three minutes, whose natural tangent is 0.001. Thus if, firing at a given range, the deflection set off on the sight be changed by one mil, the point of fall of the projectile will be moved laterally 000.1 of that range.

The number of mils in a complete circle is nearly, but not quite, 6400, and the graduation of the limb is arranged accordingly. The exact number is 6283 and a fraction; but the error caused by using

this convenient even number is so slight as to be negligible, amounting to only 1.8 per cent.

Using this sight and direct fire, the proper elevation and direction may be given the gun, and the proper deflection allowances to compensate for wind, drift, etc., made, by the gunner alone, who is seated on the left trail seat with the elevating and traversing gear at hand.

If desired, however, aiming for direction only may be left to the gunner, and the elevation given by cannoneer No. 1, who sits on the right trail seat with the range quadrant in front of him, and who has control of a second elevating crank.

To use the range quadrant, the "angle of site", that is, the angle made with the horizontal by the line from piece to target, is first measured, either with the sight or with the battery commander's telescope, and the clinometer of the quadrant set accordingly. The clinometer scale is graduated in mils, and employs the same principle of continuous graduation as the sight limb; that is, the reading when the ground is level is not zero, but 300, and the graduation is from 200 to 400; hence any desired elevation or depression is absolutely described by its number, and even the most inexpert cannoneer could not make the mistake of setting off an elevation when a depression was ordered.

The clinometer being set for angle of site, the range dial is set for the range, and the gun then elevated or depressed until the level bubble of the quadrant is centered. The gun is then correctly laid in elevation.

Much consideration has been given to the proper size of the wheels. Large wheels give easier draft, and also greater free space underneath; on the other hand, they increase the weight and necessitate a longer trail to give stability when firing,—for the

shock of discharge tends to raise the wheels from the ground, rotating the whole carriage about the end of the trail. The wheel finally adopted has a diameter of 56″, a trifle smaller than the wheel of the 3.2″ gun carriage, but larger than is usual abroad; there is an oil reservoir in the axle, which can be filled without removing the wheel.

The limber is all steel, except pole and wheels. Gun and caisson limbers are identical. Space is provided in the chest for 39 rounds of ammunition, packed horizontally, base to the rear,—three rows of thirteen each, the cases fitting into holes in vertical partitions. Three of these holes, however, are not ordinarily to be used for ammunition, but are to contain oil cans, one for kerosene, one for lubricating and one for cylinder oil. Thus there are 40 rounds with the gun, including the 4 under the axle seats.

The rear wall of the chest is hinged to form a door, which opens upward. This is corrugated, both to give increased stiffness and to prevent it from coming in direct contact with the primers in the cartridge cases. No springs or cushions are provided to protect the ammunition from jars, as such protection is found to be unnecessary.

Attachments are provided on the limber for the usual tools,—axe, pick, shovel and hatchet,—and also for lanterns, picket lines and watering buckets.

The system of draft is the same as that employed with the old materiel, that is, continuous traces throughout the team, attached to pivotted single and double trees. The harness is the same as before.

The gun and carriage complete, with shield, weigh 2300 pounds; the limber, with chest filled, weighs 1500 pounds; thus the total weight behind the gun team is 3800 pounds, or very nearly the same as with the old materiel. It is this consideration of weight which is the controlling factor in determining

the caliber to be adopted, for experience has shown that sufficient mobility for a gun intended to accompany rapidly moving columns in the field cannot be retained if the weight behind the team is over 650 pounds per horse. Six horses is the limit for teams intended for quick work; increase beyond this number renders a team more cumbrous without increasing the power in the same proportion; hence the maximum allowable weight for a light field gun is about 3900 pounds. It will be noticed that a moderate margin has been allowed in this design.

This weight has been slightly exceeded in the caisson, which, fully loaded, weighs 4000 lbs. An excess, however, is allowable in a caisson which might not be in a gun, as the removalof a very few rounds of ammunition reduces the weight materially. The old caisson was given a still greater excess of weight, weighing, fully packed, 4600 pounds.

The caisson carries only one chest, but it is much larger than that of the limber, containing 70 rounds, packed in five rows of fourteen each. Except for this matter of size, the construction of the chest is the same.

Caisson bodies, like limbers, are provided with pintles in rear, so that several bodies may be coupled together as trailers, behind one team. This will result in marked economy in animals, when moving ammunition over good roads or taking empty caissons to the rear.

The caisson bodies are furnished with shields, which fold up when travelling and are lowered upon unlimbering. The front of the chest itself gives protection above the shield, and the chest door, when open, deflects bullets clearing the chest.

A trail prop, similar to the pole prop of a limber, forms a third point of support for the caisson body when unlimbered.

From the preceding descriptions, we see that the ammunition with the battery is, for each gun carriage, 40 rounds,—36 in the limber chest and 4 under the axle seats: for each caisson, 106,—36in the limber and 70 in the caisson body.

As each four gun battery on a war footing will have twelve caissons, the ammunition with the battery will be 1432 rounds, or 358 per gun.

For comparison, the ammunition supply of a six gun 3.2″ battery is given:—each gun carriage, 42 rounds in limber chest; each caisson, 42 rounds each in limber, middle and rear chests, or 126 per caisson; number of caissons, 9; total ammunition with battery, 1386 rounds or 231 per gun.

No new type of battery wagon and forge has yet been adopted. One resembling the old type has been proposed, to weigh about 3800 pounds packed. The Ordnance Department, however, is experimenting with a large motor-car for this purpose, driven by a four-cycle gasoline engine. This experimental car weighs some 8000 pounds completely packed; it carries complete machinist's, carpenter's, saddler's and farrier's tool kits, and a limited quantity of supplies, but no spare parts for the battery.

The ammunition to be carried includes shrapnel and high explosive shell. Both projectiles have the same weight, but not the same length, and hence the ammunition chests have to be so constructed as to hold either length securely. The proportion of shell to be carried has not yet been fixed.

Shrapnel is of course the most important projectile. The model adopted consists of a strong cylindrical steel case, open at the forward end. In this are packed 300 steel jacketted balls, and a point section, containing the time fuse, is screwed on. A central channel connects the fuze with the powder charge, which is in the base.

The weight of the bullets is 53 per cent of the entire weight of the projectile, which is a high efficiency; the corresponding percentage for the old shrapnel was only 35. Each bullet, furthermore, is more effective in the new model, for they are steel jacketted, while the old ones were lead; and the new projectile has a base bursting charge, while the old one had a head charge, which decreased the velocity of the bullets on burst, while causing them to "scatter" more.

The weakest cross section is at the line of attachment of the point section. Hence, upon explosion of the charge, the head is blown off, the case usually remaining intact; the case then acts like a short shotgun, throwing its contents to the front with an added velocity of 250 f. s.

With a muzzle velocity of 1700 f. s., the remaining velocity of the shrapnel at 6500 yards range is 700 f. s. If, then, one be burst in the air at this range, each bullet will have a resultant velocity of 950 f. s., and will have roughly the same effect as a shot fired from the service revolver.

These results are entirely satisfactory against animate targets in the open. But for use against inanimate targets or entrenched troops, something else is needed. The shrapnel bullet has not sufficient power to destroy materiel; and on account of the flatness of the trajectory and the small angle of the cone of dispersion, it cannot reach troops in any but the lightest entrenchments.

Hence experiments are being made with a common shell, loaded with high explosive, and burst either by a percussion or time fuze. With the former a powerful effect against material targets is abtained; and with the latter it is expected to reach troops behind entrenchments by bursting the shells directly overhead, since the fragments fly in all directions.

The explosive used combines extreme safety in transportation with extreme certainty and force of action.

The fuze issued is a great improvement over the old one, in that it is set for time, not by punching, but by turning a disc about an axis coinciding with that of the projectile. After an old fuze was once punched, it could not afterwards be used at a longer range, while the new one can be set and reset repeatedly. Thus a battery may, if desired, go into action with its fuzes set at zero, ready to use its maximum canister effect at a moment's notice; and still reset fuzes as desired for any range.

The ease and certainty of fuze-setting is also greatly increased. A device for setting is attached to each caisson; it has two scales,—a range scale, and a "corrector" for adjusting height of burst. The corrector scale is graduated in mils, the reading 30 corresponding to the normal height of burst, 3-1000 of the range. These scales being set at the numbers ordered by the battery commander, the fuzes can be set with great rapidity and accuracy. Changes in the adjustment of the fuze-setter can be quickly and easily made as ordered.

A round of ammunition complete, with its case, weigts 18.8 pounds.

A very important accessory of the battery is the battery commander's telescope. This is an instrument very similar to the panorama sight, but larger, and mounted upon a tripod. It ia capable of measuring both vertical and horizontal angles, and its graduation conforms to that of the sight. By its aid, the battery commander determines deflection allowances, measures angles of site, and observes the fire, noting errors in range and measuring lateral deviation and heights of burst.

The gun just described is the first to be completed

of a complete series of mobile artillery, which is contemplated by the Ordnance Department. The series as planned includes the following:—

1. The mountain artillery materiel.
2. The horse artillery materiel.
3. The light field materiel.
4. The heavy field materiel.
5. The siege materiel.

This series was developed with reference to the following considerations:

Kinds of fire.—For the attack of targets that can be reached by it, flat trajectory fire is preferred, on account of its power and accuracy. Cases frequently arise, however, where such fire is useless, either the gun or its target being so concealed and sheltered by the accidents of the terrane that higher angles of departure or fall become necessary.

To provide for both cases, two types of weapon are necessary, the long gun for flat trajectory and the shorter howitzer for curved fire. Our field materiel is to include suitable proportions of each.

Caliber.—It is important to reduce the number of separate calibers to a minimum, both from considerations of economy and to avoid complication in ammunition supply. But at least three appear necessary, for light field, heavy field and siege materiel. To these should perhaps be added a smaller caliber, for horse artillery.

The mountain gun is in a class by itself. With this exception, all the materiel is to be of the general type already described. Taking up each class by itself, a brief summary of what is proposed will be given.

1. *Mountain Artillery.*—The present gun is of foreign manufacture; it is of modern construction, has a caliber of 75 mm., and is arranged for either pack or wheel transportation. It is proposed to re-

tain this type of weapon, simply increasing the caliber to full 3″ and making some improvements.

2. *Horse Artillery.*—This is essentially the companion of the Cavalry, and so requires great mobility. Our horse batteries are now armed with the regular 3″ field gun, and it is felt by some that there is not sufficient difference in mobility between horse and field batteries.

The Ordnance Department has been studying the question of a smaller caliber gun, and it is possible that some such weapon may be adopted for this purpose.

A five-pounder was proposed, to have a caliber of about 2″ and to use only high explosive shell. After some tests, the idea was abandoned; a gun is now in contemplation which shall have a caliber of 2.38″ and fire a 7½ pound projectile, it being deemed necessary to retain the shrapnel, and this being considered the smallest caliber that can employ that projectile effectively.

It is desired to keep the weight behind horse artillery teams down to 3000 pounds.

3. *Light Field Artillery.*—This constitutes the bulk of an army's artillery, and it is here that the 3″ gun is properly classified. The considerations determining the selection of that caliber have already been mentioned. As a companion piece to the gun, a 3.8″ howitzer has been planned, having about the same mobility and carrying a thirty pound projectile.

4. *Heavy Field Artillery.*—Recent experience in Manchuria shows the importance, in a pitched battle, of heavy guns. The same thing was forcibly brought out in South Africa, where one or two heavy Boer guns sometimes prevented the English field guns from accomplishing anything at all.

Much of the mobility insisted upon in the light

field gun may here be sacrificed to secure high power, as these heavy guns would not be expected to accompany quickly moving columns, and need be capable of rapid gaits only for short distances. It is considered desirable, however that they be not too heavy to be handled by six-horse teams, which places the total weight at about 4800 pounds.

On this weight a 3.8″ gun can be constructed, carrying a thirty pound projectile, and this it has been decided to do, The corresponding howitzer will be of 4.7″ caliber, and carry a sixty pound projectile.

Desirable as it is to reduce the number of calibers, it has not appeared best to follow the example of England, and have only one horse and one field gun. The new English horse artillery gun is a 3″, 12½ pounder, and the weight behind the team is nearly 3400 pounds; the field gun is a 3.3″, 18½ pounder, weighing 4300 pounds. It would seem that the latter has hardly the mobility desirable in a light gun, and falls far short of the power requsite for a heavy gun.

5. *Siege Artillery.*—For the siege train, a gun is desired which shall have as much power as possible without exceeding a weight that can be handled by eight horses. Since rapidity of motion is not necessary, it is held that 8000 pounds is allowable, and on this weight a 4.7″, 60 pounder gun, and a 6″, 120 pounder howitzer are planned.

It will be noted that throughout this series the calibers have been so selected that the howitzer of each class takes the projectile of the gun of the next heavier class. This is in accordance with the principle, already dwelt upon, of simplifying as much as possible the ammunition supply.

With the changes in materiel have come corresponding changes in the handling of it, both technical and tactical. For the present, this discussion will

be limited to the technical side, avoiding, in so far as possible, tactics proper.

In order to provide for the numerous extra caissons, the battery is divided into four *gun sections*, Nos. 1-4, and four *caisson sections*, Nos. 5-8: the former consist of one gun and one caisson each, the latter of two caissons each. Two sections constitute a a platoon, the first and second being composed of gun sections, the third and fourth of caisson sections. A supernumerary or 9th section is made up of all remaining vehicles of the battery.

When the battery goes into action, the first line, or *firing battery*, is composed of the four gun sections, and the first caisson section, No. 5.

The thing that first strikes the attention of an observer watching the new guns come into action is the position of the caissons. The caisson of each gun section is on a line with its piece, one foot to its left; one caisson of the 5th section is on each flank of the battery. All these caissons are unlimbered, and all limbers placed under cover, preferably on a flank.

The gun is served by a squad consisting of a gunner, who is a corporal, and five privates. The gunner sits on the left trail seat; he has the immediate command of the squad, and lays the piece, either for direction only or for both direction and range.

No. 1 sits on the right trail seat. He opens and closes the breech, lays for range when so ordered, and fires the piece.

No. 2 is posted near the trail; he moves the trail under the orders of the gunner so as to give approximate direction, and loads the piece.

The remaining cannoneers are posted behind the caisson body: No. 4 operates the fuse setter and serves ammunition, the others assisting as he directs.

The battery, placed as described, is ready for

either direct or indirect fire. The former is used habitually when the target can be clearly seen through the sights; the latter when it cannot.

There is nothing calling for special comment at this time in the manner of delivering direct fire. Indirect fire, however, involves many details which may appear, at first sight, somewhat troublesome.

Such fire can be delivered from any position, provided a place can be found for the battery commander's telescope, from which both guns and target are visible. It is only necessary to take care that, if any high obstacle intervene between gun and target, the position be far enough removed from it to cause the trajectory to clear it.

The observation station is preferably on a flank of the battery, approximately in prolongation of the line of guns, and near enough to allow the battery commander to keep in touch with both guns and station. If necessary, some form of field telephone will be used.

The position of the observing station having been selected, the chief of the third platoon and the chief of his right section (No. 5) take post there, and set up and adjust the iustrument. The battery commander meanwhile notes the distance from the observing station to his right gun, which is habitually the directing gun of the battery, and makes his first estimate of the range from the directing gun to the target; the Weldon range-finder is issued as an aid to this.

Since the gunners cannot see the target, an auxiliary point is next selected, upon which they may aim, after setting off the proper deflection on the sights. This point should be distinct and unmistakeable; something tall and slender, as a flag-staff or church spire, is best; and, to reduce the error which may arise from aiming at different parts of the ob-

ject, its angular breadth should be made as small as possible by selecting it at a considerable distance, preferably a mile or more. The range to this point is determined as in the case of the target.

The problem is now to determine the deflection which must be set off on the sight of the directing gun, so that when the sight is brought to bear upon aiming point, the gun shall be trained upon the target. A verbal description of the process of solution sound a trifle complicated, but in actual practice the complication is not felt.

The determination of this angle requires that three other angles be known. These are—(1) the angle at the observing station between the aiming point and the target (marked S in the figure), (2) the angle at the target between the directing gun and the observing station (marked T), and (3) the angle at the aiming point between the directing gun and the observation station (marked P).

(Figure:—Solution of problem of indirect fire).

Of these three angles, the first may be directly measured with the battery commander's telescope, in the same manner as with a transit; it will be remembered that the reading of this instrument is not in degrees and minutes, but in mils.

The other two angles cannot be measured, but must be computed. The data for the computation are the ranges to the target and aiming point, and the distance between the directing gun and the observing station.

It has already been explained that one mil is the equivalent of a lateral displacement equal to 1-1000 of the range. Knowing the range, the value of a mil in linear measure is instantly known. Dividing this value into the distance between the directing gun and the observing station will give the value in mils of the second angle required, and a repetition of

the same process, using the range to the aiming point, will give the third.

Referring again to the figure, it will be noted that the required deflection is the angle marked G. In the two triangles, SPX and GTX, the angles X are equal. Hence S plus P equals G plus T, or G equals S plus P minus T.

These calculations may be very quickly made in the note book, or, in many cases, mentally. It must not be overlooked that if the aiming point is in rear of the line joining gun and station, the angle P is negative, and that if the aiming point and observing station are on opposite sides of the line of fire, P and T exchange algebraic signs.

If the direction of the aiming point is very far from the normal to the line joining the directing gun and the observing station, a correction must be applied to these results, since the measurement of an angle in mils is absolutely accurate only when the successive lateral displacements are laid off as separate tangents to a circle of which the range is the radius,—or, what is nearly the same thing for small angles, on a single tangent thereto. This correction is made by multiplying the distance between the directing gun and the observing station by the trigonometric sine of the angle between the direction of the aiming point and the line joining gun and station, or dividing the range to the aiming point by the same quantity, and using this so-called "virtual distance" in place of the true one. A similar correction is necessary if the position of the observing station is very much in front or rear of the line of guns, which is naturally placed facing as squarely as possible towards the target. For this calculation, various time-saving devices may be employed; for example, a table showing the angles, in mils, corresponding to the natural sines 0.1, 0.2, etc., may be carried in the note book or memorized.

It is true that one important element in this calculation, range, is not certainly known, but only approximated. However, with an observing station near the battery, the error in range finding must be very considerable to cause a serious error in the angle. And if it be objected that the process is too long and intricate, it must be remembered that it is all done at leisure, before the enemy can have any knowledge of the presence of the battery, which remains in concealment. It has for its object the accurate placing of the first shot, in order to facilitate ranging; and if it can do this the time is well spent, since after the first shot is fired the enemy has his warning. If there is need of haste, the process can be abbreviated by sacrificing some of its accuracy.

Another method, found in the French regulations, for getting the deflection, is to turn the battery commander's telescope first on the gun sight, then on the target, and read the angle; compute, as before, the angle at the target between gun and telescope: set the sight at 3200 mils, or 180 degrees, less the angle read, and increase or diminish, according to the relative positions of gun and telescope, this setting by the amount of the angle computed. Then use the telescope itself for an aiming point; or transfer the reading to any other point desired, reading the angular difference from the sight itself. If the lines from gun to target and observing station are not nearly at right angles, the calculated angle must be corrected as before for obliquity.

The angle of site has next to be measured. Since the gunner cannot see the target, this cannot be done directly; but the angle of site at the observing station can be measured with the battery commander's telescope, and corrected for difference of level between gun and station, which difference also may be

taken with the same instrument. This angle is needed in order that the clinometer of the range quadrant may be set.

The information known as "firing data" is now complete for the directing gun, and it is ready to commence its ranging fire. But first it is necessary to determine how the fire of the other pieces shall be distributed on the target.

The old method of distribution is still applicable, when the fire is direct. This consists merely in assigning to each gunner a separate part of the target upon which to aim. This method is called "individual distribution."

In "collective distribution" all the pieces have the same aiming point, but the deflection set off on the different sights is not the same, increasing or decreasing from that of the directing gun in arithmetical progression.

By changing the common difference of the series, the fire of the whole battery may be made to converge upon a single point, or to diverge as much as desired. The lines of fire of the pieces, thus distributed; constitute the "sheaf of fire."

In this method of distribution, indirect fire is habitually used; but it is also applicable to direct fire, in which case the common aiming point is some conspicuous part of the target.

Ranging fire has for its principle object the determination or verification of the firing data. It may be executed in three ways,—by battery salvos, by platoon salvos, and by piece; the method to be adopted depends upon circumstances, such as the nature of the target, the facility of observing the fire, and the available supply of ammunition.

The old gun habitually employed percussion shell or shrapnel in ranging; the facilities for observation of fire being now much better, either time or per-

cussion fuzes may be employed. Usually, that fuze is adopted which it is intended to use in the subsequent fire for effect; when time fuzes are used, the first bursts are habitually made a little lower than the normal.

In ranging by battery salvos, all the pieces are loaded and laid as directed; the guns are then fired in turn, beginning at either flank, with an interval of about three seconds between shots. The battery commander then announces any necessary corrections in range and height of burst, and makes such alterations as he sees fit in the distribution of fire, either shifting the whole sheaf to the right or left, or opening or closing the lines of fire, like the sticks of a fan. If a single shot is out of its proper place in the sheaf, the chief of platoon, in case of direct fire, makes the necessary changes to place it correctly on the next salvo; in indirect fire, the battery commander makes this correction also.

A modification of this method, used chiefly in case of moving targets, consists in giving each platoon a different range, and firing a battery salvo as before.

Ranging by platoon salvos and by piece is conducted in the same way, except in one case the platoons, and in the other the pieces, alternate in firing, corrections being announced after each platoon salvo or single shot.

Fire for effect may be either continuous or by volley. Fire at will is also used, but only in exceptional cases.

Continuous fire is the old "fire by piece"; the guns are fired in regular rotation, from one flank to the other, at such intervals as may be ordered.

A volley, or, as the French term it, "*Rafale*", consists of a specified number of rounds, usually from two to four, fired by each piece, independently of the others, as rapidly as is consistent with accuracy.

Volley fire is extremely effective if the position of the target is such that the fire can be reliably observed. If this be impossible, "progressive fire", or "fire by successive volleys", may be used. This consists in firing several volleys in quick succession at the same target, increasing or decreasing the range after each volley by from fifty to one hundred yards. By this means an area of any desired depth may be swept. The breadth of the zone which may thus be covered by a single battery is, at a range of 3000 yards, from 100 to 125 yards, using time shrapnel. Using percussion shell, the zone is natually much narrower, being only twenty-five or thirty yards.

If it is desired to cover a broader zone, sweeping fire is resorted to, which enables the battery to cover about twice the above breadths. The deflection difference is increased, causing the lines of fire to diverge, and each piece is then traversed, right or left as directed, five or six mils after each shot of the same volley.

Both progressive and sweeping fire can be used at the same time, the direction being changed after each shot of the same volley, and the elevation after each complete volley. The bursts of the shapnel are thus distributed over the selected zone in an almost geometrical pattern.

Such fire, of course, causes a great expenditure of ammunition. This is drawn, in the first instance, from the caisson placed beside each piece. This is preferably replaced from the caissons of the 5th section, one of which is placed on each flank of the battery. . These, when empty, join the battery reserve, whence they are sent to the ammunition column to refill; their places in the firing battery are taken by another caisson section from the reserve.

If necessary, the caissons of the gun sections draw ammunition from their own limbers and those

of the guns. This is, however, done only in case of necessity, as the ammunition in these limbers, and especially in the gun limbers, constitutes the emergency supply. If it is done, the limbers are refilled from the reserve at the first opportunity.

As is well known, the French were the pioneers in developing rapid fire field artillery materiel and a system for handling it. All important nations have followed their lead, and adopted some form of rapid fire materiel.

Some adopted an intermediate type, having "accelerated fire",—so called for lack of a better term,—which could be constructed by modifications in the old materiel. Of this type is the field gun used by Japan in the present war. It is not safe to say that all the excellent Japanese artillery work was done with this gun, for many modern heavy guns have also been employed by them, but a few words of description of it may be of interest.

It is known as the Arisaka gun, and was adopted in 1901, superseding a bronze Krupp nine-pounder. It is of steel, built-up, has a caliber of 75 mm. or 2.95", and fires an 11-pound projectile. Its effective range is 5,000 yards. The ammunition is "semi-fixed", that is, the powder charge and primer are put up in a brass case, but the projectile is separate. The breech mechanism is of the slotted screw type, and swings downward to open; the block contains the percussion firing mechanism.

The gun is rigidly mounted on the carriage by means of trunnions. The whole carriage, therefore, runs to the rear on firing; but a device consisting of a recoil brake and wheel shoes is used to check recoil and return the piece to battery. This device is constructed as follows:—

On the inner side of the hub of each wheel is an annular groove, in which a rope runs. One end of

each rope is fastened to the wheel shoe, the rope then passed around the hub, and the other end attached to a cross-head at the end of a piston-rod lying between the flasks of the trail. The flasks are grooved to make a slide for the cross-head. The wheel shoes are hung from the axle by chains, and have spade-like projections on the underside, which the wheels, on recoil, force into the ground.

When the piece is fired, the wheels run back onto the shoes, forcing them down. A pull is thus brought upon the ropes, which is transmitted to the cross-head and piston rod, compressing powerful springs. The pull ceasing, the springs expand again, returning the gun to battery. The average length of recoil is fifty centimeters.

Since the gun seldom returns into precisely the same position, it must be relaid for each shot. The rate of fire is given as seven shots per minute.

The sights are not telescopic, but an arrangement is provided by which indirect laying is practicable, using an aiming point situated in any direction from the gun.

This may be taken as a fair example of the type of "accelerated fire" guns; it is, however, a type that is rapidly disappearing, cannot be considered as truly modern, and is mentioned here only on account of its performances during the present war.

Returning to the subject of rapid fire guns, it must be said that there is not at present anything like a consensus of opinion in regard to the best method of utilizing their great power. There are numerous open questions, calling forth voluminous discussion in the technical periodicals, and giving rise to tests and experiments of various kinds; and these open questions are not tactical ones alone, but some relate to more purely technical matters, such as ranging, and selection of positions.

The French, the pioneers, have the most completely worked out system, and have made the most radical departures from old ideas.

They adopt indirect fire and positions far down the reverse slope of hills, not only as the habitual, but almost as the exclusive method of procedure, in in cases where it can possibly be applied. Such a position does not give actual protection, as is often thoughtlessly assumed; for whenever a position has in its front a slope sufficiently gentle to permit guns to fire out of it, other guns can certainly fire into it. But it offers very effective concealment, and when a battery is completely masked it is a very difficult matter indeed to locate it.

In the matter of ranging they have taken a very bold step. The principle upon which they work has been very well stated by Colonel Gordon, of the English Artillery, as follows:

"The changes that have been introduced are based on the supposition that a storm of shrapnel bursting over a given area of ground will paralyze every movement within that area. As the suddenness of the squall is an important factor, time must not be wasted in exact ranging, though every precaution is taken to conceal the battery and to make every possible preparation before the first shot is fired. An examination of the technical question of ranging does not come within the scope of this paper. Volumes have been written about it; thousands of rounds have been expended in experiments, and tens of thousands of practice records have been searched in the attempt to solve difficulties which we may safely leave to the Artillery Schools to deal with; but we may take it for granted that close accuracy in ascertaining the correct elevation and direction, as well as the length of fuze, is not conducive to rapidity. But the French theory is dependent on rapidity; they

count on hitting the enemy before he can hit back, or knocking him down when he is not looking and keeping him down; and to do this they sacrifice exact ranging to rapidity, and trust to the storm area including the enemy somewhere, and to its being violent enough to reduce him to inaction. These squalls, or *rafales*, are necessarily short, some sixty to eighty rounds are expended in five or six minutes, the number varying according to the difficulties of ranging. It is true that that in some cases, as shown in Examples 8 and 20 of the Reglement, a more careful ranging is then proceeded with, and the target (a battery in each of these cases) is destroyed at leisure."

The action of a French battery, it will be observed, is intermittent. It opens fire suddenly, sufficient preparation having been made beforehand to insure the first shot being a fairly good one; little time is then spent in verification of the firing data, but rapid volley fire, progressive and sweeping, is distributed for a few minutes over an area sufficiently large to include the target; the fire then ceases for a time.

Some of the objections to such a course have been pointed out by Major Stappaerts, a Belgian Artillery officer, who writes:

"The fire tactics of the new French Regulations may be summarized as follows: (1) Prepare the fire, under cover as much as possible, and act by surprise. (2) Establish a wide bracket, of from one to two hundred meters, by means of salvos. (3) Fire one or *rafales*; after which, interrupt the fire until a new target appears, or it is found necessary to fire again upon the first one.

"The idea of preparing fire under cover as much as possible, and opening it unexpectedly, may be approved without reserve. It is certain that a care-

ful preparation of the fire contributes much to shorten the ranging period, which is the critical time for the Artillery.

"But many French officers of the extreme school do not attach sufficient importance to the necessity of accurate ranging, and advocate the reduction of this period to the smallest limits; some even go farther, and insist upon getting, at any cost, an immediate effect upon opening fire, so as to accomplish the destruction of the target in the shortest possible time. They believe that ranging causes too great loss of time; even the determination of a bracket delays too much the furious storm of iron and lead which should beat down the enemy at the moment when he least expects it, and destroy him before he can recover himself.

"But it must not be forgotten that the weight of ammunition for the field gun has not diminished, and that the total weight to be transported can be increased but little; and there is no good reason why we should be more prodigal than before in the expenditure of ammunition, when the conditions of the battle do not require a great rapidity of fire. If it is necessary to expend much ammunition in the decisive moments of a fight, at short range, it is necessary to be very saving of it at ranges over 3000 meters, and never to fire at the maximum rate at those ranges.

"If the fire is well regulated and effective, it will disorganize the enemy whether it will be six or twelve shots a minute. If it is inaccurate or ineffective from any cause whatever, its rapidity is of little value; on the contrary, the most rapid fire will be the most disadvantageous, on account of waste of ammunition.

"It is impossible to see any progress in this systematic employment of rapid fire with the field gun. No supply of ammunition would permit the applica-

tion of such fire to all the zones where an enemy may be supposed to exist, and where, even if present, they would not have to wait long before the exhaustion of ammunition would bring an end to the *rafales.*

"The ineffectiveness of such cannonades on invisible targets has been seen clearly in the Transvaal. True, in the fights of the future, it is probable that the two adversaries will try to hide themselves as much as possible, and this will be facilitated by smokeless powder; but it will be necessary in the end for the assailant to show himself if he wishes to advance, and for the defender to let his emplacements be seen if he wishes to repulse the attack. He will then be the stronger who has reserved his ammunition for this moment, instead of expending it in raining shrapnel over zones where the presence of the enemy is doubtful."

The German Regulations represent the opposite, or ultra-conservative views. They still favor direct fire as the habitual method, although ready to resort to indirect laying on occasion; their favorite position is behind the crest of a hill, near enough the top to enable the gunner to see the target through his sights.

As regards methods of fire, the Germans continue to hold to accurate ranging and a steady, continous fire, both in order to economize ammunition, and to spare the nerves of the gunners the strain of very rapid firing except in special cases.

Our own Regulations are still incomplete, and even in so far as they have been worked out are considered as provisional only. It is therefore impossible to say what their final form will be; it appears certain that the French model will be followed, but it is doubful to exactly what extent. Probably some of the more radical points will be modified. From what has already been done, it seems probable that indi-

rect fire from concealed positions will be prescribed as the preferable, though by no means invariable, course; and that the rapid volley fire will be used, not constantly and indiscriminately, but in those cases, numerous enough, where other methods seems inadequate.

It is the desire of the Military Art Department that there be appended to this paper a brief discussion of machine guns.

Two general types of this weapon may be distinguished, of which the Gatling and Colt may be taken as representatives, they being the guns now in use in our service.

In the Gatling gun, a group of rifle barrels, from six to ten, is assembled about a central shaft, to which all are parallel. Each barrel has its own bolt, firing pin, etc. Several kinds of feed device are used, all supplying a continuous stream of cartridges to the loading point. The whole mechanism is actuated by a crank.

When the crank is turned, it causes the shaft, with barrels, locks etc., to rotate; by the bearing of lugs on the bolts in grooves on the inner surface of the barrel casing, all bolts on the right hand side are forced to move forward, and all on the left backward.

As each bolt in rotation reaches the "loading flat", a cartridge drops from the feed in front of it. As the rotation continues, the bolt moves forword, until, on reaching the "firing flat", the cartridge has been completely inserted and the bolt closed. During this motion a groove on the casing catches the head of the firing pin and retains it, thus compressing the main spring and cocking the pin. A continuation of the rotation causes the firing pin to pass out of this groove, when the action of the main spring

drives the pin forward and fires the cartridge. The motion still continuing, the bolt is withdrawn by the left hand groove, and the empty case thrown out by the extractor.

The rate of fire is 800 shots or more a minute.

In the Colt gun, there is only one barrel. Underneath this, near the muzzle, is placed a small cylinder containing a piston. The barrel and cylinder are connected by a vent, which admits a part of the powder gas to the cylinder just before the bullet leaves the muzzle.

This gas, expanding in the cylinder, forces back the piston. The motion of the piston, acting through suitable mechanism, unlocks and opens the breech bolt, ejecting the empty cartridge case. A fresh cartridge is supplied at this instant by the feed device, and thrust home by the bolt, which returns to its place, driven by a spring. The firing pin is cocked at the same time.

If now the pressure on the trigger, which caused the firing of the first shot, be continued, the firing pin flies forward, discharging the next cartridge; the firing is thus continuous as long as the trigger is held. The action is so rapid that it is very difficult to fire only a single shot; the maximum rate of fire is about 480 rounds per minute.

The gun itself, exclusive of mount, weighs forty pounds.

In many guns of the single barrel type, the mechanism is actuated, not by powder gas, but by the recoil. Such guns allow the barrel and attached parts a slight motion on recoil, with respect to the other parts; this motion unlocks the breech bolt, which continues to move to the rear when the barrel reaches the end of its travel; the remainder of the action is similar to the Colt. Some models, notably the Vickers-Maxim, utilize both gas pressure and recoil.

The single barrel gun is rapidly superseding the older revolving type for most uses.

While the machine gun is not by any means a new weapon, there is as yet no entire agreement as to its proper use.

In the first place, however, an important distinction must be made between the small gun, using Infantry ammunition, and the so-called "machine gun of caliber", large enough to fire an explosive projectile. The fire action of the first class approximates to that of Infantry; of the second, to that of Artillery.

To the second class belong the famous "pom-poms", of which so much was heard during the war in South Africa. These were chiefly Maxim-Nordenfelts; they were 37 mm., or 1.45", in caliber, and threw shells weighing about a pound, at the rate of fifty or sixty a minute.

The Boers had, as nearly as can be determined, nine pieces of this type. They were mounted on wheeled carriages, provided with shields, and were treated in all respects as Artillery weapons.

As to the actual efficiency of the pom-pom there is a difference of opinion. Some place it very low; others, and probably the majority, very high. One German officer, serving with the Boers, says—

"The Maxim-Nordenfelts made a remarkable showing; even beyond 3000 meters some of them sustained the struggle against three, four or even six field pieces. At the battle of Boschrand, I myself fought with one of these pieces, well covered, it is true, during a whole day against four English pieces. Some of the latter were even reduced temporarily to silence, without our having suffered the least damage. Against Cavalry they showed themselves superior to every other piece. At Thabanchu, two regiments of Lancers were thrown into confusion in a very short

time by two Maxim-Nordenfelts. The uninterrupted series of points of burst on the ground permits readily following up a rapidly moving target, which cannot be done by a field piece using shrapnel and a much less rapid fire. I have gained the impression that the Maxim-Nordenfelt is a formidable weapon.

Whatever one may think of the absolute destructive power of this gun, there is no question about its moral effect upon troops in the open. The English were unable to find any answer to it, except other guns of the same type.

It is not believed, however, that such incidents as the ones mentioned above could take place in a contest with modern field guns; the English guns at that time, it will be remembered, were of old type and low power. With its carriage and shield, the pom-pom offers a target as large as a field gun; it has inferior range and power, and must expose itself more in firing.

As has been said above, its fire *approximates* to that of Artillery, but it can hardly be said to *be* Artillery. The English, who ought to know more about it than anyone else, evidently do not consider it as such, and are trying to find out just where it does belong. Their latest experiment is to assign one to each regiment of Cavalry and battalion of Mounted Infantry. Another plan suggested by English officers is to attach one to each group of rifle caliber machine guns, the idea being that it can act as a range-finder for them.

The rifle caliber machine gun is a totally different weapon; it is simply a consolidation into one piece of a number of rifles, and can be compared only to the rifle. Its value in rifles is variously stated, from ten up; the Germans go so far as to say that, everything considered, it is equal to 100 or even 120 rifles. Such a measure of its value is of little use, however,

as its utility varies so greatly according to circumstances.

The range once found, it can put a continuous stream of bullets into the target. It will be evident, however, that ranging is much more difficult than with the pom-pom; the projectiles are not explosive, and their points of fall are not easily visible except under very favorable conditions. This difficulty increases with the range, and at the same time the depth of the zone beaten by the fire diminishes, being only about sixty yards at a range of 1500 yards; hence an error of thirty yards in estimation at this range, will take the shots off the target, and there will be little hope of bringing them on by observation.

It will then be necessary in most cases to sweep a zone deep enough to allow for any probable error. The practical procedure will be about as follows:

Suppose the estimated range is 1500 yards, and the error is thought to be not over 100 yards. The sight will be set at 1400 and the gun aimed, the sight will then be raised to 1600, firing begun, and the piece slowly elevated until the sights are again on the target: the gun will then be traversed a little right or left, and the process reversed; and so on.

Such firing cannot, of course, be continued indefinately, regardless of ammunition supply; 10,000 rounds seems to bo about the limit for continuous fire, even with a water-jacketed barrel.

It is unsafe to leave a cartridge in the barrel after it has become well heated. On one occasion, after several thousand rounds had been fired from the Colt gun, firing was stopped while a few cartridges still remained in the feed belt, in order to see how long the dangerous heating continued. It was found that eight successive cartridges were exploded by heat alone, the interval between shots, of course, gradually lengthening, until nearly a minute and a half elapsed between the seventh and eighth.

The value of these guns is primarily defensive. They can hardly accompany Infantry in the attack; light as they are, their mobility is not sufficient for this, and, even if it were, they would offer too good a target, since they must come to effective Infantry ranges before they themselves become effective. Still, when they are able to approach unseen and come into a concealed position near enough to the enemy, they can give powerful support to an attack. Another use for them will be found in an advance guard.

In Cavalry operations they may be found useful, both offensively and defensively. Some foreign armies are, experimentally attaching one or more light machine guns to each squadron, expecting thus to add greatly to its capacity for fire action, and even to avoid, in many cases, the necessity of resorting to dismounted action. Some of the guns used in this manner are remarkably light, approximating to an automatic rifle.

In the defense of a position, it requires no argument to show the value of the machine gun. It can here take the place of many rifles, perhaps even justifying the German estimates; and if at all well protected, it will not be easily injured by Infantry fire. An illustration of a special defensive use is found in an incident of the South African War. Two Maxims, belonging to the 1st Battalion Mounted Infantry, were in the reserve; a Boer column being observed, about to turn the flank of the battalion, these guns prevented it by moving out at a gallop, and coming into action on the flank of the flanking force.

Our own service has been backward in taking up the machine gun question. Although some experience was gained with Gatlings in Cuba, it has not been followed up, and no system has been developed.

At present, such experiments as are being made are along the line of attaching single guns to Infantry battalions. The Colt gun is being used, and several types of mounting.

Pack transportation is best for guns used in this manner. In some pack outfits, the gun is placed on a tripod for firing; in others, on a light wheeled carriage.

European opinion appears to be generally in favor of separate machine gun companies. Germany is unusually well provided with them, having sixteen companies, each with six Maxim guns. These are now attached to regiments of Infantry; but it is intended to increase the number of companies, and assign one to each Army Corps and Cavalry Division, as independent tactical and administrative units.

Wheel transportation is used, much as in the Artillery. Each gun is drawn by a four horse team, and each pair of guns has three ammunition wagons, carrying a total of 87,000 rounds. The personnel consists of 80 of all ranks.

Russia is also well supplied with permanently organized machine gun companies; she has twelve, each equipped with eight Maxim guns.

The field companies have their guns mounted upon wheeled carriages, with limbers, each drawn by two horses. Each gun has a one horse ammunition cart. The war strength of the company is 5 commissioned and 95 enlisted.

Mountain companies are similarly organized, except that their guns are arranged for pack transportation. Each gun has a mmunition packhorse, in addition to its one horse cart. The war strength is 5 commissioned and 119 enlisted.

These companies are considered to belong to the Infantry arm. Teey are assigned singly to Infantry Divisions, and made a part of some regiment of the

Division, under the direct orders of the colonel. The officers are selected by the Division Commanders.

In Switzerland, on the contrary, machine guns are attached to Cavalry Brigades. Each company has eight Maxims, with 10,000 rounds per gun. Pack transportation is used: the strength of the company is 72 officers and men and 99 horses.

The most evident principle in the use of machine guns is that they must never attempt to engage Artillery; this was proved once for all by the experience of the French in 1870.

It is also clear that this weapon is not one for general purposes, but for use on special occasions, when its timely intervention may be decisive, as in the case of the 1st Battalion Mounted Infantry, already mentioned.

It is with this latter idea in mind that the Germans have adopted their present organization. They consider that single guns have not sufficient power to be used alone, and therefore make their tactical unit consist of six; but they also believe that larger groups would be unwieldly, and that guns so concentrated would not be on hand when needed in an emergency. Hence their regulations do not recommend the consolidation of companies.

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