WEAPONS AND MUNITIONS OF WAR

PART III

ARTILLERY WEAPONS

BY

CAPTAIN OLIVER L. SPAULDING, Jr.,
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DEPARTMENT OF MILITARY ART
INFANTRY & CAVALRY SCHOOL
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The New Field Artillery Materiel; its Characteristics and Powers.

Our Field Artillery has just been rearmed, with an entirely new type of gun. That is to say, it is new in the sense that it differs in almost every essential particular from that which it supersedes; the type itself is one which, in its general characteristics, is familiar to our artillery officers, and all important foreign nations have now adopted something more or less similar to it.

New Field Gun, U. S. A.

The new materiel has been very carefully worked out in every detail, and, it is believed, compares favorably with that of foreign powers. It is from the designs of our own Ordnance Department; but, prior to its adoption, thorough competitive tests were made, in which the best work of private manufacturers, both American and foreign, was tried out.

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, or even the most important characteristic of the type.

Most of the members of the class have undoubtedly had the opportunity to observe the work of this gun, or at least to become familiar with its general appearance; but, since the rearmament has so recently been completed, it may be well to make a rough comparison with the old 3. 2″ gun, now withdrawn from the regular service.

Comparison with 3.2″ Gun.

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 the continuous motion of one single 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, and the gun is loaded in the same manner as a rifle.

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. With the new ammunition, the primer is not a separate part, but is fixed in the cartridge case; so that the gun is ready for firing the instant the breech is closed.

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 the carriage through a considerable angle, 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 slow, difficult and inaccurate; with the new one, it is as easy and accurate as direct aiming; in fact, in some respects, it is even a more simple and accurate process.

The old gun, with its carriage, recoiled bodily along the ground; the cannoneers had to step clear before firing, and the piece had to be run up into position again and relaid for each shot. The new piece recoils independently of its carriage, which remains motionless, and is returned immediately to the firing position by springs; all cannoneers remain at their posts, and the gun remains trained on the target.

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 for shrapnel has been increased about 50 per cent.

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

Breech Mechanism.

The breech mechanism is of the slotted screw type; the block has two threaded and two planed sectors, hence requiring ninety degrees rotation to unlock. The breech is opened by a single horizontal motion of the operating lever; the first part of this motion rotates and unlocks the block, and latches it to the block carrier, and the remainder swings block and carrier to the right, pivotting on the hinge-pin; this leaves the block clear of the breech recess, and with its axis at right angles to to that of the gun. The lever latch, which guards against accidental opening of the breech, is placed in the lever handle, in such a manner that the grasp of the hand on the handle releases the latch.

Since fixed ammunition is used, no pad or other obturating device on the breech block is necessary; the cartridge case itself acts as a gas check, preventing the escape of powder gas to the rear.

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

Percussion primers being used, a firing pin and and appropriate mechanism are enclosed in the block. As the block is rotated in opening, the firing pin is drawn back and held by the sear; but the firing pin spring is not compressed until the last motion of locking the block. The axes of the gun and block do not quite coincide; the firing pin is placed eccentrically in the block, so that in the firing position it lies in the axis of the piece, and consequently in line with the primer of the cartridge. As the block is rotated to open the breech the pin moves to one side, clear of the primer, and remains in that relative position until the block is again rotated in closing the breech. As a further precaution, the trigger engages the sear only when the mechanism is in the locked position.

The trigger handle is on the right hand side of the piece, and is fixed to a non-recoiling part of the carriage. This handle engages the trigger mechanism only when the gun is "in battery," that is, when counter-recoil is complete. A lanyard may be attached to the trigger if it is desired to stand clear of the carriage in firing; as, for example, on a pavement or hard ground, where it is feared that the trail spade, which is intended to anchor the carriage, may not take hold.

Gun proper.

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 for shrapnel, 6500 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 only longitudinally.

Recoil: hydraulic brake.

The recoil of the gun in the cradle is limited and controlled by means of an hydraulic cylinder and piston. The cylinder lies within the cradle, under the gun; it is a steel tube, about six feet long and a trifle less than three inches in outside diameter. Its rear end is bolted to a lug on the under side of the gun.

The steel piston rod is secured at its forward end to the cradle, and passes through a stuffing box in the front cylinder head. The bronze piston fits easily in the cylinder bore, and has three 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 of the piston head controls the recoil, which is limited to 45."

To check the force of recoil gradually and easily, three longitudinal ribs, or throttling bars, of uniform width but varying height, are formed on the interior walls of the cylinder. These lie in the notches of the piston head, and gradually close them during recoil; thus the resistance to recoil is constantly increased, until the piece is brought to rest.

A diagrammatic representation of these parts is seen in Fig. 1.

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

Springs.

Helical springs, assembled in the cradle around the cylinder, absorb enough of the energy of recoil to return the gun promptly to its firing position. The spring column, consisting of three springs, end to end, is assembled under an initial compression of something over 500 pounds, and will return the piece to battery even at maximum elevation. The motion is very quick; some twenty unaimed shots per minute are possible.

Counter-recoil.

The springs being thus powerful, some means must be provided for checking the *counter-recoil* with the least possible shock, so as not to injure the parts or unnecessarily derange the aim. This is accomplished by fitting a slightly tapered bronze rod, about 18" long, to the inside of the rear cylinder end; this fits, with very slight clearance, into a hole bored axially in the piston rod. As the piece returns to battery, liquid is caught in this cup, and can escape only through the small clearance, thus forming a cushion.

Fig. 2 shows the principle of this device.

Traversing and elevating gear.

The cradle rests upon a platform called the rocker, upon which it is pivotted so as to have a *motion in azimuth* of eight degrees——four degrees on each side of the normal. This rocker is journalled on the axle, about which it may be rotated; it thus forms an intermediate part, connecting the upper carriage, already described, with the lower carriage, which consists of the wheels, axle, trail and *elevating device*; the last named part is a double screw arrangement, the outer screw connected to the trail and the inner screw to the breech end of the rocker. The maximum elevation is 15 degrees; maximum depression, 5 degrees. The height of the axis of the piece above the ground is 41″.

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

Trail spade.

The energy of recoil, though taken up and distributed in the manner described, must of course come ultimately to the lower carriage. To prevent the carriage from being moved out of place, 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; a short trench is often dug to receive it. The ordinary road brake may be used to lock the wheels, and so relieve the pressure on the trail spade.

For the protection of the personnel againt small-arm and shrapnel bullets, a steel shield, 0.2″ thick, is provided. It consists of three plates, apron, main and top shields, which fold together for traveling. When extended, the bottom of the apron is 5″, and the top of the top shield 62″, above the ground. This is sufficient height to afford protection to cannoneers on the trail seats, even against long range or high angle fire.

Shield.

Before acceptance, each plate is tested by firing at it, at a range of 100 yards, with the service rifle and ammunition; the plate must not be penetrated, cracked, broken or materially deformed. Each accepted plate bears the scar of this test, in the form of a slight indentation.

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

Under the axle seats are four steel tubes, each intended to carry one round of ammunition, for emergency use only.

The laying apparatus consists of two instruments, —the sight, mounted on the left side, and the range quadrant, on the right side, of the piece unlimbered. In use, both instruments are fixed to non-recoiling parts of the carriage; when traveling, they are carried in leather-lined, sheet-steel cases, supported upon springs and fixed to the rear face of the main shield.

Laying apparatus.

The *sight* is *telescopic*, of peculiar form. Light entering at the reflect or opening is reflected directly downward through a tube, and then again reflected ninety degrees to the eyepiece. The vertical distance between eyepiece and reflector opening is such that when a man's eye is at the former, the latter is above the top of his

Sights.

head. 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 sight is supported upon a shank, curved to an arc of a circle, fitting into a bracket rivetted to the cradle; by means of this shank, with suitable gearing, proper elevation may be given the sight for different ranges. A cross-level is also provided, to correct for difference in the level of the wheels when in position. A sighting port is, of course, cut in the shield.

An ordinary *peep-sight* is supported upon the same shank; it is used in connection with a front sight on the forward end of the cradle. The distance between front and rear sights is about 37 inches; this, consequently, is the radius used in striking the arc of the rear sight shank.

The height of the line of sight above the ground is, for the peep-sight, 45″ when the gun is at zero elevation. With the telescopic sight, the reflector opening is about 7″ higher.

The most noticeable thing about this telescopic sight 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 constructed 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 sometimes occurred, even with good gunners, through allowances being set off on the wrong side.

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

The "mil."

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 at the next shot will, theoretically, be moved laterally $\frac{1}{1000}$ of the range.

The number of mils in a complete circle is nearly, but not quite, 6400, and the graduation of the sight limb is arranged accordingly. The exact number would evidently be 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 aiming, 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 alone 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.

Quadrant.

The quadrant is a special form of clinometer, and measures vertical angles from the horizontal. The sight measures its vertical angles, not from the horizontal, but from the line joining piece and target. All range tables, necessarily, give sight elevations. In order to use the quadrant, therefore, it is necessary to correct the sight elevation by adding to it or subtracting from it another angle, called the "angle of site",—that is, the angle between the horizontal and the line joining piece and target. The result is what is called the "quadrant elevation" for the range in question, and evidently varies, not only with the range, but also with the difference in level of gun and target.

Fig. 3 shows the different angles mentioned.

This quadrant is so constructed as to give, automatically, this algebraic sum, or "quadrant elevation."

The angle of site is first measured, with the battery commander's telescope or in any other convenient manner, and the clinometer scale of the quadrant is set accordingly. This scale is graduated in mils, and employs the same principle of continuous graduation as the sight limb; the reading when level is not zero, but 300, and the graduation is from 200 to 400. Hence any desired elevation or depression is absolutely designated by its number alone, the number being less than 300 for a target below the gun, and greater for one above; and even the most inexperienced cannoneer could not make the mistake of setting off an elevation when a depression was ordered, or *vice versa.*

The clinometer scale being set for angle of site, the range dial is set for the range. The result of these two operations is that the instrument mechanically combines the two angles,—angle of site and sight elevation,—and that a level borne by the quadrant is set at an angle to the axis of the piece equal to their algebraic sum.

The gun is now elevated or depressed until the level bubble is centered; it is then correctly laid in elevation.

Wheels.

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 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. There is an oil reservoir in the axle, which can be filled without removing the wheel. The breadth of tire is 3″; the track, 60″.

Limber.

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, bases 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 forty rounds with the gun, counting the four under the axle seats.

The rear wall of the chest is hinged to form a door, which opens downward, being held in a horizontal position by chains. This door is corrugated, both to give increased stiffness and to avoid direct contact between it and the primers in the cartridge cases. No springs or cushions are provided to protect the ammunition from jar, as such protection has been found to be unnecessary.

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

Draft system.

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 doubletrees. The harness is the same as before.

Weights.

The gun and carriage complete, with shield and four rounds of ammunition, weigh 2480 pounds; the limber, with all equipment and with full chest, weighs 1612 pounds; thus the total weight behind the gun team is 4092 pounds,—65 pounds more than with the 3.2″ gun. 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 can not be retained if the weight behind the teams is very much over 650 pounds per horse. Six horses is the usual limit for teams intended for quick work; increase beyond this number does not increase the power in the same proportion; hence the the weight for a light field gun should not greatly exceed 3900 pounds. This materiel, it will be noted, approximates fairly well to this requirement.

Caisson.

The weight of the *caisson* is somewhat greater, being 4258 pounds when fully loaded and equipped. An excess, however, is allowable in a caisson which might be objectionable in a gun carriage, as the removal of a very few rounds of ammunition reduces the weight materially. The old caisson was given a still greater excess of weight, weighing, fully packed, 4553 pounds.

The caisson body carries only one chest, but it is much larger than that of the limber, containing 70 rounds of ammunition, packed in five rows of fourteen each. The front of the chest is of armor plate, the same as is used in the gun shield. An apron shield of the same plate is hinged under the axle, so as to be lowered in action and raised when traveling. When lowered, it reaches to within 5.5″ of the ground.

The rear wall of the chest forms the door; it opens upward, swinging 120 degrees, in which position it catches and holds. It is of armor plate, like the shield, but slightly thinner, and is intended to deflect upward any bullets that may clear the chest. Instead of corrugations to form the primer guard, steel T's are rivetted to the inner face of the door; when this is closed, the upright legs of the T's fall between rows of cartridges, and the horizontal legs extend a short distance across the cartridge heads; the cartridges are thus held firmly in place, without contact between door and primer. The T's also give additional stiffness.

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

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

Ammunition Supply.

From the preceding descriptions, it will be seen that the *ammunition with the battery* is, for each gun carriage, 40 rounds,—36 in the limber chest and four under the axle seats: for each caisson, 106,—36 in 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 rounds per gun.

Battery and store wagons.

The *battery wagon and forge* is constructed like a caisson, except that the chests are arranged to carry blacksmith's, carpenter's and saddler's tool kits and materials. The *store wagon* is similar to the battery wagon and forge, but the chests are fitted to carry repair material and spare parts for the battery. Both battery wagon and store wagon carry spare wheels, two each.

The Ordnance Department has been experimenting with a motor car as a battery wagon, but has not as yet adopted it. The experimental car is driven by a four-cycle gasoline engine, and weighs some 8000 pounds, completely packed; it carries complete machinist's, carpenter's, saddler's and farrier's tool kits and supplies, but no spare parts for the battery.

Ammunition.

The ammunition to be carried includes shrapnel and high explosive shell. The issue of cast iron common shell will be discontinued when the present supply is exhausted. The projectiles all have the same weight, 15 pounds, but not the same length; the ammunition chests are so constructed as to hold either length securely. The proportion of shell to be carried has not been definitely fixed; present allowances are $\frac{6}{7}$ shrapnel and $\frac{1}{7}$ shell.

Shrapnel.

Shrapnel is of course the most important projectile. Several models have been and still are in service, but all but one will disappear as soon as the present supply is exhausted.

In the model adopted, the case is of drawn steel, with solid base. The mouth of the case is closed by an aluminum head, screwed in and tapped to take the service combination time and percussion fuze.

The bursting charge is $2\frac{3}{4}$ ounces of loose black powder; it is placed in the base, and covered by a steel diaphragm. The diaphragm supports a steel central tube, which extends forward through the aluminum head to the fuze, and thus affords a conduit for the flames to the bursting charge. At the lower end of the central tube a stopper of dry gun-cotton is fitted, to prevent the loose powder charge from getting into the tube, and also to help the ignition of the bursting charge.

The shrapnel filling is composed of 262 balls, each 0.49″ in diameter and approximately 167 grains in weight. The balls are assembled around the central tube and rest upon the steel diaphragm, the interstices containing a smoke-producing matrix. This matrix serves not only to hold all the parts securely in place, but, on explosion, makes a clearly visible burst and so facilitates observation of fire.

The weakest cross-section is at the line of attachment of the head. Hence, on explosion of the bursting 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 about 250 f. s.

With the service muzzle velocity of 1700 f. s., the remaining velocity of the shrapnel at 6500 yards range is 700 f. s., about the same as the muzzle velocity of the service revolver. If, then, the shrapnel be burst in the air at this range, each bullet will have a resultant velocity of about 950 f. s., enough to make a bullet of this weight effective at 200 or 300 yards.

These results are entirely satisfactory for a projectile to be used 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 can not reach troops in any but the lightest entrenchments.

Shell.

Hence a steel *shell* is issued, holding about two pounds of the service high explosive. This is burst by a detonating percussion fuze. Those heretofore issued carried this fuze in the point; a new design uses a base fuze, and is provided with a base cover to prevent any possible leakage of powder gas into the interior, through the fuze screw threads.

Since this shell, on detonation of the filler, gives from 500 to 600 effective fragments, it has been proposed to use it in place of shrapnel against troops in entrenchments; if burst at the proper point, by means of a time fuze, the fragments would fly in all directions, and search cover in a manner impossible to shrapnel. No definite results of this nature have been obtained, however, and no such projectile is issued.

The explosive used is a secret compound, and combines extreme safety in transportation with extreme certainty and force of action.

Combination fuze.

The *combination time and percussion 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. One half the time train is contained in the disc, the other half in the fuze body; the angle through which the disc is turned determines the amount of train which must burn before the flame reaches the bursting charge. After an old model fuze was once set, it could not be used at a longer range, while the new model can be set and reset repeatedly. Thus a battery may, if desired, go into action with all 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, with normal fuzes, to the normal height of burst, $\frac{3}{1000}$ of the range. The two scales being set as directed, the cannoneer has only to insert the point of the projectile, containing the fuze, into the instrument, and turn it as far as it will go. The fuze is then set so as to burn the requisite number of seconds before exploding.

Fuze-setter.

If the corrector were set at zero, this number of seconds would be equal to the full time of flight for the range set on the range scale, and, theoretically, the time and percussion elements of the fuze would act at the same instant. Setting the corrector at any number above zero changes the relative position of the parts in such a way that the time setting of the fuze will be less than the time of flight; that is, the higher the corrector setting the shorter the burning time of the fuze, and consequently the higher the burst.

The propelling charge is about 24 ounces of smokeless powder, nitro-cellulose; the exact amount varies with the lots of powder, being adjusted so as to give the standard muzzle velocity of 1700 f. s. To ignite this charge completely and uniformly, two black powder igniters are used, each of 110 grains weight. One is placed in the primer, the other at the front of the charge.

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

A very important accessory of the battery is the *battery commander's telescope.* This is an instrument somewhat similar to the panorama sight, but larger and more powerful, and mounted on a tripod. It is capable of measuring both horizontal and vertical angles, and its graduation corresponds to that of the sight. By its aid, the battery commander determines deflection allowances and measures angles of site; it may also be used to observe the fire, or, if a little time is available, as a range finder. For quicker and rougher measurement of angles a short rule is issued, provided with a cord by means of which it can be held at a fixed distance from the eye, and graduated in mils.

Telescope.

The gun just described is the first to be completed of a *series of mobile artillery* which is contemplated by the Ordnance Department. The series as planned includes the following:

Other guns, U. S. A.

1.—Mountain artillery materiel.
2.—Horse artillery materiel.
3.—Light field materiel.
4.—Heavy field materiel.
5.—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 entrenchments or the accidents of the terrain that higher angles of departure or fall become necessary.

To provide for both cases, there must be two types of weapon, the long gun for flat trajectory and

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 calibers 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 just 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 has a recoil on the carriage of 14″; the recoil and counter-recoil mechanism are on the same principle as described above, although different in detail. The wheels are 36″ in diameter; the track is 32″. In firing, the wheels may be attached to the trail by ropes to prevent their revolving; this arrangement, together with a trail spade, reduces, but does not entirely prevent, recoil on the ground. The shrapnel weighs 12½ pounds; the muzzle velocity is 920 f. s.; maximum range, about 4000 yards. Four pack mules are required for each piece, one carrying the gun, one the cradle with attachments, one the trail with attachments, and one the wheels and axle. Additional mules carry ammunition, twelve rounds each. All loads approximate 200 pounds. This is a very useful and, in general, satisfactory gun; it is proposed to retain the type, but perhaps increase the caliber to a full 3″, and give the piece a longer recoil on the carriage, in order to secure more stability in firing.

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 suggested by some that there is not sufficient difference in mobility between horse and field batteries. It is thought desirable to keep the weight behind horse artillery teams down to 3000 pounds.

The Ordnance Department has been studying the question of a smaller caliber gun, but it does not now seem probable that such a weapon will 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 is deemed necessary to retain the shrapnel, and this is considered the smallest caliber that can employ that projectile effectively.

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 this 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 a light field gun may here be sacrificed to secure high power, as these heavy guns would not be expected, ordinarily, to accompany quickly moving columns, and need be capable of rapid movements only for short distances. It is considered desirable, however, that they be not too heavy to be handled by six horses, 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. This piece corresponds to the old 3.6″ twenty-pounder gun, but is heavier and more powerful. The corresponding howitzer will be of 4.7″ caliber, and carry a sixty pound projectile.

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 may be allowed; on this weight a 4.7″ sixty-pounder gun, and a 6″ 120-pounder howitzer have been constructed, and are now undergoing proof. The corresponding old guns were the 5″, 45-pounder rifle, and the 7″, 105-pounder howitzer.

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

Organization.

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 platoon, the first and second being composed of gun sections, the third and fourth of caisson sections. A supernumerary or ninth 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 one caisson section, the fifth.

The thing that first strikes the attention of the 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 fifth section is on each flank of the battery. All these caissons are unlimbered, and all limbers are placed under cover, preferably on a flank.

Service of piece.

The gun is served by a squad of six men,—the gunner, who is a corporal, and five privates. The gunner sits on the left trail seat; he has 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 in rear of the gunner; he moves the trail as directed, so as to give the approximate direction, and loads the piece.

The remaining cannoneers are posted behind the caisson body; No. 4 operates the fuze-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 can not.

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

Indirect fire.

Such fire may be delivered from any position, provided a place can be found for the battery commander's station, from which both guns and target are visible; or even, sometimes, when no such place is available, if an auxiliary observer can be stationed so as to observe the fall of the shots and telephone or signal the results to the battery. It is only necessary to take care that, if any high obstacle intervene between battery and target, the position be far enough removed from it to cause the trajectory to clear it.

The battery commander's station is preferably on a flank of the line of guns, approximately in prolongation of it, and near enough to allow the battery commander to keep in touch with both guns and station. If necessary, a buzzer line is laid.

The position of the station having been selected, the chief of the third platoon and the chief of his right section (the fifth) take post there, and set up and adjust the telescope. The battery commander meanwhile notes the distance from the station to his right gun, which is the directing gun of the battery, and makes his first estimate of the range to the target; the Weldon range finder is issued as an aid in this.

Since the gunners can not see the target, an auxiliary point is next selected, upon which they may aim, after setting off the proper deflection on the sights. The object chosen should be distinct and unmistakeable; something tall and slender, as a flagstaff or church spire, is best. It should preferably be a mile or more distant, the farther the better; this reduces its angular breadth, so minimizing the error which may result from aiming at different parts of the object, gives more convenient numbers for use in the calculations of deflection, and minimizes the effect of inaccuracy in estimating the range of the point,—for this range, as well as that to the target, is noted and used in the calculation.

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

General solution of problem.

The determination of this angle requires that three other angles be known. These are, (1) the angle at the battery commander's station between the aiming point and the target (marked B in Figure 4), (2) the angle at the target between the directing gun and the battery commander's station (marked T); and (3) the angle at the aiming point between the directing gun and the battery commander's station (marked P).

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

The other two angles can not be directly 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 battery commander's station.

It has already been explained that one mil is the equivalent of a lateral displacement equal to $\frac{1}{1000}$ of the range. Therefore, the range being known, the value of a mil in linear measure is obtained by simply pointing off three places. Dividing this value into the distance between the directing gun and the battery commander's 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 Figure 4, it will be noted that the required deflection is the angle marked G. In the two triangles BPX and GTX, the angles at X are evidently equal. Hence B plus P equals G plus T, or G equals B plus P minus T.

This, of course, is merely an outline of the principles upon which the solution depends. In practice, various simple expedients are adopted for facilitating the calculations, which may be very quickly made in the note book, or in many cases mentally. The algebraic signs of all the elements must be kept carefully in mind; for example, if the aiming point is in rear of the line of guns, as is usually the the case, the value of P is given the negative sign.

Obliquity corrections.

If the direction of the aiming point is very far from the normal to the battery front, a correction must be applied to these results, since the measurement of an angle in mils is accurate only when the successive lateral displacements are laid off as 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 battery commander's station, by the trigonometric sine of the angle between the battery front and the line from telescope to aiming point, and using this "virtual distance" in place of the true one. A similar correction is necessary if the battery commander's station is very much in front or rear of the line of guns, or if the battery front is very oblique to the line of fire; in practice, however, these last corrections are seldom necessary. In applying corrections, use may be made of correction tables, which are often carried in complete form. A brief table, giving only a few values, is engraved on the back of the battery commander's rule, mentioned above; another plan is to have a table showing the angles, in mils, corresponding to the natural sines, 0.1, 0.2, etc., which, being very brief, may easily 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 the battery commander's 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 usually done at leisure, before the enemy can have any knowledge of the position or even 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 observation and ranging; and if it can accomplish this, the time is well spent, since after the first shot the enemy has his warning. If there is need of haste, the process can be abbreviated as much as desired, by sacrificing some of its accuracy.

Another method, found in the French regulations, for getting the deflection, is to turn the telescope first on the gun-sight, then on the target, and read the angle; compute, as before, the angle at the target between the gun and telescope, making any necessary corrections for obliquity; 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, by the amount of the angle computed. Then use the telescope itself as an aiming point, or transfer the reading to any other point that may be convenient, reading the angular difference by the sight itself.

The angle of site has next to be measured. Since the gunner cannot, in general, see the target, this can not be done directly, but the angle of site at the battery commander's station can be measured with the telescope and corrected for difference of level between gun and station. This angle is needed in order that the clinometer of the range quadrant may be set.

Angle of site.

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 is called "individual distribution", and consists simply in assigning to each gunner a separate part of the target upon which to aim.

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 principal 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

Ranging.

upon circumstances, such as the nature of the target, the *facility of observing* the fire, and the available supply of ammunition.

In ranging, either shell, time shrapnel or percussion shrapnel may be used; usually, that projectile and fuze are adopted which are intended to be used in the subsequent fire for effect. When time shrapnel is used, the first bursts are frequently made a little lower than the normal, to facilitate observation.

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 the 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 especially in the 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 that 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.

Fire for effect may be either continuous or by volley. Fire at will is also used 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 beordered.

A volley, or, as the French regulations term it, a "rafale," consists of a specified number of rounds, usually not exceeding 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 effect of the fire can be observed. If this be impossible, or if the target be a deep one, "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 steps of from 50 to 100 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 about 100 yards, using time shrapnel. Using percussion shell the zone is naturally much narrower, being only about 25 yards.

If it is desired to cover a broader zone, the sheaf of fire may be shifted laterally after each volley or series of volleys. This is the usual plan in our service. In the French service, "sweeping fire" is used; that is, a deflection difference is announced which will cause the lines of fire to diverge, and each piece is then traversed, right or left as directed, a few mils after each shot of the same volley.

Both progressive and sweeping fire may 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 shrapnel 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. It is, as a rule, replaced from the caissons of the fifth section, one of which is unlimbered 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.

Ammunition service.

If necessary, the caissons of the gun sections draw ammunition from their own limbers and those of the guns. This, however, is done only in case of necessity, as the ammunition in these limbers, 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 gun.

Foreign guns.

Some chose an intermediate type, having "accelerated fire,"—so called for lack of a better term,—which was often constructed by modifications in old materiel. Of this class is the field gun used by *Japan* in the late war. This is not to say that all the excellent Japanese artillery work was done with this gun, for many modern heavy guns were also employed by them; but it was the standard and predominant weapon, and a brief description of it may be of interest.

Japan.

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; the maximum range for shrapnel is 5000 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; the block, which contains the percussion firing mechanism, opens downward.

The gun is rigidly mounted on its 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 under side, 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 its original position, it must be relaid for each shot. The rate of fire is given as seven shots per minute.

The carriage has no shield. 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 "accelerated fire" guns; it is, however, a type that has now almost disappeared, and is mentioned here only on account of its performances in the late war.

Russia.

The Russian guns opposed to this were of several types. The one that appears to have predominated was a 3″, 13½ pounder; it had recoil on the carriage, checked by hydraulic buffers and by rubber pads, which latter also served to return it to battery. The carriage jumped more or less on firing, the sights recoiled with the gun, and there was no shield. Although superior to the Japanese armament, this was not satisfactory; a new gun, known as Model 1902, was adopted, and later further improved as Model 1903, but it is doubtful if many of these had been put in service before the end of the war.

The 1903 gun is of nickel steel; the caliber is 3″ and length 30 calibers; the projectile weighs a trifle under fifteen pounds. The breech mechanism is of the single motion, slotted screw type.

The piece recoils 40″ on the carriage, its motion being controlled by an hydraulic brake; return to battery is by springs. The carriage is mounted on 53″ wheels and provided with a shield.

The traversing device differs radically from our own; instead of the gun being pivotted on the lower carriage, the entire carriage may be slid along the axle, pivotting on the end of the trail. By this arrangement, the force of recoil is always in line with the trail, not, as with us, often at an angle with it; but a great deal of lateral motion is necessary in order to give a small change in direction, since the radius of rotation is so long.

The elevating gear is a double screw of novel design.

Panoramic sights were not adopted for the 1902 gun, but have been introduced in this newer model.

Fixed ammunition is used; both shrapnel and high explosive shell are carried. Gun limbers hold 36 rounds, caissons 96. The muzzle velocity is higher than that of any other field gun,—1930 f. s. This high velocity has its advantages, but also its disadvantages.

The weight behind the team, limber filled, is given as about 4200 pounds.

Russian batteries have a peculiar organization, not now in use in any other country. Each one has 8 guns and 16 caissons, is divided into two half-batteries commanded by captains, and is itself commanded by a lieutenant colonel. The ammunition supply is 1824 rounds, or 228 per gun.

Germany.

Germany clung to the "accelerated fire" gun longer than any other first class power; and even now, when re-armament with new guns is in progress, German ideas do not seem to incline to very radical changes in the handling of them.

The gun now being withdrawn from service, Model 1896, was a steel 15-pounder, caliber 77mm., or a little over 3", length 27.3 calibers; the ammunition was only semi-fixed. The gun and ammunition are retained, but the breech mechanism and carriage are new.

The gun trunnions have been removed, clips added, to slide on the cradle guides, and an attachment at the breech end provided to connect the gun and the recoil buffer.

The breech mechanism is of the Ehrhardt single motion pattern; instead of a screw block, a wedge is used, sliding laterally in a recess cut through the breech end of the gun. The firing handle is on the piece itself, not on a non-recoiling part of the carrige, and so is pulled out of the firer's hand by the recoil.

The recoil arrangements are on the same principle as our own; the length of recoil is 44″. Elevating and traversing gears also are similar to ours, but there appears to be no lock for them when traveling.

Model '96 wheels, 53.3″ in diameter, are retained. The height of the axis of the piece is 40.″ The shield is in three parts, something like ours.

In the matter of laying apparatus, the Germans have been very conservative. Panorama sights are looked upon as complicated contrivances, not reliable for service. Even ordinary telescopic sights seem to be regarded with suspicion. A set of instruments has been devised, and apparently officially adopted, which includes a telescopic sight on the left of the gun, and a separate appliance, not telescopic, on the right, for giving direction in indirect laying. But even this equipment has not won the unanimous approval of artillery officers, many of whom, at least, still adhere to open sights. Direct fire is favored; and indirect fire, when used, is often managed by some of the older methods.

The muzzle velocity is low,—1525 f. s. As already stated, the ammunition is only semi-fixed; it includes both shrapnel and high explosive shell. Each gun limber carries 36 rounds, each caisson 88. The weight of the gun, with limber filled, is about 4175 pounds.

A battery is now composed of 6 guns and 6 caissons; 3 caissons are to be added. Some high authorities, including General Rohne, are strongly in favor of a four-gun battery, but apparently no change is to be made at present. To each six batteries is allowed a light ammunition column of 21 caissons, 12 carrying shrapnel and 9 shell.

After the increase in number of caissons, the battery will carry 1008 rounds, or 168 per piece. The light column has 1848 rounds more, making a total of 219 per gun.

France.

The French gun about which so much has been written, is somewhat different from any of those above described. The essential distinction is in the recoil device, and, specifically, in the means adopted for returning the piece to battery after firing.

This part of the carriage consists of three cylinders; two contain liquid, the third, air under a compression of 12 atmospheres. When the gun is fired, the hydraulic cylinders act as already described to check the recoil at about 42″; but the return is accomplished by the pneumatic cylinder, the air contained therein being still further compressed by the motion of recoil.

The weakness of this system is evidently the multiplication of stuffing boxes and valves, with consequent danger of leakage of oil or air. If the air pressure, from either of these causes, becomes reduced, the gun does not return completely to battery. If it comes within 8 cm. of its true position, firing is safe; if it does not, it is necessary to bring up the pressure again. Marks are placed on the gun and buffer, to show whether or not return is complete.

The French claim that no serious difficulty is experienced with this mechanism, and even insist that it is superior to the spring column; but it should be said that in 1897, when this gun was adopted, the spring system was far from its present efficiency, it having been a matter of much time and labor to produce suitable springs. Incidentally, the report may be mentioned that the hydro-pneumatic feature is to be abandoned in a new gun projected for horse artillery. This gun, it is said, will be uniform in caliber with the present field gun, but lighter in weight.

The present gun is of nickel steel, caliber 75 mm., or 2.95″, length 35 calibers, weight of projectile nearly 16 pounds. The breech mechanism is the Deport eccentric screw. The breech block is cylindrical, some 6″ in diameter; on one side of the axis it is cut out so as to leave a hole the size of the bore of the gun. This block is placed with its axis parallel to that of the gun, but lower, and so secured that it is capable of rotation only. When it is turned so that the cut-out side is up, the breech is open, for loading or ejection of an empty cartridge case; when it is turned 180 degrees, the breech is closed and the firing pin is opposite the primer.

The elevating system consists of two independent parts. One moves the gun and its recoil-controlling attachments with reference to the upper part of the carriage, and is controlled by a crank on the right side of the piece; the other moves the whole upper carriage, to which is attached the sighting apparatus, and is operated by a hand wheel on the left side. The elevation corresponding to the range is given by the firing number, on the right. When indirect laying is resorted to, a level on the left side is set by the laying number to the angle of site, and the bubble centered by means of the hand wheel.

To lay in direction, an instrument called the "collimator" is used. This has not the advantage of including a telescope, but it does away with the front sight, using instead an optical line of sight contained in the instrument itself. The collimator is mounted on the left side of the carriage, 46″ from the ground; it is capable of being turned about a vertical axis, and has a limb graduated in mils.

The piece traverses on the axle, like the Russian gun; the limits of traverse are about 50 mils on each side of the normal. The traversing hand wheel is on the left side.

There are two separate shields, one on each side of the gun, the space at the top, between them, being unprotected. Ammunition is fixed, and includes shrapnel and high explosive shell. The weight behind the team is about 4100 pounds. The muzzle velocity is 1650 f. s.

A battery has four guns and twelve caissons. Since limbers carry 24 rounds each, and caisson bodies 72, the ammunition with the battery is 1248 rounds, or 312 per gun. Chests constructed for shrapnel will not carry shell; hence two caisson bodies per battery are fitted for the latter, making 144 shell with the battery.

England.

Since the Boer War, *the English* have insisted upon high power for field guns. They experimented with 12- and 15- pounders from Armstrong, Maxim and Ehrhardt, but have now adopted a 3.3″, 18½- pounder for field, and a 3″, 12½- pounder for horse batteries. The ammunition is fixed, and the muzzle velocity 1610 f. s. for the 3.3″ gun, 1658 for the 3″. Gun limbers hold 24 rounds, caisson limbers and bodies 38 each. The weights behind the teams are 4350 and 3400 pounds. There are no peculiarities of construction requiring mention here.

The English battery has six guns, and is commanded by a major.

Most of the other armies now have guns approximating more or less closely to some of the types described. In some quarters a tendency is perceptible to go farther, and adopt some kind of automatic breech mechanism. This may perhaps come in time, but as yet there is no indication of its being generally adopted.

Technical open questions.

The best method of handling the new materiel is still an open question, calling forth voluminous discussions in the technical periodicals, and giving rise to tests and experiments of various kinds. The points in dispute are not tactical only, but some are connected with 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 thoroughly masked positions, not only as the habitual, but almost as the exclusive, practice, whenever it is at all practicable. Such a position, even when behind a hill, does not give actual protection, as is sometimes 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 effectual concealment, and a battery completely masked is very difficult indeed to locate.

In the matter of ranging, they have taken a bold step. The principle upon which they work is 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 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 conductive 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 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 seen, 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 more *rafales*; after which, interrupt the fire until a new target appears, or until 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 careful preparation of the fire contributes much to shorten the ranging period, which is the critical time for 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 go even 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 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 application 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 steady, continuous 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 provisional, and what their final form may be is not certain. But the French model, rather than the German, will be followed, probably modified in some of the more radical points. From what has already been done, it appears probable that indirect 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 seem inadequate.

The "pom-pom".

Another weapon, somewhat allied to the field gun, should properly be mentioned here. This is the "pom-pom", or "machine gun of caliber", whose fire effect is intermediate between that of infantry and of artillery.

By "machine gun of caliber" is meant a machine gun sufficiently large to throw an explosive shell. Since 1868, fourteen ounces is, by international agreement, the minimum weight for an explosive projectile.

The earlier weapons of this class were made with several barrels, and operated by means of a crank, as in the familiar Gatling gun. Of this construction was the Hotchkiss revolving cannon, formerly used in our service. This had five barrels, caliber 1. 5", and fired 1-pound shells at the rate of 80 per minute.

The gun generally known as the "pom-pom" bears the same relation to this revolving cannon that our present machine gun does to the Gatling. The best known model is the Maxim, of 37 mm. or 1.46" caliber, throwing a 1-pound shell with 1800 f. s. muzzle velocity. Its first use in the field was by the Boers in the late war.

They had, as nearly as can be determined, nine pieces in all 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 was a great difference of opinion; some rated it very high, others very low. One German officer, who served with the Boers, writes:

"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 can not 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, especially mounted troops, in the open. The English found no answer to it, except other guns of the same type.

It is probable, however, that such results against cavalry as mentioned above, could in most cases be obtained equally well with rifle caliber machine guns. And it is not believed that the artillery fight described could be duplicated against 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.

So, in spite of good reports such as the one just quoted, the value of this weapon for general use is doubtful. It is too weak to engage field guns, and has more power than necessary to engage rifles. This characteristic has been recognized from the outset, as is shown by the following quotation from "The Engineer," of London, May 11, 1900:

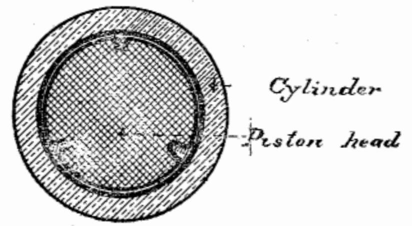
"It is impossible to dispute the fact that except on abnormally hard ground or in rocky defiles, one to three-pounder explosive shells, which burst only on impact, have their man-killing properties confined to a very restricted area. Owing to its size the projectile can be used solely as a locomotive mine—that is to say, it is impossible to adapt it to shrapnel, and its efficiency, therefore, depends entirely upon the shattering and scattering of the metal walls. These fragments, again, are comparatively few in number, and the small bursting charge limits the distance at which they can take effect. Striking a hard bursting screen this small shell may possibly cause casualities among two or three men in the immediate vicinity, but plunging into earth the burst can hardly be more dangerous than that of a powerful squib. Of course, if the projectile actually strikes a man it will almost blow him to pieces; but the damage ends with the man so struck; while, as the aim in warfare is to put the enemy out of action, not necessarily to kill him, this is accomplished equally well and far more economically with a projectile of small-arm caliber. It is more than doubtful, therefore, whether the great rate of fire—in the case of the 37mm. Maxim 300 shots per minute—can compensate for any or all of these drawbacks in the aggregate. Lastly, there is the moral effect of the weapon to be considered; but this cannot be taken as an enduring asset, for men will soon discover that the bark is far worse than the bite, and act accordingly. In short, machine guns of caliber, so long as they are restricted to such small explosive shells, are only repeating on a far more expensive and troublesome scale the action of machine guns of rifle caliber, over which also they appear to possess but little superiority in range."

Having introduced these guns to meet the special requirements of the Boer War, the English have retained them; but they do not seem at all sure how to use them. At present they assign one to each cavalry regiment and mounted infantry battalion, forming in each such unit a machine gun platoon armed with this gun and one rifle caliber machine gun. But they say little about the effect they expect from the pom-pom; the explanations most commonly seen for its retention are, that it makes a good range finder for rifle caliber machine guns, because the bursts are so clearly visible; and that it is a first rate thing for frightening horses.

No other army has yet incorporated the pom-pom into its permanent organization. It may yet make its place as a recognized arm, as its elder brother, the rifle caliber machine gun, has done; but so far its utility appears limited.

Fig. 1.

Transverse section Piston head



Longitudinal section throttling bar.

Fig. 2.

Longitudinal section counter recoil buffer

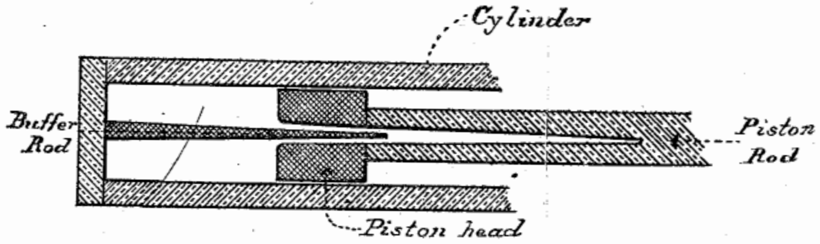


Fig. 3.

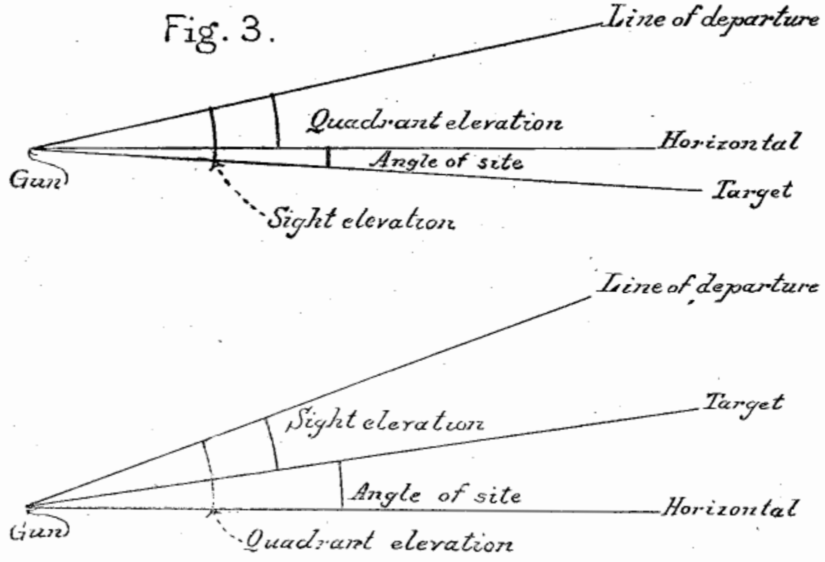


Fig. 4.