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TREATISE
ON
CARDED
MILITARY SMALL ARMS
AND
AMMUNITION,
WITH
THEORY OF THE MOTION OF A RIFLE BULLET.
A TEXT-BOOK FOR THE ARMY.

*Compiled at the School of Musketry, with the assistance of the
Superintendents, Royal Laboratory, Royal Small Arms Factory,
Royal Gunpowder Factory.*

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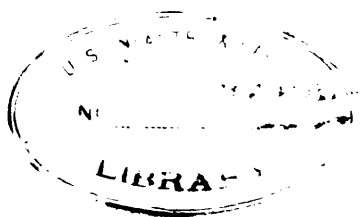
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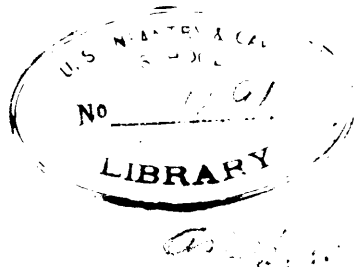
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P R E F A C E

THE necessity for a reprint of the Treatise on Military Small Arms and Ammunition, compiled by Colonel Bond, R.A., which has been used as a Text Book at the School of Musketry, offered the opportunity for revision.

While adhering to the general plan, which has been found clear and convenient, of Colonel Bond's book, an effort has been made to bring the reprint as nearly as possible up to date, and to make it more useful both as a Text Book for Hythe and as a book of general reference.

With this object in view, much of the matter in Colonel Bond's compilation has been omitted, and much re-arranged, while necessary and useful information on technical points, and on subjects of latest interest, has been collected from reliable sources and included.

SCHOOL OF MUSKETRY,

November, 1888.

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CHAPTER I.

DEFINITION OF TERMS AND EXPRESSIONS USED IN CONNECTION WITH SMALL ARMS, AND THE MOTION OF A RIFLE BULLET.

BEFORE entering upon the investigation of the theory of the motion of projectiles, it is necessary to understand the meaning of the several terms and expressions made use of in explaining the various subjects which will fall under consideration.

Definitions.

Matter.—The substance of which bodies are composed. Matter Matter, is of four kinds, three of which have weight. First, *solid*; second, *liquid*; third, *gaseous*, or *aeriform*; fourth, *imponderable*, or destitute of weight.

Body.—Any definite portion of *matter* of which the existence Body. can be perceived by our senses, or which may act or be acted upon by other bodies.

Particle.—An atom, or portion of matter so minute as to admit Particle. of no division.

Mass.—The *quantity of matter* in any body, the sum of all the Mass. particles of a body; it is proportional to the weight, whatever be the figure, or whether the bulk or magnitude be great or small, for the weight is equal to the mass multiplied by the force of gravity, or $W = Mg$, and the letters M and W are usually employed to denote the *Mass* and *Weight* respectively.

Cohesion.—The force which holds together the particles of Cohesion. bodies; it acts only between particles of the same kind, and at insensible distances. Without cohesion all substances would be in the form of small dust.

Volume or Bulk.—The space a body occupies.

Volume or
bulk.

Figure.—The form or shape of a body: thus, a globe and Figure. cylinder may have the same volume, but have entirely different figures.

A Concentric Body.—A body whose centre of gravity and centre of figure coincide.

An Eccentric Body.—A body whose centre of gravity and centre of figure do not coincide.

Density.—The closeness of the particles of any body; or the quantity of matter in any given bulk.

Hardness.—The quality of being firm, compact, difficult to divide, not yielding to pressure.

Elasticity.—An inherent property in bodies by which they recover, or partially so, their former figure or state after the removal of external pressure, tension, or distortion. Perfect elasticity and perfect non-elasticity do not exist.

Centre of Gravity.—The point in which the weight of the body centres, on which point, if supported, the whole body would balance in any position.

Specific Gravity.—The weight of one body compared with that of another of equal bulk taken as a standard. Gases are referred to common air; other matter to pure distilled water at 60° temperature.

Friction.—The resistance which a body meets with from the surface on which it moves. This is due to the roughness or want of smoothness of the surfaces. It is a retarding force. Perfect smoothness can never be attained in practice.

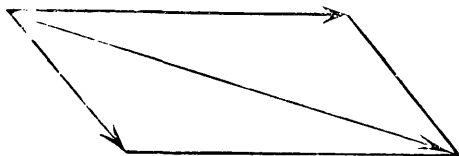
Inertia.—A term which denotes the resistance of a body at rest to being put in motion, or, if in motion, to any change in the direction or amount of its motion (*see 1st Law of Motion*); the amount of such resistance depends on the nature of the motion, or the obstacles to be overcome, such as friction, force of gravity, &c.

Motion.—The opposite to rest; the passing of a body from one place to another.

Laws of Motion.—Three in number:—

- 1st. Every body continues in its state of rest or of uniform motion in a straight line until a change is effected in it by the agency of some external force.
- 2nd. When any force acts upon a body in motion, the change of motion which it produces is in the direction and proportional to the magnitude of that force.*

* By the direction of a force is to be understood the line in which it tends to produce motion. The two motions are *compounded* with one another. If two sides of any parallelogram meeting in a point represent the magnitude and direction of two forces, the magnitude and direction of their resultant is represented by the diagonal passing through that point.



3rd. Action must always be equal and contrary to reaction, so that in the case of one body impinging upon another, whatever momentum is lost by one is gained by the other, the sum of their momenta remaining unaltered.

Force.—Any power which moves or stops, or tends to move or stop a body. It is measured by weight, *e.g.*, forces which will bend a spring into the same positions as weights of 1 lb., 2 lb., 3 lb., &c., are called respectively forces of 1 lb., 2 lb., and 3 lb. Force.

Gravitation.—That force or universal law by which all bodies and particles of matter are *attracted* towards each other. Gravitation.

Terrestrial Gravitation.—The force attracting every body in a straight line towards the centre of the earth. Air gravitates towards the earth's centre with such a pressure that at the level of the sea the barometer standing at 30", its weight is $14\frac{3}{4}$ lbs. on the square inch. In vacuo everything falls to the earth at the same rate, but not so in nature. Things lighter than air, in consequence of the pressure of the atmosphere, ascend until they reach the strata of air of the same density as themselves; things heavier than the air descend at rates in proportion to their surfaces and densities; this is caused by the air's resistance. In vacuo, everything in the latitude of London* falls nearly $16\frac{1}{2}$ feet in the *first* second, and it has been found by experiment that the fall increases according to the square of the time the body is exposed to the influence of gravitation. Gravity is thus an accelerating force, and at the end of the second second will have caused the body to have fallen *four* spaces of 16 feet (omitting fractions) or 64 feet, and so on. In dropping a bullet from a considerable height, we find that during the first second of descent it acquires a velocity of 32 feet per second. Its velocity at the commencement was 0, for it began to move from a state of rest; at every one of the instants into which we may conceive a second of time to be divided, it acquired more and more velocity until it attained the final velocity of 32 feet in a second. All these acquisitions of speed are equal in equal times, because the force of gravity is constant, and therefore exerts equal influences in equal times, or, in other words is a *uniformly accelerating force*, and such a force is measured by the velocity acquired from *rest* at the end of one second, or, which is the same thing, by *twice* the *space* described from rest in one second. Had the bullet descended during the whole second at the final velocity of 32 feet per second, it would have passed through 32 feet of space. Had it retained its initial velocity, which was nothing, it would have descended through 0 feet; but as the velocity began with 0 and ended with 32, its *mean* velocity or average throughout the second was 16 feet per second, and therefore the bullet descends in the first second through a space of 16 feet. During the second second, the bullet starting with a velocity of 32, acquires an additional velocity of 32, and therefore ends with a velocity of 64 feet a second, the average being 48 feet per second, and therefore the descent is 48 feet in height; adding this to the space descended during the first second, 16 feet, we find that in Terrestrial gravitation or attraction, commonly known as the force of gravity.

* Gravity varies with latitude.

first two seconds the total descent is 64 feet, and so on. The velocities acquired in descending from rest are in exact proportion to the times of descent, and the *spaces descended are proportional to the squares of the times*, and therefore to the *squares of the velocities*. The times being as the velocities, and the spaces as the squares of either

If the times are as the numbers 1 . 2 . 3 . 4 . 5 .

The velocities will be as .. 1 . 2 . 3 . 4 . 5 .

And the *total spaces* as the *squares*

of those numbers, or as .. 1 . 4 . 9 . 16 . 25 .

And the space for each second as 1 . 3 . 5 . 7 . 9 .

or the series of odd numbers, which are the differences of the squares, denoting the whole spaces; so then actually,

The times being .. 1 . 2 . 3 . 4 seconds

The velocity will be .. 32 . 64 . 96 . 128 feet per second,
that is, the time multiplied by 32, or $v = gt$, where v is the velocity acquired in a time, t .

The spaces fallen in the whole

times 16 . 64 . 144 . 256 feet

The spaces in *each* successive

second 16 . 48 . 80 . 112 ,,

of which latter spaces the *common* difference is 32 feet, the *natural and obvious measure of the force of gravity*; this force is usually denoted by the letter g .

In each of 1 . 2 . 3 . 4 . 5 seconds,

A body falls through .. 1 . 3 . 5 . 7 . 9 $\left\{ \begin{array}{l} \text{spaces of 16} \\ \text{feet each;} \end{array} \right.$

total number of spaces = 25, or 5^2 , the *square of the time* (5 seconds); or $s = 16 \times t^2$, where s is the whole space described in a time, t ; but $g = 32$, therefore $s = \frac{1}{2} gt^2$. This is under the influence of the accelerating force of *gravity*; if f represent the amount of any other uniformly accelerating force, then we have $s = \frac{1}{2} f t^2$; and $v = f t$.

These rules apply in vacuo. The resistance of the air materially retards velocities; if it did not, every raindrop, descending, as it does, from a height of several hundred feet, would strike with a force as great as a rifle bullet.

Velocity.	The degree of rapidity with which a body moves is called its velocity. In this country the velocity of a bullet is estimated by the number of feet through which it would move in a second, and the muzzle velocity of the Martini-Henry bullet is spoken of as 1315 f.s., meaning that if it continued moving with this velocity it would pass through 1315 feet in a second.
Uniform and variable velocity.	The velocity of a body may be either <i>uniform</i> or <i>variable</i> . It is uniform when it describes equal distances in equal times, and is variable when equal distances are not described in equal times. The speed of a bullet is an <i>example</i> of variable velocity, since it is constantly losing velocity from the time it leaves the muzzle of the rifle until it strikes.
Uniform velocity, how measured.	Uniform velocity is measured by the number of units of length passed over in a unit of time. Thus, suppose a body moving with a uniform velocity to pass over 100 feet in 4 seconds, its velocity is $\frac{100}{4} = 25$ feet per second.
Variable velocity, how measured.	Variable velocity is measured by the number of units of length which would be described in a unit of time if at that moment the velocity were to cease to vary. Thus, the velocity of a bullet at any point is said to be 1000 feet per second, not meaning that it passed through 1000 feet the second before or the second after it passed this point, but that if it continued with the velocity it had at that instant, it would go through 1000 feet in one second.
Accelerated and retarded velocity.	When the velocity increases it is said to be accelerated; and when it diminishes it is said to be retarded.
Muzzle velocity.	Again, accelerated or retarded velocities may be either uniformly or variably accelerated or retarded. Muzzle velocity is the velocity with which the bullet leaves the muzzle of the barrel from which it is fired. It depends on the nature and amount of the powder charge, the quality of the powder, the weight of the bullet, and the amount of friction the bullet has to overcome when passing through the barrel, the length of the barrel, &c.
Remaining velocity.	Remaining velocity is the velocity of a bullet at any given point in its trajectory.
Striking velocity.	Striking velocity is the velocity of the bullet on impact.
Final velocity.	The velocity of the bullet at the end of any given range.
Terminal velocity.	The velocity attainable by falling bodies, which they cannot exceed on account of the resistance of the air becoming equal to the force of gravity. From this point, if the air were equally dense, the body would fall at a uniform rate. The terminal velocity of the old musket ball is said to be about 213 feet per second.
Grooves.	Grooves are spiral furrows cut in the surface of the bore, with the object of imparting a rotatory motion to the bullet as it passes from breech to muzzle.
Grooves of progressive depth.	Grooves are said to be of progressive depth when they increase or diminish in depth from breech to muzzle. With the Snider and Martini-Henry the grooves are deeper at the breech than at

the muzzle, the object being to ease the bullet at first and ensure its being gripped tightly on leaving the bore.

Lands are the portions of the surface of the bore left between the grooves; or, as in the Henry system of rifling, any portions of the original bore left by the cutter in rifling. Lands.

Rifling is the name given to the spiral grooves cut in the inside of the barrel of a firearm in order to give rotation to the bullet round that axis which coincides with the axis of the bore before the rifle is fired. Rifling.

The calibre is the diameter of the bore, and in the case of a rifle it is measured across the lands. Calibre.

When the diameter of the bore of a rifle is less than 0.5 inch, it is usually described as a "small bore." Small bore.

Windage is the difference between the sectional area of the bore of the gun and that of the projectile. It is measured practically by the actual linear difference between the diameter of the bore and the diameter of the bullet. With muzzle-loading smooth-bore small arms the windage was the cause of great inaccuracy in shooting, but with rifles there is no windage, as on discharge the bullet is set up or expanded and completely fills the bore and grooves. Windage.

A bullet is said to strip when it is driven out of the bore across the lands without following the grooves of the rifle; this seldom occurs in modern rifles. Stripping.

When a charge of gunpowder is ignited in a rifle barrel a certain amount of residue will be found adhering to the surface of the bore and clogging the grooves of the rifling. This residue is called fouling, and if it is deposited to any considerable amount good shooting with the barrel is impossible. With match rifles, when the bore was wiped out after every round, the fouling of the barrel was of no great importance; but with military rifles an efficient wad must be used to remove the fouling left by the previous round. Badly made gunpowder, or gunpowder which has been injured by damp, causes much fouling. The deeper and more angular the form of groove, and the quicker the twist, the greater the likelihood of the bore becoming foul and leaded. Fouling of the barrel.

A rifle barrel is said to be leaded when particles of lead are detached from the bullet as it passes up the bore, and adhere to the lands and fill up the grooves. If a barrel becomes very foul it is certain to become leaded, when the shooting at once becomes wild. Even a clean barrel is liable to become leaded, and it is to prevent this being the case that the Martini-Henry bullet is papered. Leading of the barrel.

When the motion of bullets fired from rifles is considered, it is necessary to distinguish between the *motion of translation* and the *motion of rotation*. The motion of translation and rotation of a bullet fired from a rifle.

Motion of translation refers to the onward motion of a bullet through the air; the motion of rotation to its spinning round its longer axis.

Both these motions are combined in the motion of an elongated bullet fired from a rifle, but they are best considered separately.

The velocity of translation of a bullet is measured by its linear velocity in feet per second. Velocity of translation.

Velocity of rotation.

This depends upon the muzzle velocity and the inclination of the grooves or twist. In order to find the muzzle velocity of rotation of a bullet, divide the muzzle velocity by the distance in which one complete turn is made by the bullet; thus, suppose the muzzle velocity of the Martini-Henry bullet to be 1315 feet per second, and that the bullet makes one complete turn in 22 inches, then the number of revolutions of the bullet in one second, supposing the velocity to be uniform, will be $\frac{1315' \times 12''}{22''} = 717.28$ revolutions.

Linear velocity of rotation.

Linear velocity of rotation is the velocity with which a point on the surface of the bullet revolves round the axis of rotation, and is obtained by multiplying the muzzle velocity of rotation by πd , d being the diameter of the bullet in inches, to get the number of inches per second through which the point travels; thus, $717.28 \times 0''.45 \times 3.14159 = 1014$ inches per second.

Angular velocity of rotation.

Angular velocity of rotation is the number of units of angular measure revolved through in one second; the angular velocity of a bullet making one turn in one second is 2π , or 360° .

A spherical or an elongated bullet can be fired from a rifle, but only a spherical bullet can be used with advantage from a smooth-bore. If a conical bullet were fired from the latter arm, it would, owing to the resistance of the air, tumble over (or commence rotating round its shorter axis) immediately on leaving the muzzle, and range but a short distance, owing to the great resistance it would meet with in its passage through the air when thus rotating.

In vacuo no rotation would be necessary.

In vacuo, no rotation to correct the flight of the bullet would be necessary; the existence of the air is the sole cause of their upsetting or deviating from their true path.

Uniform and increasing or gaining twist.

In some cases the grooves of rifles are made with a uniform twist or spiral, others have what is called an increasing or gaining twist.

Grooves with a uniform twist make the same angle with a straight line drawn in the bore from the breech to the muzzle at all points, while with the increasing twist the angle is constantly varying.

With the increasing twist it is usual for the grooves to begin with a slight inclination at the breech, and the twist or spiral to increase regularly until it reaches the muzzle; then the twist towards the muzzle is said to be sharper or quicker.

Increasing twist unsuitable for military arm.

An increasing twist is unsuitable for a military arm, for the following reasons:—From want of care and other causes the grooves of rifles get rusty and require repair; to effect the removal of the rust a process called "lapping" is resorted to, which consists in taking a leaden cast of a portion of the bore; this plug of lead is then attached to a rod and worked up and down the barrel, and, with the aid of emery, soon removes the rust; with an increasing twist the plug of lead could only fit the portion of the bore in which it was cast, and the process would be impossible. It is also evident that a bullet must alter its shape in conforming to the grooves of an increasing twist while passing through the barrel, and in the case of deep grooves, this would certainly take away from the effective pressure of the powder gas.

The twist of *uniform* rifling is estimated by the distance along the bore (expressed in calibres or inches) in which the spiral makes one turn; with the *increasing* twist it is estimated at any point by the distance in which the spiral would make one turn had the angle of the spiral remained uniform and the same as at the given point.

Twist of rifling, how estimated.

The reader will see the similarity in the modes adopted for measuring an increasing twist, and a variable velocity.

The twist of rifling is often expressed in calibres, and that this is the best method for comparison will be made clearer by an example:—

The grooves of both the Martini-Henry and the Mauser rifle make one turn in 22 inches, but as the calibre of the former is 0''·45, and of the latter 0''·433, the actual twist of rifling in each is not identical. When, however, two rifles have grooves which make one turn in the same number of their calibres, then the actual twist of rifling in each is the same.

The tendency of an elongated bullet fired from a rifle with insufficient twist is to rotate round its shortest axis through the centre of gravity.

Tendency of bullet to rotate round its shortest axis.

The greater the length of the bullet in calibres the greater must be the velocity of rotation. Although the Martini-Henry and Snider bullets have the same weight, their length is different, the former being 2·82 calibres long, and the latter 1·806 calibres. It is for this reason that the Snider bullet can be fired with so much less velocity of rotation than the Martini-Henry bullet.

The longer the bullet in calibres the greater must be the velocity of rotation.

The twist of rifling in any rifle is so arranged that the bullet may have a sufficient velocity of rotation as it leaves the muzzle to ensure its rotating steadily round its longer axis during its flight.

The angle of spiral or twist of rifling.

No more twist should be given to the grooves than is necessary, for grooves with a quick twist foul more rapidly, and are difficult to clean.

Before settling the twist of rifling of any rifle it must be known what muzzle velocity, diameter, and length the bullet is to have; the degree of twist required by these data can be approximately ascertained by theory, but it is practically almost entirely determined by careful experiment.

The drift is the deflection of a bullet due to the rotation imparted by the rifling and the resistance of the air. The greater the velocity of rotation the greater will be the drift of the bullet.

Drift.

The deflection due to drift is found to increase in a greater proportion than that due to the range.

With our rifles, which have always a right-handed twist, the upper surface of the bullet rotates from left to right with reference to the firer, and the bullet deflects to the right.

The experimental 0''·303 bore, the French Gras and some other foreign rifles, have a left-handed twist, and consequently their bullets deflect to the left.

The axis of the bore is an imaginary line passing down the centre of the bore.

Axis of bore.

- Axis of rotation.** The axis of rotation is a line through the centre of gravity of a body about which the body revolves.
- Line of fire.** The line of fire is the direction in which the bullet is moving on leaving the rifle; or, in other words, a tangent to the trajectory at the muzzle.
- Line of sight.** The line of sight is an imaginary line passing through the sights and the point aimed at.
- Plane of sight.** The plane of sight is the vertical plane passing through the line of sight.
- Lateral deviation.** The lateral deviation is the perpendicular distance of the point of impact of the bullet to the right or left of the plane of sight.
- Angle of elevation.** The angle of elevation is the angle which the line of sight makes with the axis of the bore.
- Angle of descent.** The angle of descent is the angle which a tangent to the trajectory at the first point of impact makes with the horizontal plane. It is always greater than the angle of elevation, slightly so at short ranges, but as the range increases the difference between the angles of elevation and descent becomes greater and greater. With the present military rifles at 1000 yards range the angle of descent is about one-third more than the angle of elevation.
- Range.** The range is the distance from the muzzle of the rifle to the intersection of the trajectory with the line of sight.
- Interchangeable arms.** Arms are said to be interchangeable when the component parts of any one arm will exactly replace those of another of the same pattern. This important object is attained by machining the various parts, and subjecting them to a rigid examination at different stages of manufacture; they must also fit standard gauges, which ensures perfect coincidence in form and dimensions.
- Long and short butts.** Long and short butts are terms met with in descriptions of small arms. The Martini-Henry long butt is $14\frac{5}{16}$ inches, and the short butt $13\frac{1}{8}$ inches in length measured from the trigger to centre of the butt plate. Long and short butts are issued to the army in the proportions $\frac{2}{3}$ long to $\frac{1}{3}$ short. The Martini-Henry carbines have all long butts.
- Resistance of the air.** The resistance of the air to a bullet during its flight is the force which tends to stop the bullet, and so continually diminishes its velocity. If the force of gravity did not exist, the resistance of the air would, after a certain time, cause a bullet when fired from a rifle to come to rest. The greater the velocity of a body the greater the resistance of the air. The air consists of particles of matter in a gaseous condition, and on a bullet being projected with a high velocity into this medium, collision takes place between the particles of the air and the head of the bullet. Considerable force is expended in overcoming the inertia of these particles, and thus the velocity of the bullet is quickly diminished.
- The muzzle velocity of the Martini-Henry bullet may be taken at 1315 feet per second (this being an average muzzle velocity), and the following remaining velocities at different ranges will show the loss of velocity due solely to the resistance of the air:—

Range.	Velocity.
0 yards.	1,315 feet per second.
500 "	869 " "
1,000 "	664 " "
1,500 "	508 " "
2,000 "	389 " "
2,500 "	301 " "
3,000 "	233 " "

Retardation is the rate at which the bullet loses velocity, Retardation. owing to the resistance of the air.

This depends on—

1. The muzzle velocity of the bullet.
2. The density of the air.
3. The form of the head of the bullet.
4. The power of the bullet to overcome the resistance of the air due to its sectional density.

Sectional density is a term used to express the relation which exists between the weight of a bullet and the area of its greatest cross section. This ratio may be expressed as

Sectional density, or power to maintain velocity.

$$\text{Sectional density} = \frac{\text{Wt. of bullet}}{\text{Area of cross section}}.$$

In this country the weight of the bullet is expressed in pounds avoirdupois, and the cross section in square inches. Abroad it is expressed by the number of kilogrammes per square centimetre of section.

It has been deduced from careful experiments that the retardation a bullet with a given form of head meets with in its passage through any medium, such as the air, is directly proportional to its cross section, and inversely proportional to its weight. Thus—

$$(1.) \text{ Retardation is proportional to—} \\ \frac{\text{Area of cross section}}{\text{Wt. of bullet}}.$$

Conversely, the power of the bullet to overcome resistance must be directly proportional to the weight, and inversely proportional to its cross section. Thus—

$$(2.) \text{ Ranging power is proportional to—} \\ \frac{\text{Wt. of bullet}}{\text{Area of cross section}}$$

This latter method is the one used on the Continent to compare bullets; it agrees with the definition of sectional density, and if the sectional densities of bullets are tabulated, their comparative powers of overcoming resistance are obtained.

In this country (1) is employed, and the comparative retardations the bullets would meet with are tabulated, and are called the $\frac{d^2}{W}$ of the bullets.

$\frac{d^2}{W}$ is thus obtained.

Retardation is proportional to—

Section in square inches
Weight in pounds.

is proportional to $\frac{\pi d^2}{4} \times \frac{1}{W}$,

is proportional to $\frac{\pi}{4} \times \frac{d^2}{W}$,

where d = diameter of bullet in inches, and W = weight of bullet in pounds.

As $\frac{\pi}{4}$ is a constant, it may be neglected when comparing the powers of different bullets, and the value of their $\frac{d^2}{W}$ need only be calculated.

For example :—

Find the value of $\frac{d^2}{W}$ for the Martini-Henry and Snider bullets.

Diameter of the Martini-Henry bullet = 0.45 inch.

Weight " " " = 480 grains.

Number of grains in 1 lb. " " = 7000.

$$\therefore \frac{d^2}{W} = \frac{(0.45)^2}{\frac{480}{7000}} = 2.953.$$

Diameter of the Snider bullet = 0.577 inches.

Weight " " " = 480 grains.

$$\therefore \frac{d^2}{W} = \frac{(0.577)^2}{\frac{480}{7000}} = 4.855.$$

From this it will be seen that the retardation which the Snider bullet would meet with in its passage through the air is much greater than in the case of the Martini-Henry bullet moving with the same velocity, or in the proportion of 4.855 to 2.953.

If two bullets of the same form and dimensions, but of different material, are fired with the same muzzle velocity, the resistance of the air to each will be the same, but the retardations they will experience will be inversely as their weights.

It will be seen that by diminishing the calibre of a rifle, and increasing the length of the bullet, a very favourable $\frac{d^2}{W}$ can be obtained, but there are limits which must not be exceeded in this direction; for example,

1. The bullet must have sufficient diameter to cause destructive effect to men and horses.

2. When ordinary powder is used, there is a difficulty in burning a sufficient powder charge in a very small bore to give the necessary muzzle velocity.

3. By reducing the bore its surface is also reduced, and the deposit of fouling is increased.

4. The lengthening of the bullet makes it more sensitive to the action of a side wind.

The table in page 55 gives the value of $\frac{d^2}{W}$ for bullets fired from various rifles of the present day.

The trajectory is the curve described by the bullet in passing from the muzzle of the rifle to the first point of impact.

It is of the greatest importance that the rifle bullet should, during its flight, have a trajectory approximating as much as possible to a straight line; and in order to attain this end, a large powder charge is now invariably used, which (the weight of the bullet remaining the same) gives a high muzzle velocity. It is chiefly to this high muzzle velocity that flatness of trajectory must be looked for at short ranges; at long ranges a bullet must have in addition a favourable $\frac{d^2}{W}$. Flat trajectories.

It is known that the bullet must drop below the line of fire about 16 feet during the first second of its flight, 48 feet during the second, and so on, so that the object is to impel the bullet forward with a velocity as great as possible, and thus to get over the range before the force of gravity has had much time to act, bringing the bullet to the ground. The elevation (given by the back sight on the rifle) is for the purpose of giving time to the bullet to range, but the more elevation that is given in aiming at an object, the higher will be the trajectory.

The great object in rifle shooting is to get range with as little elevation as possible. This can be effected in three ways:— Great object to obtain range with little elevation.

1. By increasing the powder charge, without altering the weight of the bullet.
2. By decreasing the weight of the bullet, leaving the powder charge the same.
3. By increasing the weight of the powder charge and decreasing the weight of the bullet.

Of course it is to be understood that the same rifle is dealt with in each case, for if the calibre of the rifle is decreased using a suitable weight of bullet and charge of powder, it is possible to obtain a very high muzzle velocity, while the bullet has a low $\frac{d^2}{W}$, and therefore there is a fourth means of obtaining a low trajectory.

The objection to the first method is that the recoil will be increased, so that once the calibre of the rifle and the weight of the bullet have been fixed, the powder charge cannot be increased beyond a certain limit on account of recoil.

Methods 2 and 3 are those met with in sporting rifles of the Express class. For short ranges these rifles have very high muzzle velocities and low trajectories, but at long ranges the high $\frac{d^2}{W}$ of the bullets causes so much loss of velocity and consequent increase of elevation and height of trajectory, that as military arms they would be useless.

Advantages of
flat trajec-
tories.

* The advantages of a flat trajectory are as follows:—

1. Greater accuracy, since the direction of the bullet is less oblique to the target with the flatter trajectory, consequently small errors in aiming or judging distance are of less importance.

2. Harder hitting, because the velocity being higher, and the bullets being of the same weight and fired out of similar rifles, the blow must be greater and the penetration increased.

3. Greater efficiency in covering the ground, because for the same range the bullet does not rise so high in the air.

Dangerous
zones for
cavalry and
infantry.

Dangerous zones for cavalry and infantry are the terms given to those portions of the range which are swept by the trajectory of the bullet at a height not greater than 8 feet 6 inches for cavalry and 6 feet for infantry.

Work.

When a bullet has been set in motion from rest, some force or pressure must have been exerted upon it. This force or pressure is then said to have done *work*, and the amount of *work done* is measured by the product of the *pressure* into the *distance* through which the bullet has been moved. Work done is usually expressed in foot lbs.†

Thus, if P be the pressure in pounds exerted on a bullet through the space of S feet, then the work done on the bullet is

$$P \times S \text{ ft. lbs.}$$

But in practice the pressure exerted on a bullet during its passage through the bore of the rifle is not constant, but *variable*; so that to obtain the approximate amount of work done, the product of the *mean pressure* on the bullet into its *distance* moved through the bore of the rifle must be taken. Then

P = mean pressure on bullet.

= mean pressure on the bore of the rifle.

Example.—If the total mean pressure on the base of a Martini-Henry bullet was 712·64 lbs., what would be the work done on the bullet at the muzzle?

The distance through which the pressure acts must be the difference between the length of the bore and the length of the powder charge.

Length of bore = 33 inches.

Length of powder charge = 2 "

The difference will be the distance passed over by the bullet from its seat to the muzzle, viz., 31 inches = $\frac{31}{12}$ feet; conse-

quently, work done by the powder on the bullet = $\frac{31}{12} \times 712\cdot46$
= 1841 foot lbs.

* See "Principles of Gunnery," by Major J. Sladen, R.A.

† It is necessary to have some means of estimating *work* numerically, and for this purpose the amount of work done in raising 1 lb. through 1 foot is called the unit of work, or foot lb.

If 1 lb. is raised through 1 foot, 1 unit of work is done.

If 1 lb. is raised through 2 feet, 2 units of work are done.

If 4 lbs. weight be taken in the hand and raised through 5 feet, 20 units of work will be performed.

When a bullet is in motion, it is said to have *energy*, i.e., it is capable of doing work, or overcoming resistance. The amount of energy is measured by the *product of the weight of the bullet into the height due to its velocity*, and is expressed in the same units as those of work done.

Thus, if W be the weight of the bullet in pounds, h the height, it would require *in vacuo* to attain a velocity v in feet per second, then the energy of the bullet is—

$$Wh = \frac{Wv^2}{2g} \text{ ft. lbs.}$$

Where $h = \frac{v^2}{2g}$.

Now if V be the muzzle velocity of the bullet, its energy at the muzzle of the rifle is $\frac{WV^2}{2g}$; and since the energy of the bullet at the muzzle is equivalent to the work done on it in the bore—

$$E = \frac{WV^2}{2g} = \text{PS};$$

where E represents the energy at the muzzle.

It will therefore be seen that the energy of the bullet at the muzzle is equal to the work done by the pressure of the powder gas in the bore of the rifle.

Example.—Find the energy of a Martini-Henry bullet at the muzzle. Weight of bullet = 480 grains or $\frac{480}{7000}$ lbs., muzzle velocity = 1315 feet per second.*

$$\begin{aligned} \text{Energy at muzzle} &= \frac{\frac{480}{7000} \times (1315)^2}{2 \times 32.2} \text{ ft. lbs.,} \\ &= 1841 \text{ ft. lbs.} \end{aligned}$$

i.e., if a uniform resistance of 1841 lbs. were opposed to the bullet, it would penetrate *one foot* before it was brought to rest; or if the resistance were 712.64 lbs., it would penetrate $\frac{31}{12}$ feet, and so on.

In order to estimate the comparative power of rifles for piercing various substances, it is usual to express the energy of the bullet in terms of the number of inches in its circumference, i.e., by dividing the energy by the number of inches in the circumference of the bullet. Thus, energy per inch of circumference

$$= \frac{Wv^2}{2g \times \pi d} \text{ ft. lbs.}$$

where d is the diameter of the bullet in inches.

Also, energy per inch of circumference at muzzle

$$= \frac{E}{\pi d} = \frac{WV^2}{2g \times \pi d};$$

thus, muzzle energy per inch of circumference of a Martini-Henry bullet

$$= \frac{1841}{3.14159 \times 0.45} = 1302 \text{ ft. lbs.}$$

* With rolled case cartridge; with solid drawn, velocity is greater, see Table, page 55.
(S.A.)

Energy further explained.

The *Energy*, or mechanical power, of a projectile has been most ably explained in a paper by Professor Sir F. Tyndal, from which the following is extracted:—"A sphere of lead weighing 1 lb. was suspended at a height of 16 feet above the theatre floor. It was liberated and fell by gravity. That weight required exactly a second to fall to the earth from that elevation, and the instant before it touched the earth it had a velocity of 32 feet a second. That is to say, if at that instant the earth were annihilated, and its attraction annulled, the weight would proceed through space at the uniform velocity of 32 feet a second. Suppose that, instead of being pulled downward by gravity, the weight is cast upward in opposition to the force of gravity—with what velocity must it start in order to reach a height of 16 feet? With a velocity of 32 feet a second. This velocity imparted to the weight by the human arm, or by any other mechanical means, would carry the weight up to the precise height from which it had fallen." . . . "Supposing now, that instead of imparting a velocity of 32 feet a second to the weight we impart twice this speed, or 64 feet a second. To what height will the weight rise? You might be disposed to answer, 'To twice the height;' but this would be quite incorrect. Both theory and experiment inform us that the weight would rise to four times the height; instead of twice 16, or 32 feet, it would reach four times 16, or 64 feet. So also, if we treble the starting velocity, the weight would reach nine times the height." . . . "Now, the 'energy' or 'mechanical power' is proportional to the height, and as a double velocity gives four times the height, a treble velocity nine times the height, and so on, it is perfectly plain that the mechanical power increases *as the square of the velocity*." . . . "In the case considered, I have supposed the weight to have been cast upward, being opposed in its upward flight by the resistance of gravity; but the same holds true if I send the projectile into water, mud, earth, timber, or other resisting material. If, for example, you double the velocity of a cannon ball, you quadruple its mechanical power." . . . "The *measure* then of mechanical power is the mass of the body multiplied by the square of its velocity."

Thus, if the velocity of any number of shot of a given weight at any particular distance be known, their comparative powers of inflicting mischief at that distance are also known.

The expression, therefore, for the *vis viva* or mechanical power of a projectile is MV^2 , where M is the mass and V the velocity at which it is moving. The *mass* of a body is its weight divided by g , the force of gravity, since $W = Mg$ (see page 3.) The actual "work done" in penetration is one half the *vis viva*, or $\frac{1}{2} MV^2$, for the obvious reason that at the *beginning* of penetration the work being done is MV^2 , and the projectile rapidly loses its velocity until at the *end* of the penetration the work being done is "nil," and therefore the *mean* of the expressions MV^2 and 0, or $\frac{1}{2} MV^2$ represents the actual work done. This expression, called the "equation of work," is usually written $\frac{WV^2}{2g}$, where W is the weight of the projectile, since $M = \frac{W}{g}$.

CHAPTER II.

RESISTANCE OF THE AIR TO THE MOTION OF A PROJECTILE. THE TRAJECTORY OF THE BULLET. PENETRATION. RECOIL.

THE resistance of the air to projectiles moving with high velocities, and the form of the trajectories described, have long been subjects of interest to scientific men. Resistance of the air.

Some idea may be formed of the amount of this resistance by considering that wind blowing a gale has only a velocity of 60 miles an hour, whereas a bullet moving at the rate of 1300 feet per second has a velocity of 886 miles an hour.

It is easy to conceive from this with what force the particles of air must strike against the front of the bullet during its rapid flight.

Robins, in 1742, was the first to demonstrate the immense effect of the resistance of the air. He considered it to vary as the square of the velocities up to 1100 feet per second, and for velocities above that to increase considerably. Robins.

Hutton carried out experiments in 1775, and found that even with velocities below 1100 f.s., the resistances were higher than those due to the squares of the velocities. Hutton.

M. Hélié, in France, and the Reverend F. Bashforth, in England, arrived independently at results of great importance. They demonstrated that, although no simple law could be found to express the resistance of the air in the terms of the velocity, yet that such resistance could be accurately defined by the help of a *variable coefficient*, depending (1) upon the form of the projectile, (2) upon the velocity with which it moves. Hélié and Bashforth.

Upon these assumptions, Mr. Bashforth states that it is a mere matter of convenience which *power* of the velocity is used, but he adopts the cubic law as giving the most simple formulæ for the calculation of remaining velocities, ranges, and times of flight. The expression he adopts is

$$R = kv^3$$

where k , instead of being a *fixed* multiplier, is a coefficient not only depending upon the form of the projectile, but also *varying* in amount with the velocity.

Mr. Bashforth carried out a very extensive series of experiments on the resistance of the air to elongated projectiles. By means of the electric chronograph invented by him, he was enabled to take the velocities at *several points* of the same trajectory, and thence he derived tables of values for the variable coefficient k , corresponding to every 5 feet of velocity for ogival headed projectiles.

Fluctuations
in resistances.

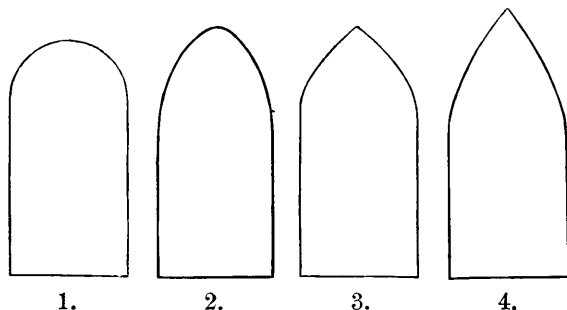
Although Mr. Bashforth has adopted the cubic law as his standard, it will prove of interest to point out the fluctuations in the resistances due to different velocities, the deductions being taken from his tables, these variations can be best shown by the ordinates of a curve, but the general results may be stated as follows in a popular form:—

1. Between velocities 430 and 850 f.s., the resistance of the air varies nearly as the square of the velocity.
2. Between the velocities 850 and 1040 f.s., the resistance varies roughly as the cube of the velocity.
3. Between the velocities 1040 and 1100 f.s., the resistance varies roughly as the 6th power of the velocity.
4. Between the velocities 1100 and 1300 f.s., the resistance varies as the cube of the velocity.
5. Between the velocities 1300 and 2800 f.s., the resistance varies as the square of the velocity.

The cause of these fluctuations does not yet appear to have been satisfactorily explained.

Professor Bashforth also experimented on projectiles with different forms of head, to determine which form offered least resistance to motion through the air.

Four different forms of head were tried, viz.: 1. Hemispherical. 2. Hemispheroidal. 3. Ogival head of 1 diameter. And 4. Ogival head of 2 diameters.



The resistances obtained under similar conditions of velocity, about 1200 f.s., were proportional to the numbers—

	Resistances.			
Hemispherical	..	..	..	132.9
Hemispheroidal.. ..	..	..	..	104.3
Ogival (1 diameter) ..	..	..	..	109.7
Ogival (2 diameters) ..	..	..	..	104.2

Further experiments carried out with higher velocities, 1700 f.s., gave the following results:—

	Resistances.			
Ogival head ($1\frac{1}{2}$ diameters) ..	..	..	..	83
Hemispherical head	..	..	..	113.6
Flat head	..	..	..	173.5

It appears that the resistance of the air to the flat head was the greatest, and to the ogival head of 2 diameters the least. It was also considered that the resistance depended more on the form of the head near its junction with the cylindrical part of the projectile than on its having more or less a sharp point.

The resistance of the air is also probably affected by the shape (tapering or non-tapering, for instance) of the hinder as well as the fore part of the bullet.

The next point to consider is the path described by the bullet. Trajectory of the bullet.

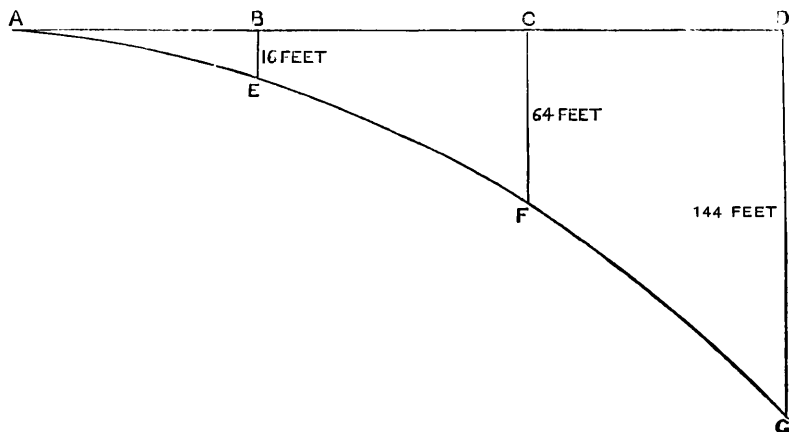
In early times it was thought—

1. That it went straight, and then fell perpendicularly.
2. That it went straight for some distance, then in a curve, and then fell perpendicularly.
3. That its flight was curved throughout, but very slightly.
4. Galileo, in the 17th century, considered that it described a parabola, except inasmuch as it was diverted by the resistance of the air, which he greatly underrated.

It is now known that a bullet, on leaving the muzzle of a rifle, is under the influence of three forces, viz., the impressed pressure of the powder gas, the force of gravity, and the resistance of the air.

To commence, the action of the first two forces only will be considered on the supposition that no atmosphere exists. From the impressed force of the powder the bullet will travel forward with uniform velocity, passing through equal distances in equal times; thus in the first second from A to B (Fig. 1), in the second from B to C, and in the third from C to D; but in obedience to the law of gravity, it will fall in the first second 16 feet, B E, at the end of the second second it will have fallen 64 feet, C F, and at the end of the third second 144 feet, D G, being at the end of these seconds at the points E, F, G, respectively, and describing in its path the trajectory A, E, F, G, which in this case would be a curve called the parabola.

Fig. 1.



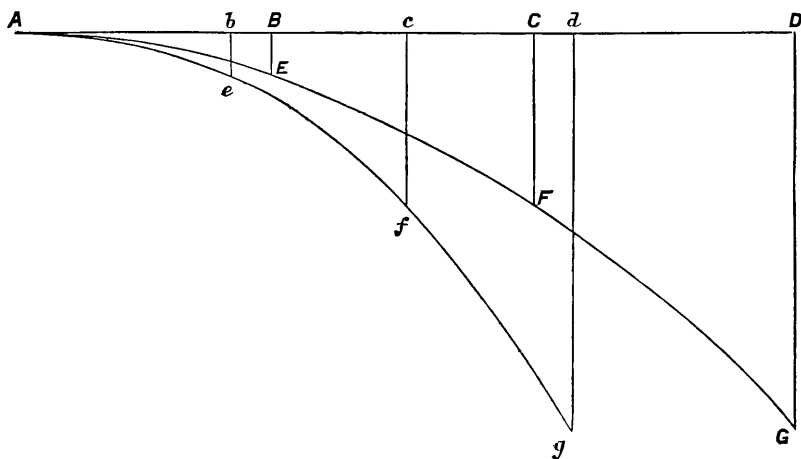
N.B.—The figure is drawn representing the bullet fired *horizontally*; but the reasoning is in the main applicable to other inclinations to the horizon.

Having now established the general form of the trajectory, under the forces of gunpowder and gravity, the following conclusion is arrived at, that supposing a rifle is laid with its axis horizontal, it is immaterial with what charge it is loaded and with what velocity the bullet is projected, the latter will reach the ground in one second if 16 feet above it, and in two seconds if 64 feet, and so on; consequently if several rifles are laid above the level of the ground, with their axes in the same horizontal plane, the bullets projected from them at the same instant would reach the ground at the same moment, irrespective of their velocities and height above the ground. The result would be the same in air, supposing the bullets to be spherical and identical in bulk and density.

Action of
powder,
gravity, and
air.

The resistance of the air will now be taken into account; owing to this resistance the flight of the bullet will be modified thus: it will not proceed equal distances in equal times, but the distances traversed will be successively less and less; instead of the bullet travelling forward a distance equal to AB (Fig. 2), in the first second of time, to BC in the second, and to CD in the third; the distance will be, say, Ab , $b c$, and $c d$; and the action of gravity being the same as before, the bullet, at the termination of each second, will be respectively at e , f , g , the actual path of the bullet differing in a great degree from that of the parabolic curve, which is never approached except with projectiles moving with very low velocities.

Fig. 2.



It will be seen from the above that the force of gravity is the sole cause of the trajectory being a curved line, and that this curvature is increased by the resistance of the air, and it is due to these causes that elevation must be given to all arms, varying in an increasing ratio according to the distance. If gravity alone acted, elevation would be necessary, but when it acts in conjunc-

tion with the resistance of the air, an increased elevation is necessary.

The resistance of the air, by reducing the velocity of a shot, increases the time of flight over a given range.

In vacuo the greatest range on a horizontal plane, with a given muzzle velocity, would be obtained by firing with an elevation of 45° ; owing to the resistance of the air, a bullet fired from the Martini-Henry rifle, with about 23° is found to give the maximum range.

Whatever the form of a bullet, its trajectory is the curve described by its centre of gravity.

The position, with respect to the trajectory, which the axis of an elongated bullet preserves during its flight, has always been a matter of much dispute. It has been supposed by some that elongated bullets preserve their primary direction, or if they leave the rifle with a certain angle to the horizon, they maintain this angle during the whole of their flight. Again, it has been stated that under certain conditions the point of the bullet droops below the trajectory and the base is elevated; while other writers declare that the axis of the bullet is a tangent to the trajectory from beginning to end.

Position preserved by the axis of an elongated bullet in its flight.

The last conclusion seems to be approximately the correct one; still it is quite possible that an elongated bullet which has not a sufficient velocity of rotation to keep it spinning steadily round its longest axis, may not follow the trajectory point foremost, as there will naturally be some intermediate condition before it begins to revolve round its shortest axis.

The deviation caused by the rotation of the earth is so slight in the range of small arms that it is not necessary to consider it.

Rotation of the earth.

The flight of a bullet is affected by the density of the air, more especially at long ranges; the denser the air the greater will be the resistance.* Changes in the density of the air are caused by variations in the pressure of the atmosphere as registered by the barometer, in the temperature as shown by the thermometer, and in the amount of moisture present.

Effect of density of the atmosphere on the flight of a bullet.

A fall in the barometer indicates less pressure and therefore less density, and *vice versa*; a rise of temperature decreases the density, and *vice versa*; the moisture in the air, though it may greatly vary in quantity, has *in itself* little effect on the flight of the bullet (*see foot-note*†); but, in the absence of a

* See paper by Captain C. B. Mayne, Royal Engineers, in Appendix.

† The density of water vapour is approximately $\frac{1}{8}$ of that of dry air at the same temperature and pressure.

Let b = the barometric pressure, p that of dry air, and e that of the vapour,

$$b = p + e \quad (1),$$

and the ratio of the density of the mixture to that of dry air will be

$$\frac{p + \frac{1}{8}e}{b} \quad (2).$$

In most climates a relative humidity of 30 per cent. of saturation is a very dry atmosphere—100 being saturation. In the British Isles 50 would be very dry indeed. Let us see what will be the difference of densities when the relative humidities are 30 and 100 respectively, the barometer standing at 30 inches, and the temperature being 70° .

barometer, a damp atmosphere may be taken as *an indication (not as the cause)* that the barometer is probably low. Moreover, the degree of moisture in the air causing hard or soft fouling will greatly affect elevation.

Corrections
for elevation
and lateral
deviation.

The scale for elevation on the back sight of the Martini-Henry rifle is graduated only to hundreds of yards; elevation for intermediate distances has therefore to be roughly judged by eye. The wind-gauge lines also give spaces of inconvenient value in application. To enable corrections for elevation and lateral deviation to be made exactly and readily, a method of graduation has been devised, in which the spaces on both the vertical and horizontal scales are in simple units corresponding to exact integral measurements on the target at 100 yards, and consequently increasing in value directly in proportion to each additional distance of 100 yards.*

Firing at
objects at a
high and low
level.

Military rifles are always sighted for horizontal distances. When firing at objects at the same distance, but at a much higher or lower level, a proportionately relative increase or decrease of elevation will be necessary. When the ranges and the variations from the level are moderate, the ordinary sighting may be taken as sufficiently accurate.

To show how the height of the trajectory of a bullet is affected by its muzzle velocity, section, and weight, diagrams of the trajectories of the Snider and Martini-Henry rifles and carbines are now given; but the reader must be careful not to be misled in his idea of the real trajectories of these rifles, by the very distorted scales on which these and all such diagrams have necessarily to be drawn. For example, if in the diagrams the heights of the trajectory of the Snider rifle at 1000 yards were drawn to the same scale as are the horizontal distances, the culminating point would be only about 0·2" above the horizontal, a space scarcely perceptible.

The elastic pressure of saturated water vapour at 70° is 0''·733 of mercury, in air of humidity 30, it is therefore

$$\frac{30}{100} \times 0\cdot733 = 0\cdot22 \text{ inch,}$$

and the total pressure being 30 inches, that of the dry air component is from (1)

$$30 - 0\cdot22 = 29\cdot78 \text{ inches.}$$

By (2) the density of this air is

$$\frac{29\cdot78 + \frac{3}{8} 0\cdot22}{30} = \frac{997}{1000}.$$

That of saturated air of the same pressure and temperature is

$$\frac{29\cdot267 + \frac{3}{8} 0\cdot733}{30} = \frac{991}{1000},$$

and the difference therefore is approximately $\frac{3}{500}$ of the whole. The same

difference would be produced by a change of two-tenths of an inch in the barometric pressure, or by one of 4·6° of temperature. Our rifles are sighted in England for our ordinary temperature at sea level; it is evident then that at considerable elevations above sea level, with a high temperature, and with much moisture in the air, the density of the air will be greatly diminished, and less elevation will be required.—H.F.B.

* See paper by Major Godsal, pp. 141, 142, Appendix.

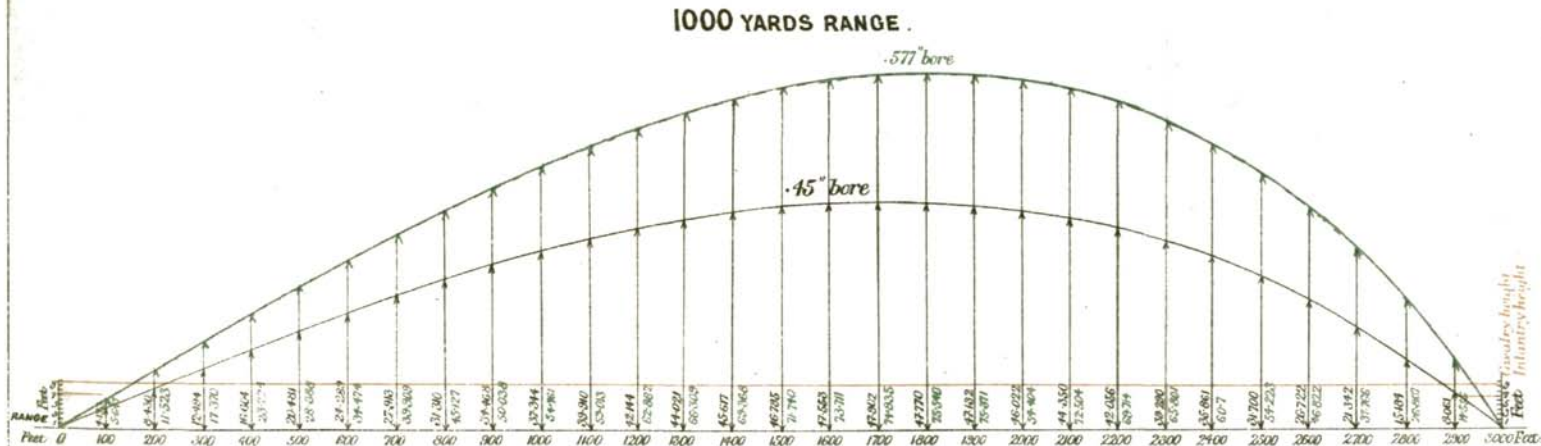
TRAJECTORIES, RIFLE. ·45" & ·577" BORE OF BARREL.

SCALE. { HEIGHT ·1" = 1 FOOT.
RANGE ·01" = 1 FOOT.

Calculated by Maj. M^c Clintock, R. A. Assis^t Sup^t
from M^r Bashforth's amended tables.
Sep^r 1881.

BORE	POWDER	BULLET	MUZZLE VELOCITY.	$\frac{d^2}{W}$	SYSTEM OF RIFLING
·45"	85 grains	480 grains.	1315 f ^t . p ^r . second	2.355	Henry.
·577"	70 " "	480 " "	1240 " " "	4.855	Enfield.

$$g = 32.2$$



S^d H. T. Arbuthnot,
Col^l Supt^t
Royal Small Arms Factory,
Enfield Lock.

TRAJECTORIES, CARBINE. ·45" & ·577" BORE OF BARREL.

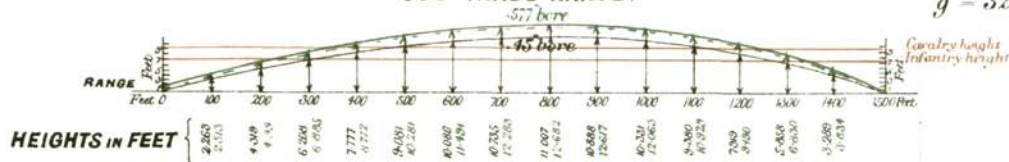
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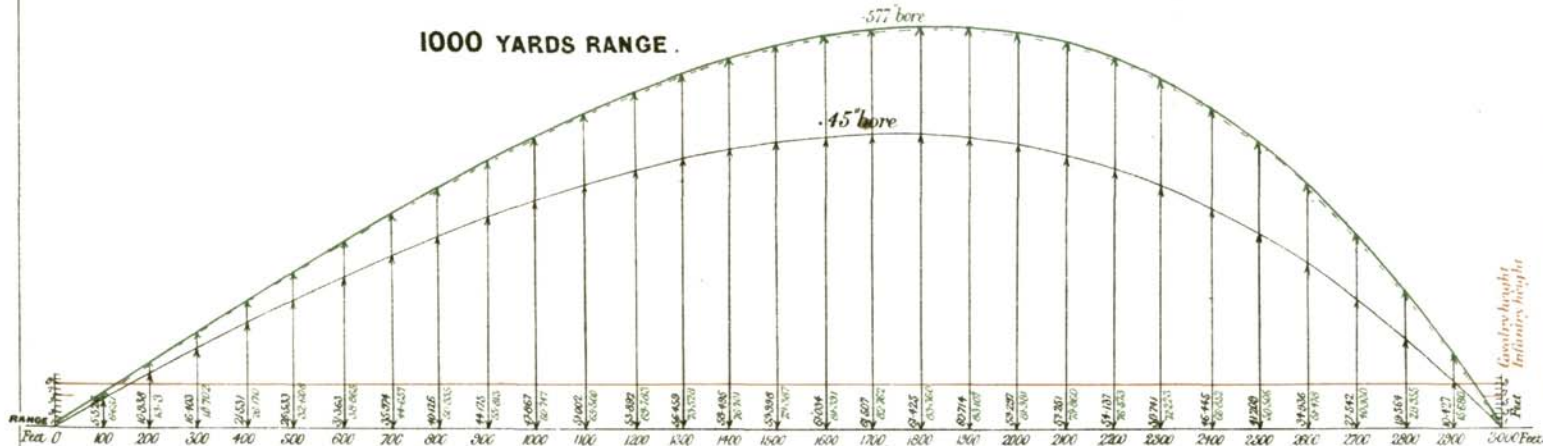
BORE	POWDER	BULLET	MUZZLE VELOCITY.	$\frac{d^2}{w}$	SYSTEM OF RIFLING
0·45"	70 grains.	410 grains.	1135 ft p ^r second	3457	Henry
0·577"	70 " "	460 " "	1120 " "	4655	Enfield.

$g = 32 \cdot 2$

500 YARDS RANGE.



1000 YARDS RANGE.



S^d H. T. Arbuthnot,
Col^t Sup^t
Royal Small Arms Factory,
Enfield Lock.

A knowledge of the exact form of the trajectory, and time of flight of the bullet, are points that should not be overlooked in the intelligent study of musketry; without it troops cannot be effectually handled whether in attack or defence. A hypothetical case would be an enemy formed up at some depth behind cover of a certain height, he might be perfectly safe from fire at short ranges, but not from fire at long ranges.

Knowledge of form of trajectory and time of flight of bullet important.

Again, in firing at objects moving laterally, it is most important to know the time of flight of the bullet in estimating how much to aim in front.

Firing at moving objects.

The following table* gives "approximately" the angle of elevation, angle of descent, dangerous space, and time of flight, Martini-Henry rifle; normal conditions of barometer, thermometer, density of air, gravity. Mean muzzle velocity, 1319 f.s.

Range.	Angle of elevation.	Angle of descent.	Dangerous space from height of 6 feet.	Time of flight.	Greatest height of trajectory.
	° /	° /	yards.	seconds.	feet.
200	21	27	throughout	·6	1·06
300	34	44	"	·8	2·6
400	49	1 2	110	1·1	5
500	1 9	1 22	85	1·4	8·5
600	1 27	1 45	65	1·8	13·2
700	1 46	2 11	55	2·1	19·4
800	2 6	2 42	45	2·5	27
900	2 28	3 15	34	2·8	36·4
1000	2 50	3 52	24	3·3	47·7
1500	5 15	8 20	12	5·6	14·7
2000	9 7	15 40	8	8·5	
2500	14 25	27 50	3·6	12·5	
3000	23 20	46 45	1·6	19·3	

Penetration.

Supposing an elongated and a spherical bullet to be fired from the same rifle with the same charge, the latter will have the higher muzzle velocity; but the elongated bullet being heavier has greater power of overcoming the resistance of the air, and will therefore maintain its velocity better, range further, and have a flatter trajectory. Hence, at long ranges, the striking velocity of the elongated will be greater than that of the spherical bullet, and it will have more penetrative effect, due both to its higher velocity and its extra weight.

From what has been said on the subject of Energy, Chap. I, it will be easily understood that an increase of velocity increases the penetration much more than an addition of weight; and that, therefore, the striking velocity of a bullet must be as great as possible, in order to produce the maximum of penetration.

Velocity more important than weight.

* Calculated by Lieut. Tanner, R.E., from results of experiments at Dungeness, 1880.

Rotation of
bullet
increases the
penetration.

The increased penetration of elongated rifle bullets is in a higher ratio than theory would assign them, and something further must be looked to than their superior energy. This is furnished by their rotation on their longer axis, which appears to aid penetration.

Hard and
soft bullets.

With small arms, the great object being to incapacitate the enemy, pure lead is sufficiently hard for the ordinary purposes of penetration, but bullets hardened with tin or antimony have a greater penetrating power than bullets made of pure lead, and would be more useful against woodwork and defences in general; this is due to the increased hardness of the metal, which causes them to be less distorted, and not to the density, as the addition of tin or antimony reduces the density.* Bullets of solid steel and iron cannot be used in the majority of rifles, which require bullets of an expanding character.

As has already been explained, the "work stored up in a bullet," or its "energy," is expressed by $\frac{WV^2}{2g}$. This gives the total blow in foot lbs. (W being the weight of the bullet in lbs.) which the bullet can strike. The power of the bullet to pierce any substance, or its "penetrative energy," differs, however, from its "total energy," and is, for comparative purposes, the number of foot lbs. *per inch of circumference* with which the bullet strikes the blow; or,

$$\text{The penetrative energy} = \frac{WV^2}{2g \cdot \pi d}$$

when d = the diameter of the bullet in inches.

It will be easily understood that with bullets of equal weights (the Snider and Martini-Henry bullets both weigh 480 grains) and different diameters, that which has the lesser diameter will meet with less resistance to penetration when it strikes any substance.

If a Snider and a Martini-Henry bullet strike an object with the same velocity, they will have the same amount of work stored up in them, or the value of $\frac{WV^2}{2g}$ will be the same for each; but the Martini-Henry bullet will have the greater penetration as, owing to its smaller diameter, its penetrative energy will exceed that of the Snider bullet.

Experiments made to test the penetrative power of the Martini-Henry and Snider bullets furnish the following results:—

* It must be understood that the proportion of tin in the M.-H. bullet is not for the purpose of increasing penetrative power. See Chap. V.

**RESULT OF EXPERIMENTS TO TEST THE EFFECT OF RIFLE
BULLETS FIRED AT UNPACKED PLATES AND OTHER SUB-
STANCES.**

Steel Plates.

Nature of rifle.	Range.	Steel Plates.		Result on plate.
		Thickness.	Nature of plate.	
Martini-Henry rifle ..	yds. 20	in. $\frac{3}{16}$	Sharp steel ..	Plate broken in pieces.
" "	"	"	Mild steel, not tempered.	Bulged, $\frac{7}{16}$ inch.
" "	"	"	Mild steel, hardened in oil.	Bulged, $\frac{4}{16}$ inch.
" "	100	"	Mild steel, not tempered.	Bulged, $\frac{5}{16}$ inch.
" "	"	"	Mild steel, hardened in oil.	Bulged, $\frac{1}{16}$ inch.
" "	20	$\frac{1}{4}$	Mild steel, not tempered.	Bulged, $\frac{2}{16}$ inch.
" "	"	"	Mild steel, hardened in oil.	Bulged, $\frac{1}{16}$ inch.
" "	100	"	Mild steel, not tempered.	Bulged, $\frac{3}{16}$ inch.
" "	"	"	Mild steel, hardened in oil.	Very slight bulge.

Wrought-iron Plates.

Nature of rifle.	Plate.		Perforated plate at	Failed to perforate plate at
	Thickness.	Nature.		
	inch.		yards.	yards.
Snider carbine	$\frac{1}{8}$	Wrought-iron	300	400
Snider rifle	"	"	400	500
Martini-Henry carbine ..	"	"	400	500
Martini-Henry rifle..	"	"	600	700
Snider carbine	$\frac{3}{16}$	"	100	200
Snider rifle	"	"	100	200
Martini-Henry carbine ..	"	"	200	300
Martini-Henry rifle..	"	"	400	500
Snider carbine	$\frac{1}{4}$	"	—	20
Snider rifle	"	"	20	100
Martini-Henry carbine ..	"	"	—	20
Martini-Henry rifle..	"	"	100	200

- Elm planks.** When fired at $\frac{1}{2}$ -inch elm planks, placed one inch apart, the Martini-Henry bullet made an average penetration of $14\frac{1}{2}$ planks; the Snider penetrated $8\frac{1}{2}$ planks.
- Fir timber.** At 100 yards' range the Martini-Henry bullet perforated three balks of 3-inch dry fir timber, placed close together, while at 50 yards' range the Snider bullet was stopped by the second balk.
- Rope mantlet.** When fired at a rope mantlet (four thicknesses 3-inch rope), the Martini-Henry bullet penetrated at 350 yards and failed to penetrate at 400 yards' range; the Snider bullet failed to penetrate at 50 yards.
- Ordinary gabion.** An ordinary gabion, filled with earth from a clay soil, was penetrated by the Martini-Henry bullet at 25 yards, but not at a longer range; the Snider bullet failed to penetrate.
- Jones' gabion.** Neither bullet could penetrate the Jones' gabion (formed with iron hoops).
- Sap roller.** The Martini-Henry bullet penetrated a sap roller at 25 yards, and failed when the range was increased; the Snider bullet failed to penetrate.
- Sand-bag.** A sand-bag containing one bushel of sand was penetrated by the Martini-Henry bullet up to 100 yards' range; the Snider bullet failed to penetrate at 10 yards.

The average penetration of the Martini-Henry bullet into dry earth at 3000 yards is 8 inches.

The following thicknesses of material may be considered proof against ordinary rifle bullets:—

Earth	..	..	..	..	2 ft.
Iron plate	..	..	..	..	$\frac{3}{8}$ in.
Steel plate	..	..	..	..	$\frac{1}{4}$ in.
Fir	{	In log	..	..	12 in.
		In 3-inch plank	..	..	6 planks.
Oak	{	In log	..	..	6 in.
		In 2-inch plank	..	..	3 planks.
Gabions filled with earth	..	..	..	..	1
Sand-bags (filled)	{	Crossways	..	..	2
		Lengthways	..	..	1
Rose mantlet	..	..	..	..	6 in.
Loose cotton	..	..	..	..	4 ft.
Compressed cotton in bale	..	..	..	..	2 ft.
Brick wall	..	..	..	..	9 in.

As it is probable the military rifles of the future will have muzzle velocities of 1800 to 2000 f.s., it is questionable if these thicknesses will afford then in all cases a sufficient protection at short ranges.

Recoil.

Recoil depends on:—

1. The weight of the rifle.
2. The muzzle velocity of the bullet.
3. The weight of the bullet.
4. On the fouling of the barrel.

On the powder charge being ignited, the gas is only able to act with effect in two directions, viz., to force the bullet out of the muzzle, and to drive the rifle in the opposite direction. The lighter the bullet the greater is its muzzle velocity (with the

same powder charge), and in the same way, the lighter the rifle the greater is its velocity of recoil.

If a rifle could be made as light as the bullet is fired, the energy of recoil of this rifle would be equal to the energy of its bullet at the muzzle; for on the powder charge being ignited, the rifle and bullet would be propelled with equal velocities, but in opposite directions.

Match rifles are generally made heavier than military arms, in order to lessen the recoil; for as the weight of the rifle is increased so is its recoil reduced. Match rifles generally heavier than military.

The friction between the bullet and the bore, as the bullet passes up the barrel is not considerable, so long as the rifle is clean, but increases rapidly when it becomes fouled, causing a great addition to the recoil; this is probably due to the increased resistance to motion of the bullet, and the charge exerting its pressure for a longer time.

The velocity of recoil and the energy of recoil are thus obtained :— Velocity and energy of recoil how obtained.

Let W = weight of rifle in lbs.

V = velocity of recoil.

w = weight of bullet in lbs.

v = muzzle velocity of bullet.

Then on firing the momentum of the rifle is equal to the momentum of the bullet.

$$WV = wv$$

$$\text{and } V = \frac{wv}{W},$$

which gives the velocity of recoil.

We can then obtain the energy of recoil—

$$E = \frac{WV^2}{2g} \text{ ft. lbs.}$$

The following table gives the energy of recoil of various military rifles, calculated on the above formulæ.

Table showing recoil of military rifles :—

Rifle.	Approximate weight of rifle with cleaning rod only, in lbs.	Weight of bullet.	Weight of powder in grains.	Muzzle velocity.	Approximate energy of recoil in ft. lbs.
Berdan	10	370	77	1444	9
Gras	9.4	386	80	1490	11
Martini-Henry	8.75	480	85	1315	14.4
Mauser	10	380	75	1430	9.3
Remington	9.5	400	75	1340	9.4
Snider	9.2	480	70	1240	13.7
Springfield	9.6	500	70	1300	13.7
Vetterli	9.3	310	62	1430	6.6
Werndl	9	370	75	1410	9.8
Experimental } British	9.25	384	85	1570	12.4
Experimental }	9.2	217	70	1800 (?)	5.6

Energy of recoil, how reduced.

The energy of recoil may be reduced (1) by decreasing the weight of the bullet; (2) by decreasing the muzzle ~~the~~ velocity, in reducing the powder charge; (3) by increasing the weight of the rifle.

When there is much recoil, accuracy in shooting cannot be expected if the rifle is in the hands of young soldiers who have not been well trained.

Manner of holding the rifle, its influence on recoil.

It is not to be supposed that every man firing a rifle experiences the same amount of recoil, as if the arm is held firmly to the shoulder, the recoil is merely felt as a push; while if the rifle be loosely held, the recoil acquires the character of a blow.

Greatest velocity of recoil.

The greatest velocity of recoil is said to be attained at the instant the bullet leaves the muzzle.

Other methods of registering amount of recoil.

Many instruments have been devised for registering the amount of recoil, such as a system of springs which are compressed, an arrangement of levers, or by allowing the rifle to swing through an arc on being fired; the recoil being shown on a dial in connection with the apparatus, but none of these contrivances are to be relied on.

Schultz and E.C. powders.

Powders, such as Schultz and Explosive Company powders, are said to give as high a muzzle velocity as black powder, without so much recoil; it is difficult to conceive how this can be the case, for if the bullet attains a certain muzzle energy, it ought to have a corresponding energy of recoil with the same rifle. It is possible with a quick explosive some of the recoil is absorbed in compressing the wood of the butt, which is always more or less elastic.

Conclusions.

It would appear from all the considerations which have been advanced, that the great object of the present day is to obtain arms from which the bullet can be projected with the greatest muzzle velocity and with the minimum of recoil, combined with the greatest possible power of overcoming the air's resistance, thus producing the lowest trajectory, and the greatest destructive effect at all distances. These desiderata are more fully explained in Chapter V., on Ammunition.

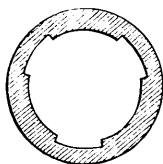
CHAPTER III.

RIFLING. BREECH-LOADING MILITARY RIFLES. RE-PEATING AND MAGAZINE RIFLES. REVOLVERS. TABLES OF MILITARY RIFLES. RIFLE CALIBRE GUNS.

BEFORE entering on the subject of military breech-loading rifles, it is desirable to give some description of different systems of rifling, the object aimed at in all being to give the necessary rotation to the bullet round its longer axis, and to effect this grooves varying in form, depth, number, and twist have from time to time been adopted.

1. Enfield rifling, 1853, consists of three spiral grooves making one turn in 78 inches; the twist is right-handed, uniform, and of progressive depth from breech to muzzle (Fig. 1).

Fig. 1.



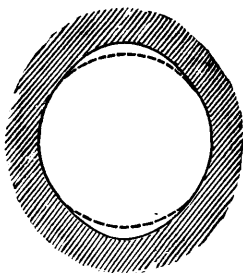
Section of the Barrel.

This form is found in the long Snider rifles, pattern '53, with which the Volunteers are at present armed.

The Snider short rifle and the cavalry and artillery Snider carbines have the same form of rifling, but are generally made with five grooves, and a uniform twist of one turn in 48 inches.

2. The Lancaster or Elliptical (Fig. 2). The barrel is cut in the interior in the form of an ellipse, the difference between the major and minor axes being $\cdot 012$ inch; the twist is an increasing one from breech to muzzle.

Fig. 2.

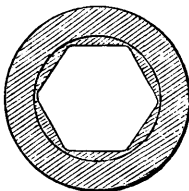


Section of the Barrel.

This form of rifling was used in the Snider rifles with which the Royal Engineers were armed; the ordinary Snider cartridge was used with these arms.

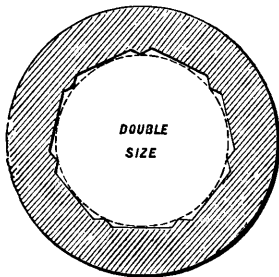
3. The polygonal (Fig. 3), as used by Mr. Whitworth. The bore is cut hexagonal in section with the angles rounded off. The twist is uniform, right-handed, one turn in 20 inches.

Fig. 3



4. Henry rifling (Fig. 4) resembles the polygonal. It has seven grooves, .03 inch of the original bore being left between each as lands. It will be seen by the figure that the lands and the centres of the grooves are contained in the same circle. Twist right-handed, uniform, one turn in 22 inches.

Fig. 4.



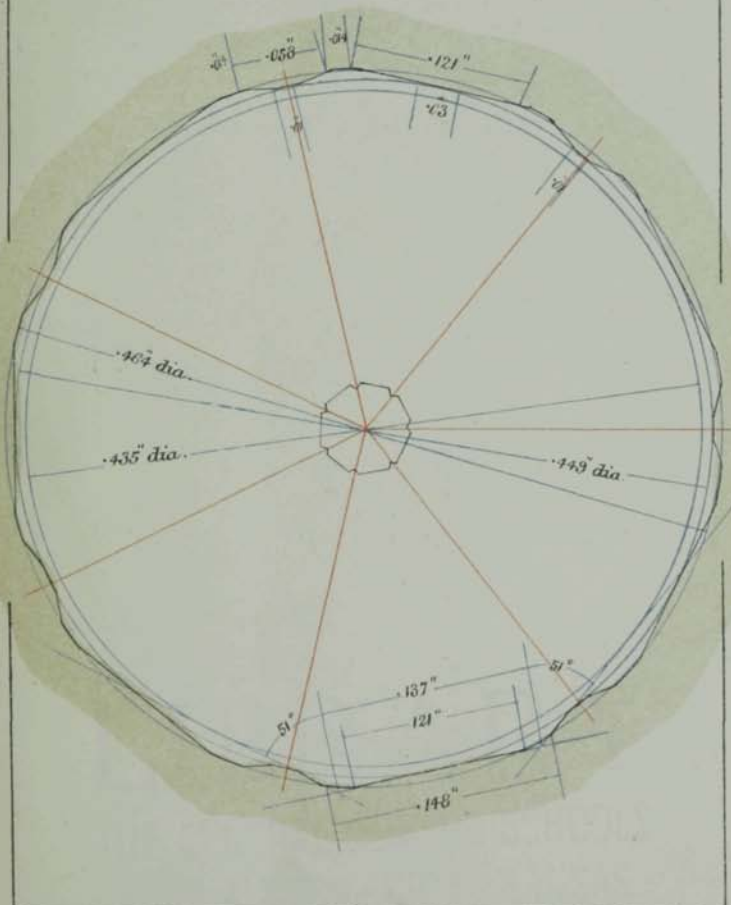
Section of Henry Barrel.

The details of Henry rifling are given in Plate 3.

5. Ratchet rifling (Fig. 5). It will be seen that each groove runs out to nothing at one side. The figure is a section of the

MR HENRYS SYSTEM OF RIFLING .

Section enlarged 8 times.



RIFLING, METFORD.

Section enlarged 10 times.

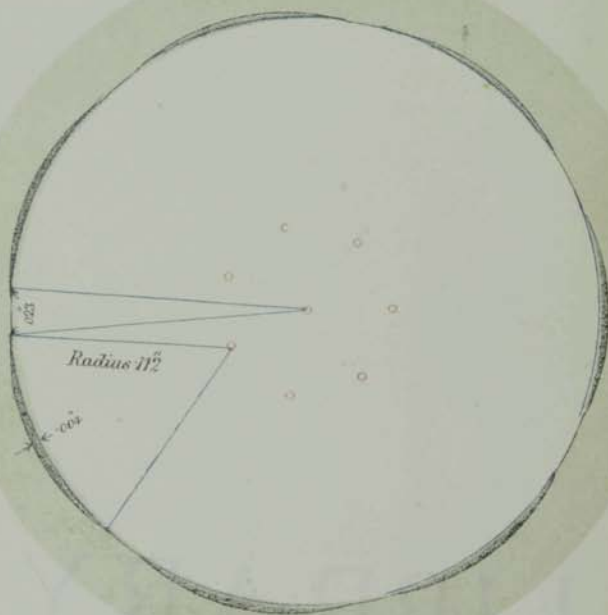
Diameter of Bore .303

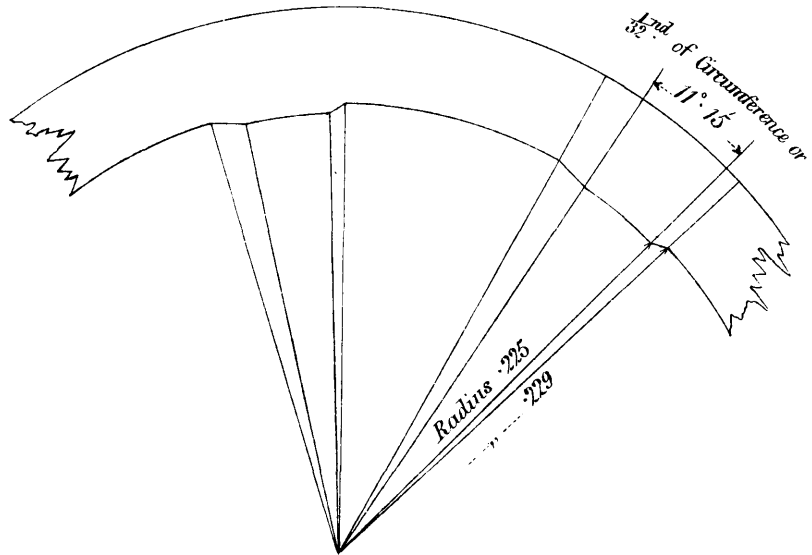
Depth of Rifling .004

Width of Lands .023

Twist of Rifling 1 turn in 10" (left hand.)

Radial Grooves.

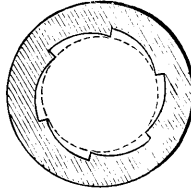




SECTION OF RIGBY GROOVE ENLARGED TEN TIMES.

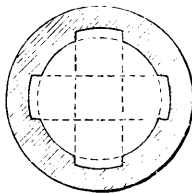
barrel looking from the breech, and with a right-handed twist the left or upright edge will be the one that resists, and causes the bullet to rotate to the right. Some advocate having the groove reversed, when with the right-handed twist the shallow sides of the grooves would be the resisting ones. This form of rifling was used in the experimental 0·4 inch Enfield barrel, 1886.

Fig. 5.



6. Some of the Continental military rifles, for example, the Gras, are now rifled with four grooves (Fig. 6) of about the same width as the lands; the twist is uniform, the grooves of the same depth throughout, and concentric with the axis of the bore.

Fig. 6.



The drawing in the above figures, with the exception of Fig. 4, is exaggerated to make the form of grooves more clear. This may be understood from the consideration that grooves of modern rifles are seldom more than ·007 inch in depth.

7. Rigby rifling. The grooves are eight in number, ·004 inch in depth, and are concentric with the axis of the bore.

The twist of rifling is uniform, 1 turn in 18 inches. The diameter of the bore is ·450 inch.

The design of this grooving will be understood by reference to the section, but in practice the angle made by the curved line forming the bottom of the groove and the side of the "land" is filled up by rounding off the angle of the cutter.

8. Metford rifling. This method of rifling will be best understood by a reference to the plate, in which it is shown as applied to the experimental 0'303 small bore barrel.

It seems to be now pretty well accepted that the simpler the form of the rifling the better; plain shallow grooves with an uniform twist appear to give as good results as those of a more complicated nature, which are more difficult to manufacture, to repair, and to keep clean.

BREECH-LOADERS.

Breech-loaders.

The invention of breech-loaders can be traced back to the 15th century, but from want of mechanical knowledge, and the failure to adapt a proper cartridge, little success attended this nature of arms till towards the middle of the present century.

The chief advantages obtained with breech-loaders may be summed up as follows:—

1. Rapidity of fire.
2. Impossibility of inserting a double charge.
3. Facility to inspect and keep the arm clean.
4. Loading in any position.
5. Employing the entire charge.

The invention of a reliable and thoroughly efficient military breech-loading action was a problem requiring considerable mechanical skill; the objects to be effected are as follows:—

1st. To open the breech of the arm and close it again rapidly and securely by simple and convenient movements without removing the hand far from the trigger, and without shifting the hold of the arm by the other hand.

2nd. To extract the cartridge case of the previous charge by the same movement as that which opens the breech, so as to present the open barrel ready for instant reloading.

3rd. To have the whole mechanism of a simple, strong, and durable character, free from risk of derangement, either by accident, long wear and tear, rough usage on active service, exposure to wet or sand, or fouling from long-continued firing. In the case of military arms the latter requirements are of special importance, as the value of a breech-loading arm in increased rapidity of fire would be outweighed by any increased liability to failure in action.

To meet the above requirements many plans have been devised for securely closing the breech; at present they may be classified under two heads—

- 1st. Bolt systems.
- 2nd. Block systems.

A breech action being simply a bolt or a block applied in a variety of ingenious ways, which closes at will one end of a tube, and contains an apparatus for exploding while it effectually supports the cartridge in front of it.

With the first the breech is closed by a bolt resembling an ordinary door bolt with handle, and contains within it the lock or striking arrangement to effect the explosion of the cartridge.

The block system has more varied forms, depending on the position of the pivot on which the block for closing the breech hinges. In the Peabody, Martini-Henry, and others, the block hinges on a pivot at right angles and above the axis of the barrel. In the Snider it hinges laterally on a pivot parallel with this axis. With the Remington the pivot is below and at right angles to the axis, and in the Wernsd the pivot is in line with the axis. With the American Sharp, Mr. Alexander Heury's, and Mr. Aston's actions, the block, sliding in a vertical slot, is lowered and the

action opened by depressing a lever. In the Springfield and Albini-Braendlin the block is pivoted above on the rear end of the barrel.

Passing over the first systems of breech-loaders, such as the needle gun, the Chassepôt on the bolt principle, the Sharp and Westley-Richards on the block principle, all of which fired paper self-consuming cartridges (*see* Chaps. V and VII), the more modern systems of breech-loaders, firing metal cartridges, will be described in this chapter.

Out of the almost innumerable inventions in bolt and block rifles, the following systems have been selected for description, with a view to illustrating notable examples of the various methods in which the bolt or block has been applied:—

Bolt.	Block.
Mausers.	Snider.
Gras.	Martini-Henry.
Vetterli.	Werndl.
Berdan.	Remington.
	Albini-Braendlin.
	Springfield.
	Aston.

The bolt principle, represented by the needle gun, was the first used in decisive warfare, and it is desirable to briefly describe this arm, as it was the parent of the bolt system, though, judged by our present knowledge, it was a clumsy weapon.

Needle Gun.

The breech of the needle gun was closed by a bolt resembling an ordinary door bolt, passing between guides, and containing within it the lock or striking arrangement to effect the explosion of the cartridge. To open the breech strike up the handle to the left till rather more than vertical, then draw back the bolt in a line with the barrel. To close the breech reverse this operation. The front end of the bolt formed a conical cup, which fitted over a corresponding conical end of the barrel, and closed the breech when pressed home by the turning down of the handle to the right into an inclined catch, thus preventing to a great extent the escape of the gas backwards; in practice, however, it was found that this joint was not sufficiently tight to prevent the occurrence of a spitting or escape of gas into the face of the firer.

The explosion of the cartridge was effected by a steel needle, which was driven forwards by a spiral spring, and, piercing the base of the paper cartridge, passed through the powder and struck the fulminate inside a cap situated within the cartridge, and immediately behind the bullet. The base of the bullet was fitted into a sabot made of compressed paper, which was forced into the grooves of the rifle by the discharge, and caused the bullet to rotate with it.

The cartridge case for this arm was of paper, and consumed by the discharge, so no extractor was necessary. The bore was .61 inch, and a bullet of 480 grains was fired with a charge of 70 grains of powder; it had a low muzzle velocity, and short effective range.

French Chassepôt.

This arm was an improved needle gun; the action was simpler and the bore smaller, viz., .433 with grooves of left hand twist. It is of interest as being the rifle used by the French in their late war with the Germans; the present French rifle, the Gras, is a modification of it.

The closing of the breech was effected by a cylindrical plug, with a packing ring of india-rubber which is pushed into the barrel, and was compressed and bulged out laterally by the back pressure of the explosion, so as to make a tight fit to the bore of the barrel.

It was found, however, that this elastic packing was liable to injury by use and by exposure to the heat of long-continued firing, and that it failed to keep the breech gas-tight.

This arm had a paper cartridge which was supposed to be consumed, but it was found that a residue was often left which fouled the breech chamber and rendered loading difficult. The weight of bullet was 385 grains; charge of powder, 87 grains.

Bolt Actions.

The bolt system of military breech-loaders is most in favour on the Continent, more probably because invention followed the type of breech action which in the needle gun had been so successful, than because it had been proved to be superior to the block system; similarly, in England, opinion perhaps leaned towards the block, following the conversion of our arms on the Snider system.

The selection of the Martini was, however, much influenced by the following objections to the bolt principle, the block being considered, on the whole, safer, while it supported the cartridge quite as well, and could be fired with equal, if not greater, rapidity:—

1. That the handle of the bolt is liable to catch in objects, and that it takes away from the symmetry of the arm.

2. A considerable length of the arm is taken up by the bolt action.

3. In the event of a cartridge case jamming, there is no leverage to effect the extraction.

4. Should the breech action fail owing to a defective cartridge or other causes, the bolt, being in a line with the firer's eye, would be more likely to cause him injury, and several accidents of this kind have occurred.

5. In the event of a projecting cap from the base of the cartridge, or an over sensitive one, the bolt, from the direction of its motion, would be more likely to explode it in closing the breech than with the block system.

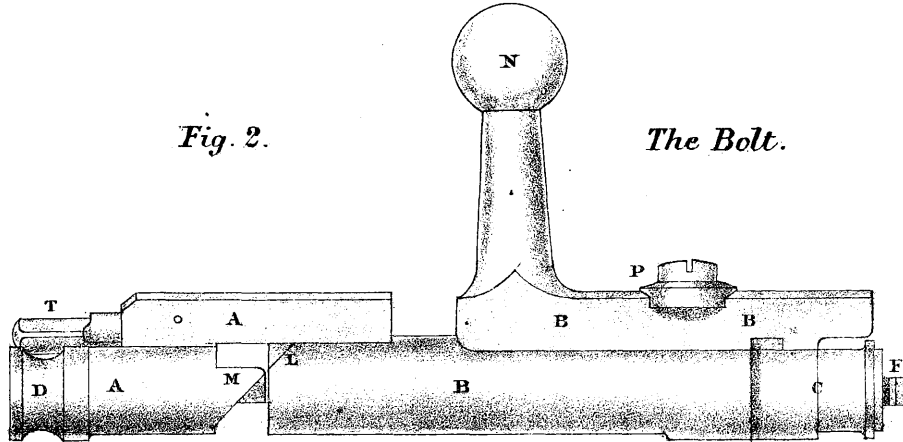
The bolt principle is, however, doubtlessly better suited for the adaptation of a magazine arrangement, and for this reason it will probably supersede the block.

The actions of all bolt guns being similar in principle, it is considered sufficient to give a full description of one only, and the Mauser may be taken as a typical arm.

MAUSER RIFLE.

Fig. 2.

The Bolt.



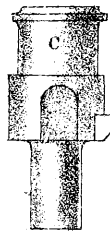


Fig. 3.

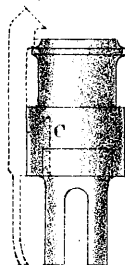


Fig. 4.



Fig. 5.



Fig. 6.

Extractor

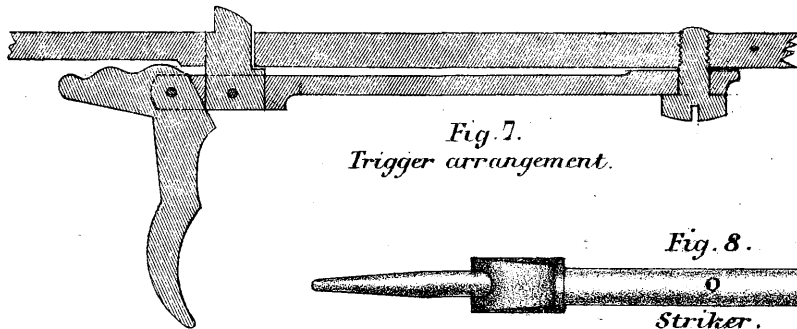


Fig. 7.
Trigger arrangement.

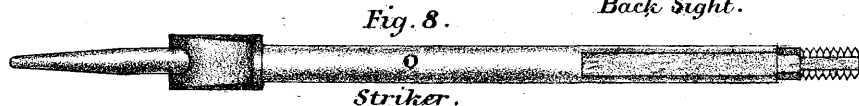


Fig. 8.
Striker.

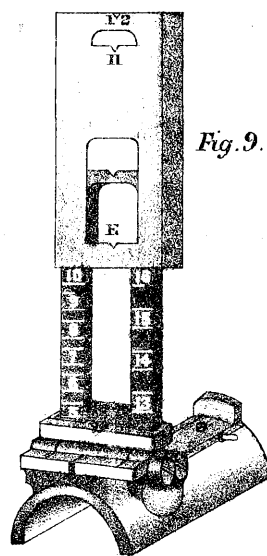
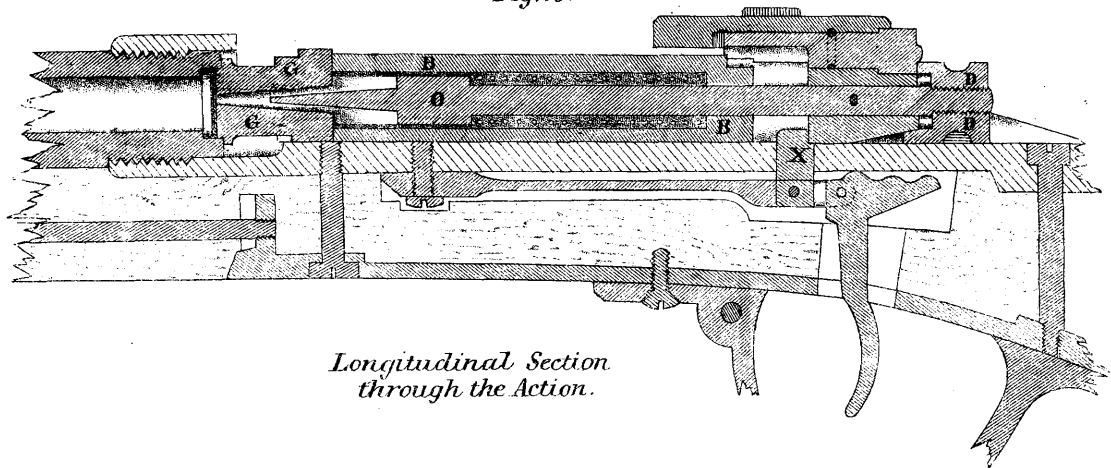


Fig. 9.

Back sight.

MAUSER RIFLE.

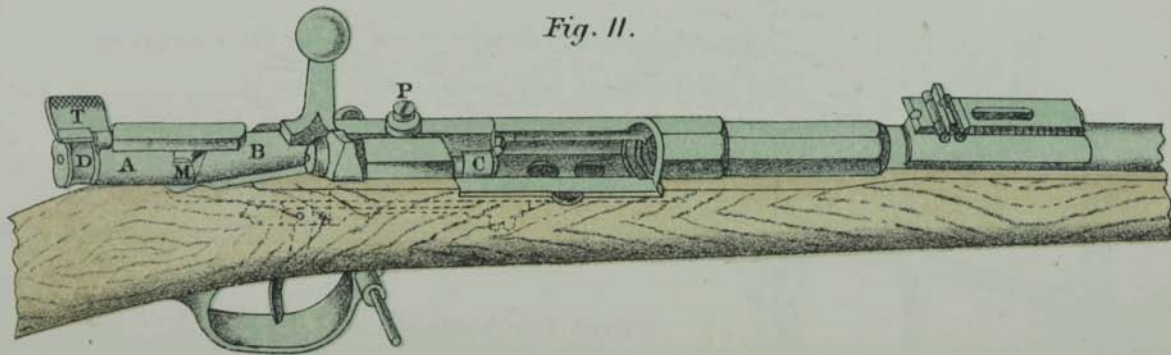
Fig. 10.



*Longitudinal Section
through the Action.*

MAUSER ACTION.
(Breech open)

Fig. II.



GERMANY.

Mauzer Rifle.

This is a bolt gun with steel barrel. Four circular grooves; diameter of bore 0.433 inch; twist, one turn in 22 inches. Right-handed twist.

To the barrel is screwed the body or shoe in which the bolt moves, cut down in front on the right side for the purpose of facilitating the loading and extraction, and to receive the handle or lever when turned down to the right in the final motion of closing the breech.

The bolt, Fig. 2, consists of three principal pieces, viz., A the hammer or rear piece; B the centre piece with handle N; and C the front piece carrying the extractor F; a nut D secures the rear end of the striker to A; the striker O, Fig. 10, passes internally through the pieces A, B, and C. The centre piece B contains a coiled spiral mainspring encircling the striker. There is a helix or curved inclined portion cut out of the centre piece at L, Fig. 2, into which a corresponding shaped projection M on the hammer fits, when these two pieces are in actual contact. To load, strike up the handle N from the right until it is vertical, as in Fig. 2, in this movement the handle first slides up the inclined surface of the shoe, and slightly moves the entire bolt to the rear, at the same time the hammer A, being incapable of rotation, its projection M is forced to slide up the inclined surface of L, and to come into the position shown in Fig. 2; this movement, besides separating the hammer and centre piece, compresses the main spring. The entire bolt can now be drawn to the rear until the washer at P, Fig. 2, strikes against the upper part of the shoe, which stops it. By this motion the empty cartridge case is withdrawn, and can be removed by hand. A fresh cartridge is now inserted, and the bolt pushed forward by the handle which sends it into the chamber. When the above movement is almost completed, the projecting trigger nose X, Fig. 10, catches the hammer A and retains it. The centre piece is now turned to the right by the handle into the recess of the shoe, and this has the effect of slightly moving forward the centre piece B as well as the front piece C, and gives a final slow motion to the cartridge into the chamber, and thus lessens the risk of a premature explosion. The pressing down of the handle to the right also further separates the hammer from the rest of the bolt, it also increases the tension of the mainspring, and brings the cavity L, Fig 2, exactly opposite the projection M. On pulling the trigger, the trigger nose X is depressed, and the hammer set free, the latter then moves forward under the action of the compressed spiral mainspring, carrying the striker with it, until the projection M falls into the cavity L, and the point of the striker, passing through a small hole in the face of the front piece, strikes the percussion cap and explodes the cartridge.

There is a half-round safety bolt attached to the rear piece of the bolt rotated by a thumb piece T, Fig. 11. When the flat side of this safety bolt is under, it does not act, but when the thumb piece is turned to the right, it brings the round side down into a

cavity in the centre piece B, and keeps this piece and the hammer or rear piece firmly apart, and in this position of the safety bolt the arm cannot be fired.

The extractor F shown in Fig. 2 moves in a groove cut in the interior surface of the shoe. Figs. 3, 4, 5, and 6 show the position of the extractor, and how it is attached to the front piece of the bolt:—

The trigger arrangement, Fig. 7, resembles that of the needle gun.

The back-sight, Fig 9, gives elevation to 1600 metres. It is of a complicated character, having no less than five notches suitable for different ranges.

1st notch on base up to 300 metres.

2nd notch in small hinged flap turning down to the rear for 400 metres.

For higher elevations there is a flap and slide, on the latter of which there are three notches. The left side of the flap is graduated to 1,000 metres; and with these graduations the lowest notch on the slide at E is used.

For 1100 and 1200 metres the slide is pushed down to the base of the flap, and the notches marked 11 and 12 give the correct elevation for those distances.

For further distances, up to 1600 metres, raise the slide and take the figures on the right of the flap, using the highest notch marked 12 in taking aim.

The motions in loading are—

1. Open the breech by striking up the handle and drawing back the bolt.

2. Insert the cartridge.

3. Close the breech by pushing forward the bolt and turning the handle a quarter circle to the right.

In 1884 the Mauser rifle was converted into a repeating arm, on a system somewhat similar to the Krapatschek (*see* page 50).

FRANCE.

Gras Rifle.

Bolt action; barrel cast steel, 4 grooves of equal width with the lands; left-handed twist, making one turn in 22 inches.

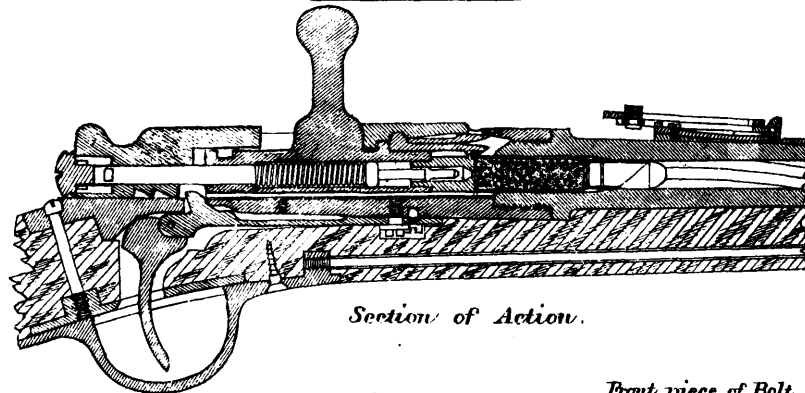
The bolt for closing the action slides in a shoe H with recess cut out on right side, into which the handle is turned to secure the breech.

The bolt consists externally of three principal pieces the functions of which are precisely the same as in the Mauser.

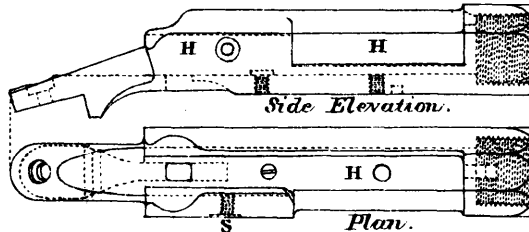
The backward movement of the bolt is limited by a screw S, which passes through the right side of the shoe, and its extremity works in a groove cut in the centre piece of the bolt.

The extractor is a spring composed of two arms, with a stud on the upper, which connects it with the front piece of the bolt. The lower arm is provided with a claw to grip the base of the cartridge. It will be noticed that on closing the breech the

GRAS RIFLE.



Section of Action.



Shoe.

Side Elevation.

Plan.

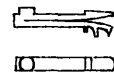
Front piece of Bolt.



*Step across
of Bolt.*



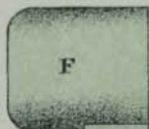
Extractor.



VETTERLI RIFLE.



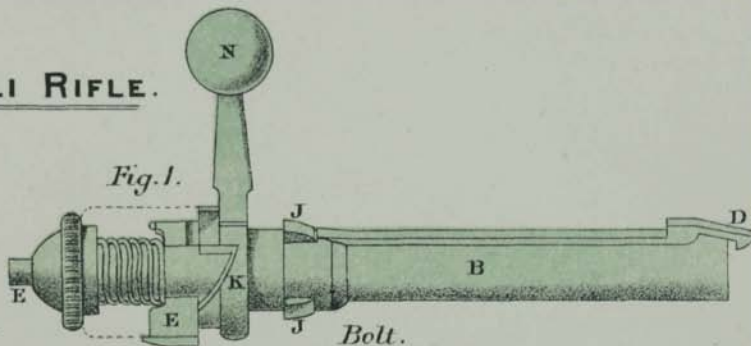
Nut.



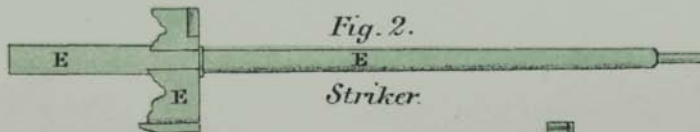
Spring Cover.



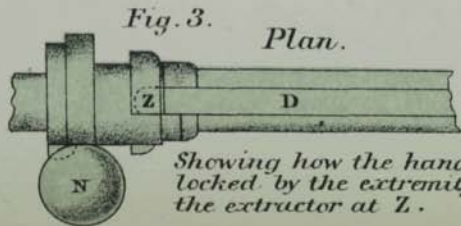
Main Spring.



Bolt.

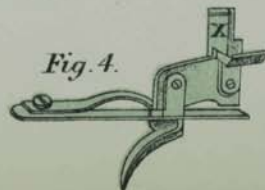


Striker.



Plan.

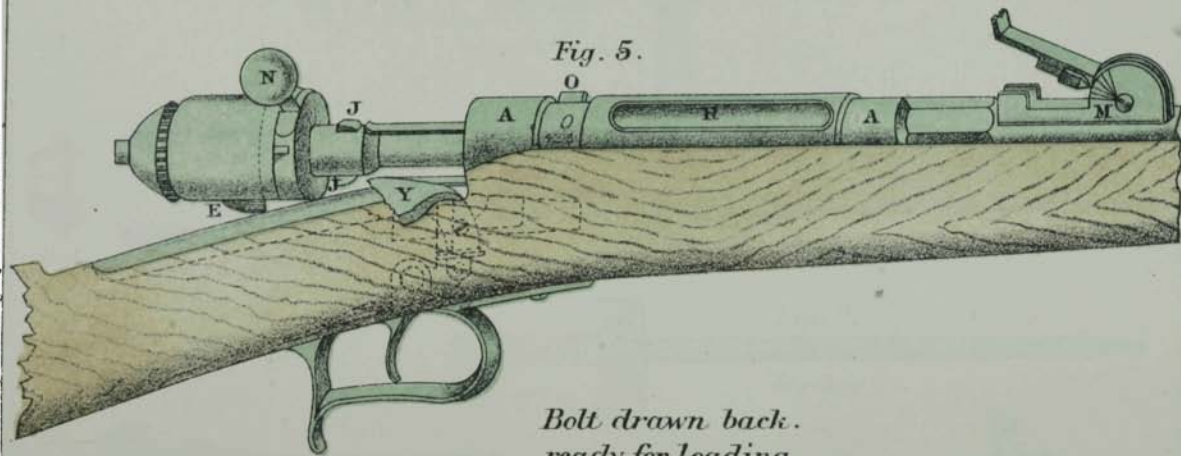
Showing how the handle locked by the extremity of the extractor at Z.



Trigger.

VETTERLI RIFLE.

Fig. 5.



*Bolt drawn back.
ready for loading.*

To face page 41.

upper arm is constrained to slide up an inclined plane, thus bringing the spring to tension, and ensuring the lower arm taking a firm grip of the rim of the cartridge. The lower arm has also sufficient play to pass easily over the cartridge rim in closing the breech.

The back-sight is hinged to a bed, which is soldered to the barrel. It consists of a flap and a sliding bar. These can be turned down to the front or the rear, or can be maintained in a vertical position by means of a flat spring in the bed. With the bar and slide, elevation can be given for a range of 1800 metres (1969 yards).

Motions in loading and firing the same as in Mauser.

1. To open the breech, turn the handle from right till vertical, then draw back the bolt; these motions put the mainspring at tension, and extract and eject the empty cartridge case.

2. Insert the fresh cartridge, pressing it home.

3. Push forward the bolt and turn the handle down to the right until in its place; the rifle is then ready for firing.

4. Pull the trigger; this frees the rear piece of the bolt, which with the striker is carried forward by the spiral mainspring, and strikes the cap in the base of the cartridge.

ITALY.

The Vetterli Rifle.

This is the military rifle now used in Italy. It is a bolt gun of peculiar design.

The shoe or body A, Fig. 5, is screwed to the barrel; within this slides a bolt B, Fig. 1, with projections J, which fit corresponding grooves cut on the inside of the shoe.

1. Raise the handle N vertical; this causes the striker E within the bolt to run up the inclined plane K, at the same time drawing the striker back and compressing the mainspring G. The bolt can now be drawn back until the forward end of the extractor D strikes a small quoin or bolt at O, Fig. 5, which stops it. To load.

On the bolt being drawn back, the rear end of the extractor, so soon as it is free of the shoe, being a spring, catches and locks the handle by entering a recess in that part, the position of which is shown by the dotted lines at Z, Fig. 3 and ensures the mainspring being kept at tension. The cartridge is now inserted through the slot or opening in the upper part of the shoe, and the bolt pushed forward, sending it into the chamber; during this movement the rear end of the extractor comes against the quoin at O which unlocks the handle N, and allows it to be turned down to the right, thus securing the bolt firmly. The projection on the striker E, Fig. 5, is at the same time caught by the trigger nose, which retains it and keeps the mainspring at tension, the arm is now ready for firing. On pulling the trigger, the trigger nose is depressed, allowing the mainspring to drive the striker forward, and explode the cap in the base of the cartridge.

The trigger arrangement is shown Fig. 4; the pulling of the trigger depresses the trigger nose as in other bolt guns.

There is a locking bolt at Y, Fig. 5, in connection with the trigger, so that the arm can with safety be carried loaded.

The back-sight is of the quadrant form, marked radially, and does not appear adapted for fine shooting.

The action is protected from the entry of dirt by a revolving cover.

RUSSIA.

Berdan No. 2.

This is the military rifle now used in the Russian Army.

No. of grooves, 6; twist, right-handed, one turn in 21 inches.

The bolt consists of three pieces; it slides in a shoe.

The extractor E is attached to the centre piece; its action is novel, being actuated by a small spiral spring, which pushes it out, and by a screw H which keeps it up to its work, but at the same time allows it a certain play.

The extractor, being attached to the centre piece of the bolt, which rotates a quarter circle, must rotate the same amount round the rim of the base of the cartridge.

To load, raise the handle vertical. This motion slightly draws back the entire bolt. Draw the bolt to the rear until the catch N enters the recess M in the bolt and stops it; this movement withdraws the empty cartridge case. Insert a fresh cartridge, and push forward the bolt; the sear nose F falls into the first catch, shown at A, and retains the rear piece, the mainspring not being at any tension, as was the case with the Mauser, Gras, &c. Continue the movement of pushing forward the bolt; this compresses the mainspring. Turn the handle down to the right, which secures the bolt. The arm is now ready to fire.

On pulling the trigger the sear nose is released from the catch, and the rear piece with striker connected moves forward under the action of the mainspring and explodes the cartridge.

There is a half-cock catch at L, so that the arm can be carried loaded with safety; to cock the arm from this position pull the button at N until the sear falls into the foremost notch at A. There is also a small bolt or latch at X attached to the rear piece of the bolt, which falls into a recess underneath in the shoe when the rear piece moves forward on firing; this is for the purpose of strengthening and giving rigidity to the bolt.

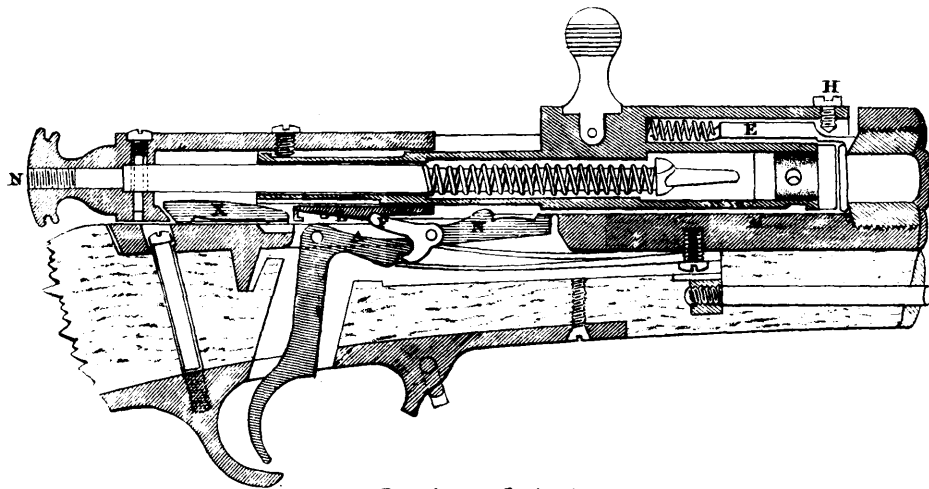
BLOCK ACTIONS.

SNIDER RIFLE.

The Snider action was adopted in 1865 as the mode of altering the existing muzzle loaders.

The shoe L is screwed to the barrel, the breech is closed by a block B, which lifts and turns over laterally for opening the breech, being hinged on a longitudinal pin on one side of the action; the

BERDAN. (N^o 2.)



Section of Action.

SNIDER.

1866.

Fig. 1 Loading.

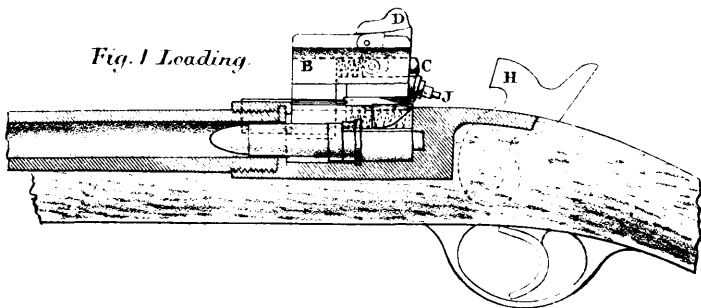


Fig. 2. Firing.

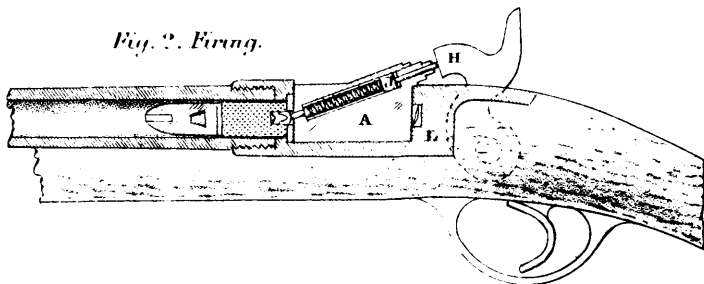
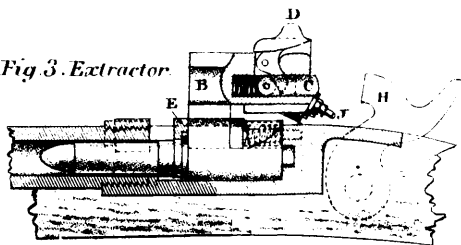
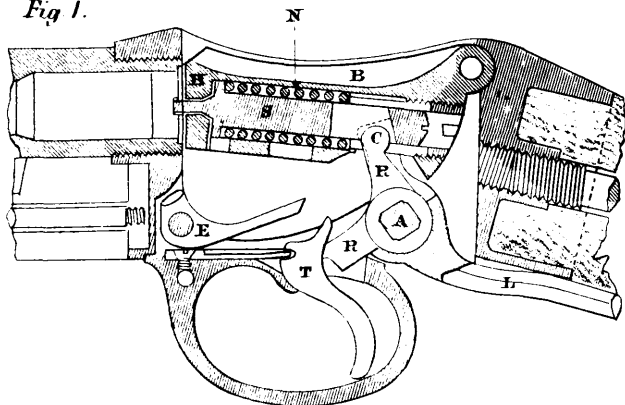


Fig. 3. Extractor.



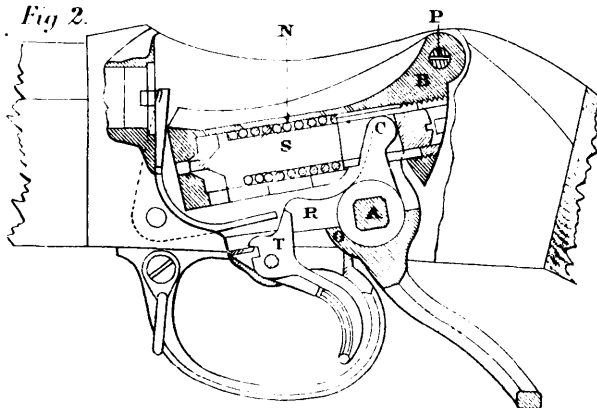
MARTINI BREECH ACTION. *(Closed and Fired.)*

Fig 1.



MARTINI BREECH ACTION. *(Open.)*

Fig 2.



MARTINI ACTION. (Cocked ready to Fire.)

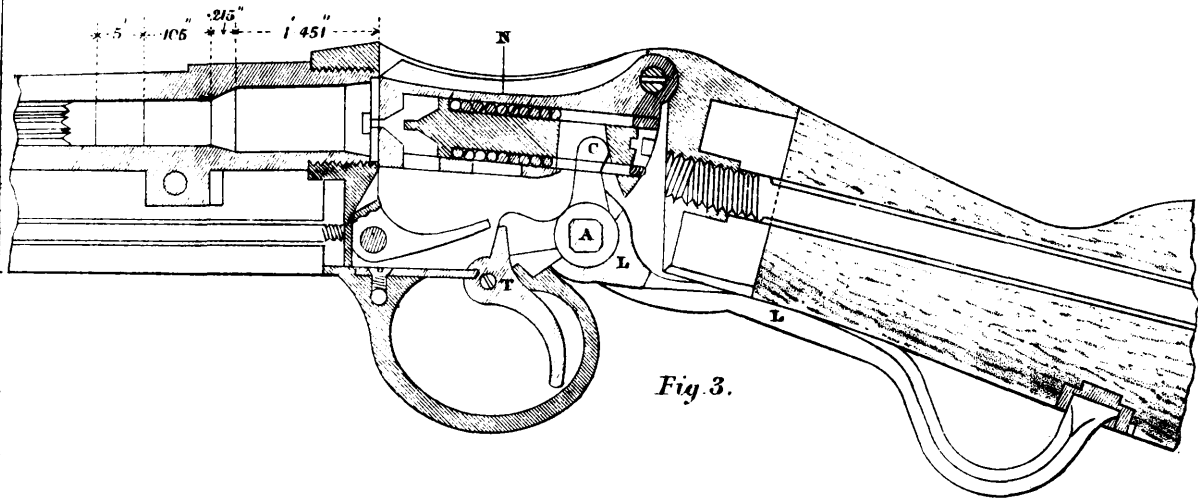


Fig. 3.

breech is then open for inserting the cartridge in loading. When closed again (Fig. 2) the block is securely locked in its place by a spring catch C, which is withdrawn by a lever D pressed by the thumb in the act of lifting the breech block. The firing of the cartridge is effected by an ordinary hammer and percussion lock, propelled by a flat mainspring in the usual manner, and acting upon a striker J which passes obliquely through the breech block, and terminates at the centre of the cartridge base; this pin has a light spiral spring to draw it back after striking the cap. For extracting the empty cartridge case an arm E is provided, which slides upon the hinge-pin of the breech block. When the breech is open, the breech block being drawn back, brings with it the extractor, which seizes a portion of the rim of the cartridge and draws it out of the chamber, so that it can be dropped out or picked out by hand.

The breech block is then forced forward again by a spiral spring on the hinge pin, which is covered by two hollow cylinders sliding the one into the other. The Snider rifle is of the large bore class, .577 inch calibre, bullet 480 grains, fired with a charge of 70 grains of powder.

Martini-Henry Rifle.

The action of this rifle resembles the Peabody, but considerable ingenuity was displayed by M. Martini in doing away with the side lock and replacing it by one in the breech block, which is cocked by the same movement as that which opens the breech.

The rifle consists of a barrel screwed into a shoe or body V (see Figure), a butt, and a fore end. The body contains the breech action, which is the mechanism for closing the breech, firing the cartridge, and extracting the empty cartridge case.

The breech is closed* by a block B, which swings on a pin P, passing through the upper rear end of the shoe or body, the recoil being taken by the back and sides of the body, and not by the pin. The cartridge is exploded by the striker S, which is driven by the action of a strong spiral spring N within the breech block. A lever L in rear of the trigger guard acts by means of two horns on the breech block, so that the action of lowering the lever causes the block to fall and to strike the extremity of the lower arm of the extractor E, thus ejecting the cartridge case. With the same motion, and at the same time, the lever carries the tumbler R round until the trigger nose falls into the bent of the tumbler, and retains that component in the cocked position (Figs. 2 and 3). The action of the lever in the above movement also draws back the striker and compresses the mainspring N by means of the crane C of the tumbler, which engages in a slot cut through the striker S.

The action of the extracting lever requires especial notice. It is so arranged as to give its greatest power at the commencement of the extraction, to overcome the first resistance and start the cartridge, and its greatest velocity at the end to jerk it away. Contact of the extractor arm with the falling block takes place

* See Figs. 1 and 2.

at two alternative points; at the beginning of the extraction it acts so as to give the shortest leverage with the block and the longest with the extractor, but after the block has moved through a certain space, still continuing to bear on the extractor by the motion of the lever, the point of contact changes, so as to reverse the conditions. It is evident that when the extractor arm has become flattened, *i.e.*, lost its proper set up, the first contact does not take place, and this has been the chief cause of the alleged failures in extraction, attributed ignorantly to the cartridge.

On returning the lever to its former position, the block is raised by the horns so as to close the breech, and the mainspring is still further compressed, but the tumbler does not move; it is retained and held firmly by the trigger nose. The arm is now cocked and ready for firing.

To make the above clearer it is as well to point out that the lever and tumbler are upon the same axis pin or spindle, A, which is square at the central part, the seat of the tumbler, and this component is incapable of rotating upon it, while the outside parts of the same pin, on which the lever works, are round, and so the lever is free to rotate upon them. On lowering the lever a projection on it at O, Fig. 2, pushes the tumbler, R, round until the latter engages the trigger nose which holds it. The lever is then free to rotate on the axis pin back to its former position.

There is an indicator on the right side of the action at I (see Figure) forming part of this axis pin, which at all times shows the position of the tumbler, and whether the arm is cocked or otherwise.

On pulling the trigger to fire the arm, the trigger nose is freed from the bent of the tumbler; the striker moves forward under the action of the compressed mainspring, rotating both the tumbler and axis pin, as shown by the indicator outside, and striking the cap in the base of the cartridge.

The barrel is of steel, which, owing to its greater strength, elasticity, and hardness, is far superior to wrought iron. It is rifled with seven grooves, right-handed twist, one turn in 22 inches; of the original bore, 0"·03 in the centre of each groove, and 0"·01 between each groove are left as lands, being both contained in the circumference of a circle with the axis of the bore as centre; this may be understood by considering that the cutting tool which forms the groove is not rounded like a gouge, but is right-lined like a chisel, consequently the centre of the tool is the last point which touches the circular bore, and when this takes place the groove is of the proper depth.

The depth of the grooves is progressive for the first 11 inches from the breech, then they are of uniform depth to the muzzle.

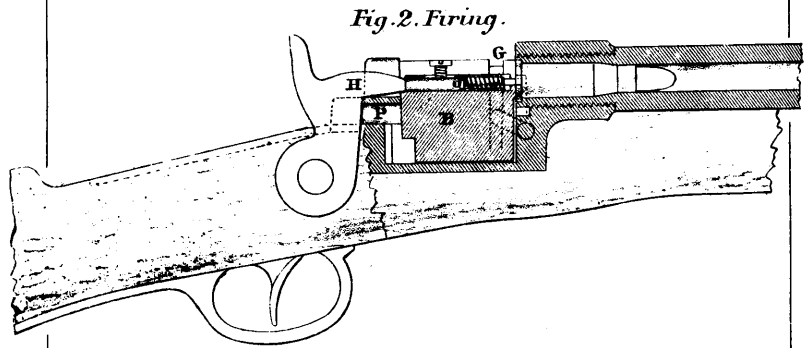
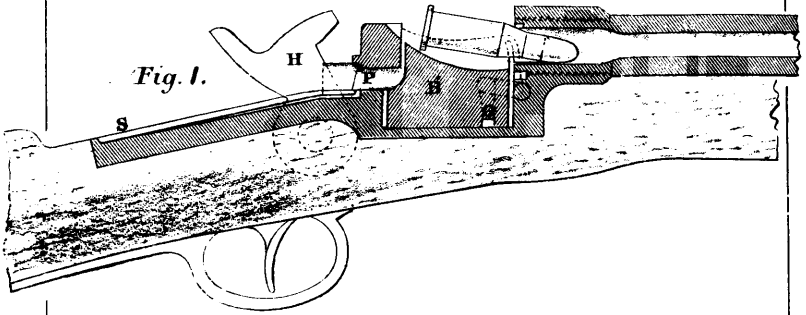
A groove is .009 inch deep at the breech, progressing to .007 inch at 11 inches from it, and continuing at that depth to the muzzle.

The bore is slightly enlarged towards the breech for 8 inches.

The chamber is coned .018 inch to facilitate extraction.

The stock is made from Italian walnut, and is in two parts, the butt, and the fore-end. The butt is secured in the socket of

WERNDL. 1867.



Elevation of Breech Block.

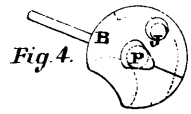


*Fig. 5.
Extractor.*

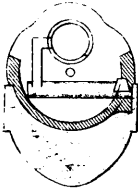


*Fig. 6.
Breech Open.*

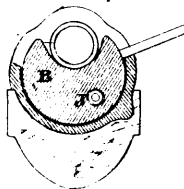
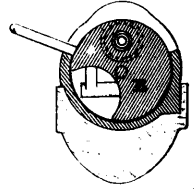


*Fig. 7.
Breech Closed.*



the shoe or body by means of a screw bolt; and a loop and pin and two bands connect the fore-end to the barrel. In the latest pattern rifle the loop and pin have been replaced by a fore-end hook, which engages into a recess in the front of the body.

Length of rifle with bayonet fixed, 5 feet $11\frac{1}{2}$ inches.

Do. without bayonet, 4 feet $1\frac{1}{2}$ inches.

Weight of rifle without bayonet, $8\frac{3}{4}$ lbs. It is sighted to 1450 yards.

Martini-Henry Carbines.

The carbines of the cavalry and artillery patterns have the same calibre as the Martini-Henry rifle (0.45 inch), and have also the same twist and form of rifling, but the barrels are only 19 inches in length. The processes of manufacturing the various parts are precisely the same as those for the rifle, with which most of the components are interchangeable.

Weight, 7 lb. 8 oz., cavalry carbine.

„ 7 lb. $10\frac{1}{2}$ oz., artillery carbine.

Length, 3 feet $1\frac{1}{16}$ inches.

The artillery carbine is made to take a sword bayonet, and is fitted with swivels for a sling; in these respects it differs from the cavalry carbine.

These carbines are sighted to 1000 yards.

AUSTRIA.

Werndl Rifle.

This arm has a rotating breech block consisting of a solid longitudinal cylinder B which turns one-quarter round upon a centre pin P at each end, situated just below the axis of the barrel (Figs. 1 and 2). A cylindrical groove is cut out along one side of the block, and when this groove is turned opposite the barrel, the breech is left entirely open (Fig 1) ready for inserting a fresh cartridge; by reversing this operation the breech is closed. The breech block is held at either extreme of its rotation by a spring S bearing against the projecting end of its centre pin P (Fig 1), which is formed with two inclined flat sides for this purpose as shown in the end elevation (Fig 4). A striker J is carried obliquely through the breech block for conveying the blow to the centre of the cartridge base from the hammer H which is on one side, similar to the ordinary percussion-lock hammers.

The cartridge extractor is carried on a traverse pin, I just below the barrel, and on the other end of the pin is a horizontal arm shown dotted in Fig. 1, having at its extremity a lateral projecting stud which enters a groove G cut round the cylindrical surface of the breech block, Fig. 3; by the rotation of the block in opening the breech, the end of the groove is brought down upon this stud, and depresses the arm of the extractor sufficiently to withdraw the cartridge partially from the chamber as in Fig. 1. The breech block is made with a slightly spiral face at the rear end, as shown in the side elevation, Fig. 3, by which it is driven home against the end of the barrel in closing the end of the breech, as in Fig. 2; and in opening the breech the stud on the

horizontal arm of the extractor bearing against the rear side of the groove G in the block which is cut slightly spiral for the purpose, gives the block a slight longitudinal movement backwards from the end of the barrel, as in Fig. 1. The extraction is evidently a weak point in this arm.

SPAIN, NORWAY, SWEDEN, DENMARK, EGYPT.

The Remington Rifle.

The breech is closed by a block B, shaped like the sector of a circle, which turns down backwards to open the barrel, revolving upon a transverse pin, and when closing the barrel it is held up against the breech by a second sector-shaped block H turning on another transverse pin behind the breech block, the two sectors mutually detaining and slipping past each other alternately, as shown in Figs. 1 and 2. The front sector B forming the breech block has a square notch in it fitting close to the end of the barrel, Fig. 1; the back sector H, carries the hammer which strikes a firing pin in the breech block. The front side of the hammer sector is hollowed out to fit the top cylindrical surface of the breech block, as shown in Fig. 1, and the rear of the breech block is similarly hollowed out to fit the top of the hammer block as shown in Fig. 2. When the breech block is open, as in Fig. 1, it holds the hammer back and prevents it from moving, and when the breech is closed and the hammer in the act of firing, as in Fig. 2, the breech block is prevented from moving by the hammer block bearing against the hollow surface of the rear of the breech block. The two blocks combine in resisting the backward force of the explosion when the gun is fired. The extractor is a horizontal slide E, Fig. 1, at the left side of the barrel laying hold of the base flange of the cartridge; a projecting nose on the under side of the extractor is caught and drawn backwards a short distance by the breech block in the act of opening the breech, and the empty cartridge case is thus drawn slightly backwards, and can be picked out by hand. A lever L pressed by a spring into a recess at the bottom of the breech block holds it steady in its position when closed, and the tail end of the same lever is made to act as a stop to the trigger T Fig. 2, preventing it from being pulled off until released by the front end of the lever entering the recess in the breech block, when the breech is fully closed, as in Fig. 1.

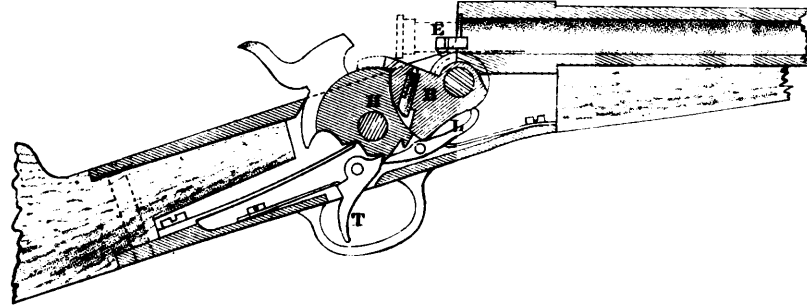
BELGIUM.

Albini-Bracndlin.

The breech is closed by a hinged block B that opens upwards and forwards, turning upon a transverse pin at the end of the barrel; when closed the block is held down by a spring catch C shown dotted in the plan, Fig. 3, which is withdrawn by the lifting handle D of the block in the act of opening the breech. The breech block contains a striker J as in the Snider, which is struck by an ordinary external hammer H, but the blow is conveyed through a sliding pin P which is hinged upon the

REMINGTON.
1867.

Fig. 1. Loading.



REMINGTON.
1867.

Fig. 2. Firing.

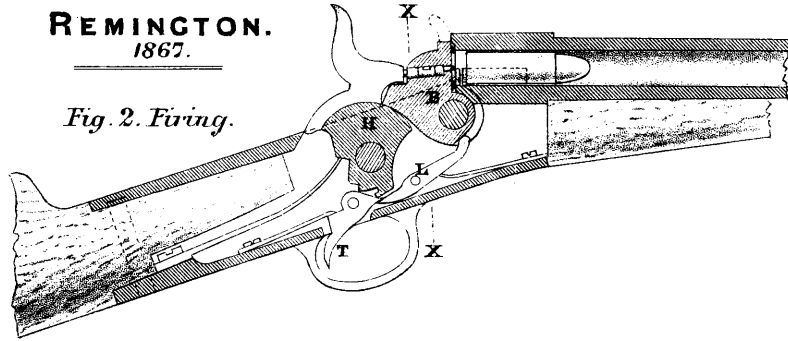


Fig. 3. Plan.

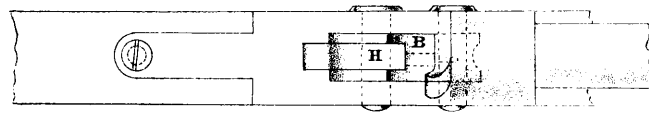
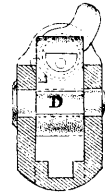


*Fig. 4.
Transverse
Section at XX.*



ALBINI-BRAENDLIN.
1867.

Fig. 1. Loading.

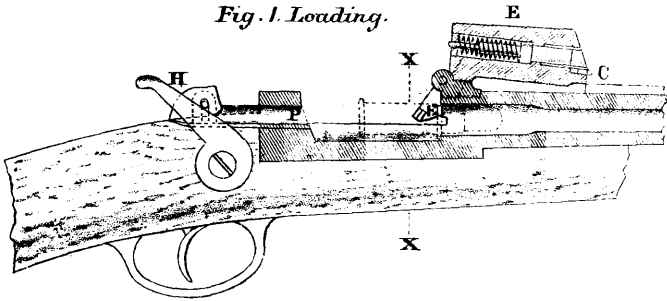


Fig. 2. Firing.

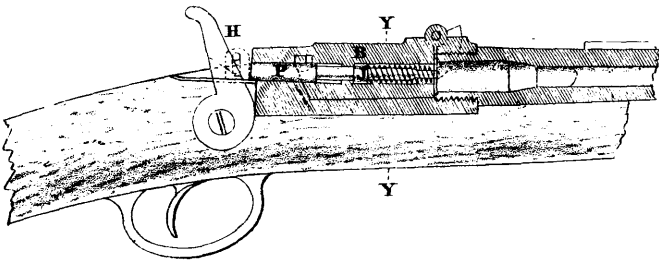
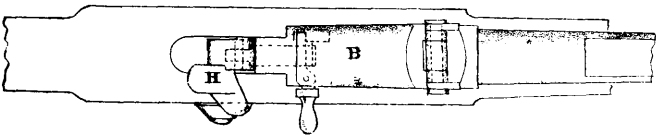
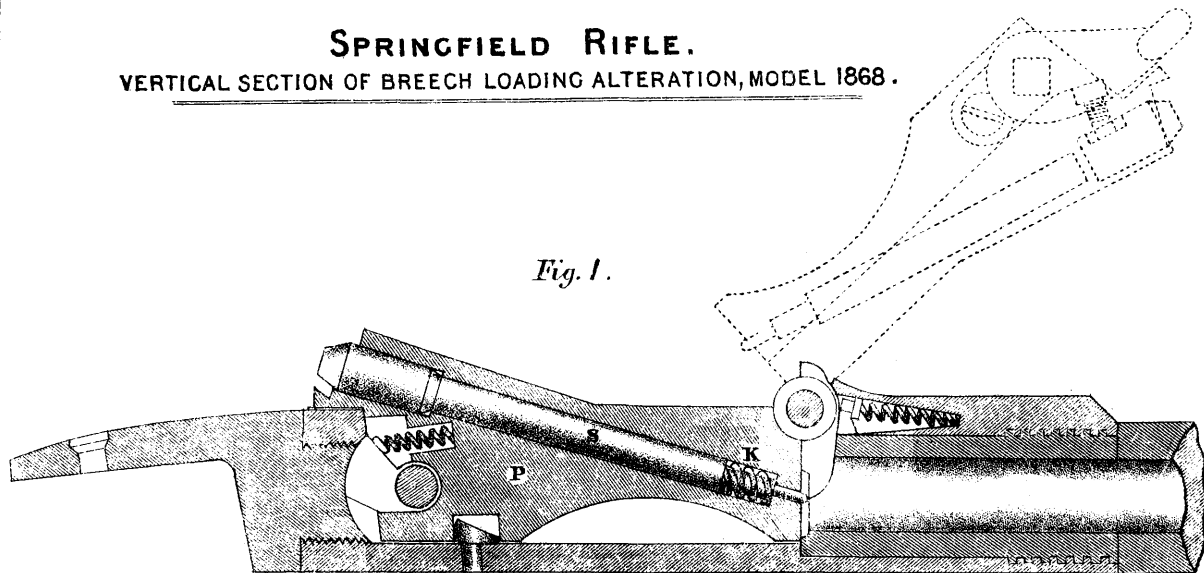


Fig. 3. Plan.



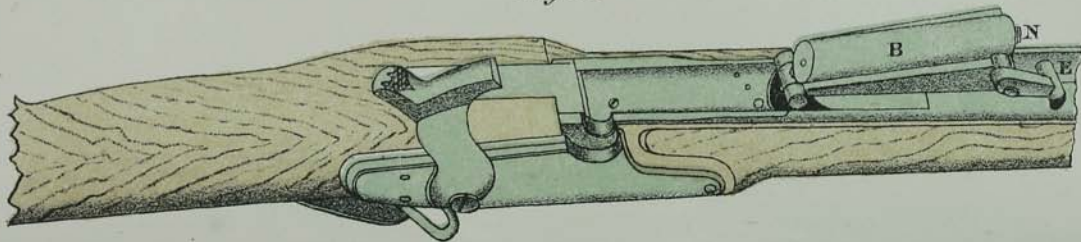
SPRINGFIELD RIFLE.
VERTICAL SECTION OF BREECH LOADING ALTERATION, MODEL 1868.

Fig. 1.



SPRINGFIELD RIFLE.

Fig. 2.



Original Pattern.

hammer, and, passing through a guide, enters a short distance into a recess in the breech block before reaching the striker, as shown in Fig. 2. This plan prevents any risk of the arm being fired without the breech block being fully home in its place, and the sliding pin P serves as a steady pin to hold the block firm at the instant of firing.

The breech block in the act of closing has the effect of forcing the cartridge home into its place in the chamber. The extraction of the empty cartridge case is effected by an arm E, Fig. 1, hanging freely on the hinge pin of the breech block, and laying hold of the base of the cartridge; a projection on the front of the arm is struck by the breech block in the last portion of its movement in opening, causing the extractor to jerk the cartridge case clear out of the barrel. The extractor is made double, with an arm on each side of the cartridge.

UNITED STATES.

Springfield Rifle. Model, 1878.

This rifle has a block action; it resembles the Albini-Braendlin; the block pivots on the rear end of the barrel, and is fastened down when closed by a bolt N and spring, actuated by means of a projection on the right side of the action E.

The striker S and spring K for its withdrawal are contained in the block.

The striker is struck by the ordinary hammer of a front action lock.

The Aston Rifle.

Although Mr. Aston's breech action, invented in 1871, has not been adopted by any Military Power, its merits deserve mention as an example of the later application of the vertical block action.

The rifle has a vertical block action, fitted with two flat springs—*mainspring* and *trigger spring*—which can be made in one piece.

The striker has two bents for full and half-cock. To strike the cap it moves a quarter circle, doing away with *piston* and spiral spring.

The breech is opened and closed by a lever on the right side, or with lever fitted underneath, which forms bow of trigger-guard; cocks, and throws out the empty cartridge case when opening the breech.

It is easy to strip and put together again, and not liable to get out of order.

The barrel can be cleaned either from the breech or muzzle.

In the construction of the rifle all projections have been avoided. It is a simple action, with very few parts, and can be fitted to any barrel carrying a central-fire cartridge.

Names of Parts.

1. Body.	7. Trigger.
2. Breech-block.	8. Trigger-screw.
3. Extractor.	9. Trigger-spring.
4. Striker and point.	10. Trigger-spring screw.
5. Lever catch and spring.	11. Trigger-plate.
6. Mainspring.	12. Side-nail.

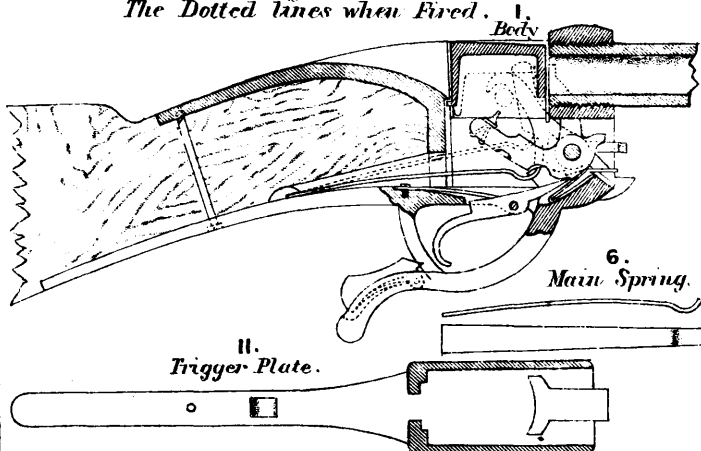
Compared with the Martini, the following advantages are claimed by Mr. Aston for his breech action:—

- 1st.—The simplicity of the action, which consists of only 12 as against 20 pieces in the Martini, and may, if desired, be reduced to 10 by making the mainspring and trigger-spring in one, in the form of the old-fashioned simple  spring.
- 2nd.—The mainspring and trigger-spring, being flat springs (the former being fixed in the action without either screw or pin, and removable with the finger and thumb), can, if broken, be replaced by any blacksmith, who could also, with the ordinary appliances at his command, repair any part of the lock which might get out of order. This alone is a *most important advantage* in the Colonies or in the field, where the services of skilled operatives, such as armourers or gunsmiths, are not easily obtained.
- 3rd.—In the Martini, when the point of the striker or mainspring is broken, the arm is disabled until another striker or spring can be replaced by someone qualified to strip and remount the action (the latter process being almost impossible to the uninstructed), but the striker point in the Aston action being a split pin of about $\frac{3}{4}$ inch in length, is so fitted as to obviate the chance of its breaking by fair wear. The action can also be stripped and remounted by any person who can use an ordinary turnscrew; the different parts, except the trigger and trigger-spring, being held in their places by the side nail.
- 4th.—The extractor is an improvement on that of the Martini; being acted on directly by the lever extraction, is made certain.
- 5th.—The construction of the action admits of the barrel being cleaned with a rod *from the breech end*, instead of (as in the Martini) from the *muzzle end only*; thus with ordinary care in cleaning no dirt or moisture ought to get into the action.
- 6th.—The compactness of the action admits of the body being case-hardened, and enables the firer *to get his forefinger well round the trigger*, which, in the case of a man with a short hand, is almost impracticable with the Martini action, the stretch between the forefinger and thumb of the right hand being so great with that action. The Aston action can also be placed and carried, when loaded, at half-cock, without touching the lever or disturbing the cartridge.

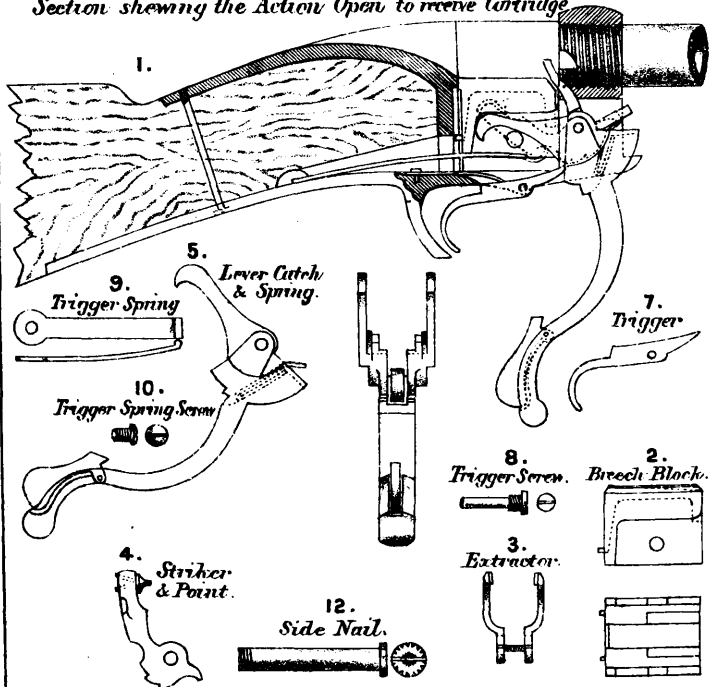
ASTON RIFLE.

To face page 48.

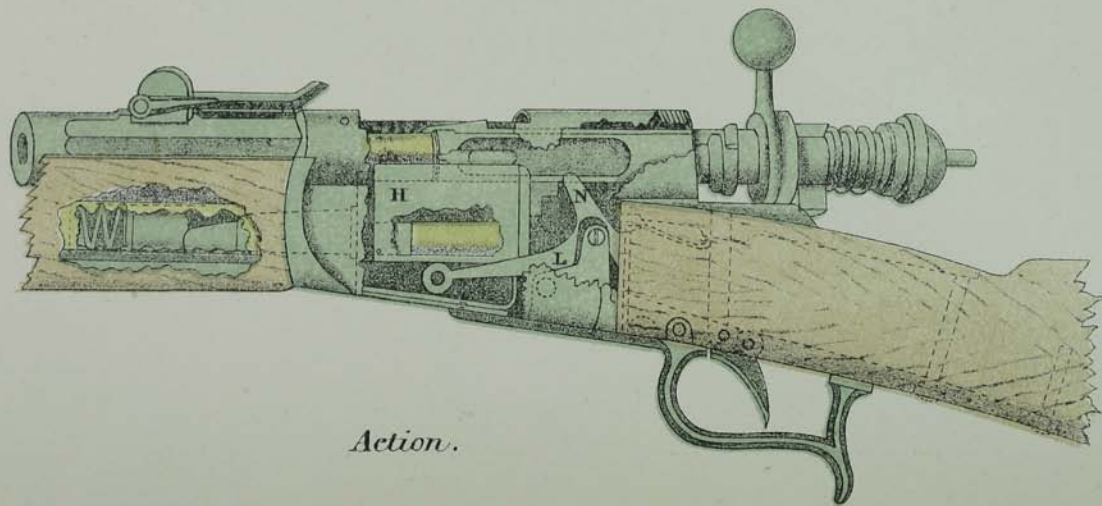
*Section shewing the Action at Full Cock.
The Dotted lines when Fired.*



Section shewing the Action Open to receive Cartridge



VETTERLI MAGAZINE RIFLE.



Action.

To face page 49.

- 7th.—Greater rapidity ; the motion of inserting the cartridge causes both the breech and the lever to close, and the rifle is then ready to be fired, thus saving one motion.
- 8th.—Last, but not least, from its extreme simplicity, the action can be manufactured at considerably less cost than that of the Martini or any other rifle.

REPEATING AND MAGAZINE ARMS.

The expressions "Repeating;" and "Magazine," applied to this description of arm, are sometimes used indifferently, but it was found necessary to establish a distinction, and the following nomenclature has been adopted :—

First—Repeating rifles, in which the cartridges are placed in a tube under the barrel, or in the butt ; to this class belong the Vetterli, Kropatschek, Hotchkiss. The base of each cartridge rests on the point of the bullet of the next, and owing to the jar of rapid firing, or an over sensitive or projecting cap, cartridges have occasionally been found to explode accidentally in the magazine. It will be also noticed that owing to the position of the magazine, the balance of the rifle constantly alters as the magazine is being emptied.

Second—Magazine rifles having detachable or fixed magazines, consisting of a rectangular-shaped metal box in which the cartridges are placed lying one upon another ; this magazine is either fixed, or can be inserted into a corresponding slot or mortice in the action underneath and just in front of the trigger guard ; or it is fixed or attachable to the side of the action. In the attachable form in either case, as soon as one magazine is emptied it can be instantly removed, and replaced by another filled one. From the position of the magazine, the balance of the arm is maintained under all circumstances. To this class belongs the Lee and the Bethel-Burton.

Third—In addition may be mentioned appliances and devices to hold cartridges for the purpose of expediting the loading of single-loaders, termed "quick loaders."

The Vetterli Repeating Rifle.

This arm, on the bolt principle, resembles the single-loader already described.

The cartridges are contained in a magazine* underneath the barrel, which contains a spiral spring, and are inserted through an aperture at the side, as in the Winchester.

On opening the breech by pulling back the bolt a stud on the latter strikes against the upper extremity N of a bell crank lever L, and causes the other extremity to raise a cage or carrier H, containing the cartridge, and to bring it on a level with the cartridge chamber of the barrel.

When the bolt is pushed forward the cartridge is sent into the chamber, and a projection on the bolt striking the bell crank lever lowers the carrier to its original position ready to receive another cartridge from the magazine.

* For facility of description the tube containing the cartridges in these repeating arms is termed a Magazine.

Hotchkiss Repeating Rifle.

The breech action of this rifle is on the bolt system.

The magazine is a brass tube contained in the butt. A hole is drilled in the shoe at its rear end and below the breech bolt, and through this hole the cartridges from the magazine are fed into the chamber, being pressed up by a spiral spring in the magazine.

There is a cartridge stop C at the end of the magazine next the shoe, and when the magazine is filled, which is done by pressing the cartridges into it through the hole in the shoe, they bear against this stop, which retains them in the magazine. On pulling the trigger the cartridge stop is depressed, and the cartridge nearest the chamber is pushed by the magazine spring past the stop, against the under side of the bolt. When the bolt is drawn back the cartridge slips quickly into the shoe, while the one following it is caught and detained by the cartridge stop C, which has only been depressed while the trigger is being pulled. It will be seen therefore that the pressing of the trigger to fire one cartridge, permits the next one to partly enter the shoe, the operation being completed when the bolt is withdrawn with the empty cartridge case.

There is a thumb-bolt on the right side of the stock at T, by turning which the magazine can be cut off, and the arm used as a single-loader. A reverse operation brings the magazine into play.

The arm carries five cartridges in the magazine.

As a magazine-gun two motions are necessary to load, viz., opened, closed.

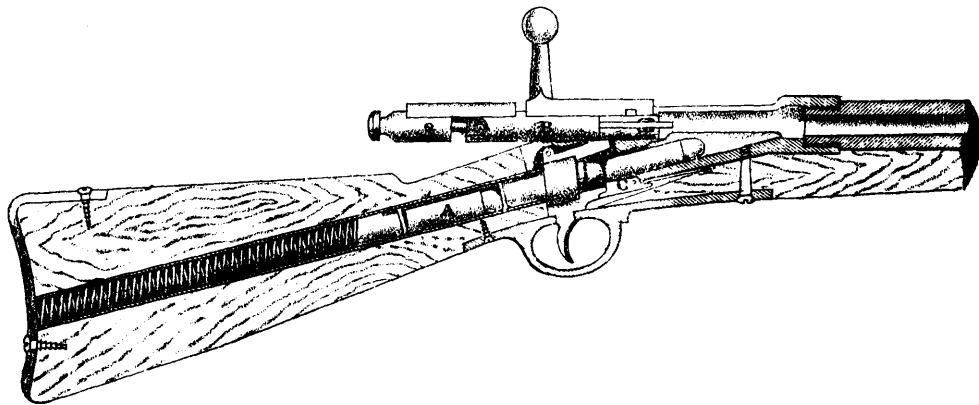
As a single-loader three motions are necessary, viz., opened, insert cartridge, closed.

Kropatschek Repeating Rifle.

This is a rifle now used in the French Navy; it is on the bolt system, and in that respect resembles the Gras. The magazine is a brass tube under the barrel, as in the Winchester and Vetterli, and contains six cartridges; another cartridge can be placed in the trough or carrier T.

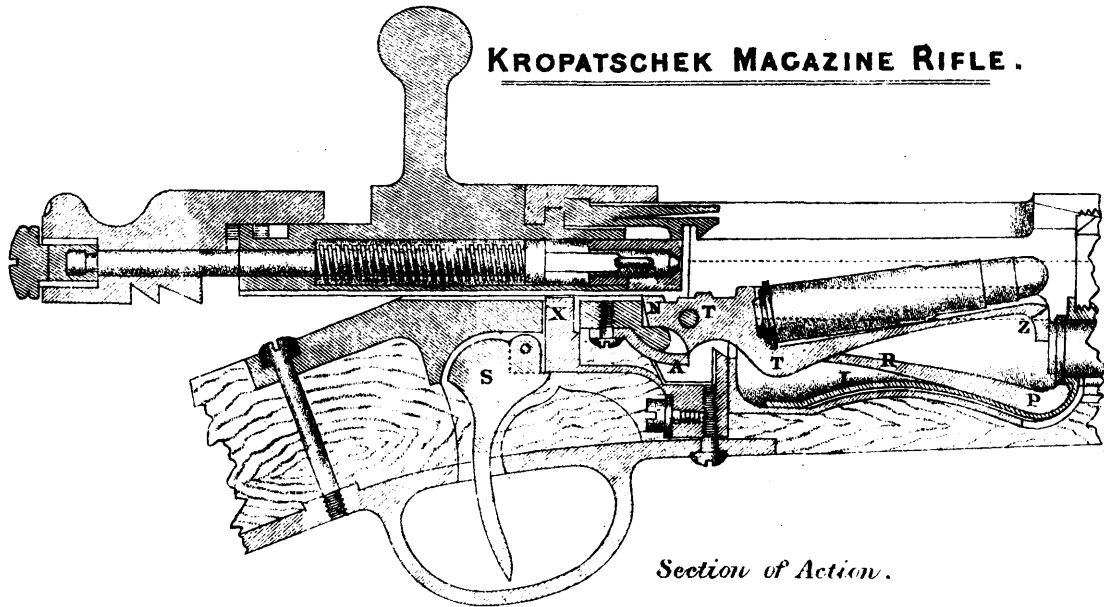
When the action is opened by pulling back the bolt, a projection on the latter strikes the trough at N, and causes the other extremity Z to rise and occupy the position shown in the Figure. This movement is accelerated by the spring A acting against a knife-edge projection on the trough T. In the upper position of the trough the spring acts upon one face of the angle, and in the lower position upon the other. On closing the action the bolt pushes the cartridge into the chamber, and on turning the handle down to the right a part of the bolt presses against a stud, and pushes down the trough ready to receive another cartridge from the magazine. The magazine can be cut off, and only be used as a single-loader, but by pressing in the magazine to the second notch it immediately comes into play. There is a spring plate in the shoe, which is pushed aside by the insertion of the magazine, but immediately springs out on its removal. This plate nearly

THE HOTCHKISS MAGAZINE RIFLE.



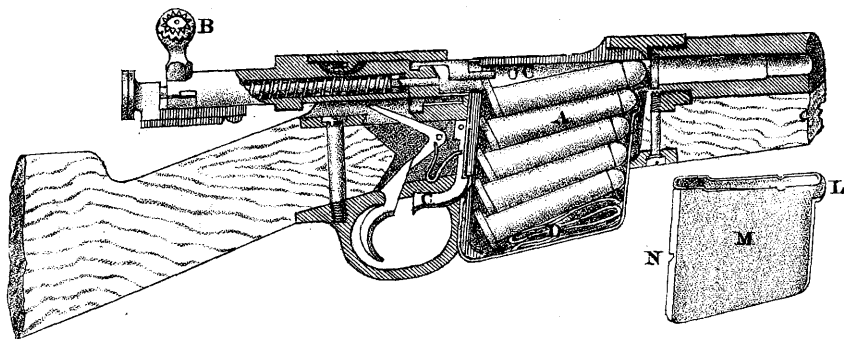
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KROPATSCHEK MAGAZINE RIFLE.



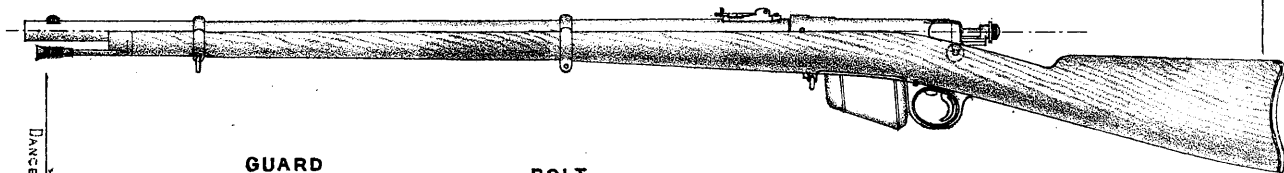
Section of Action.

THE LEE DETACHABLE MAGAZINE GUN.
M is the Magazine detached.

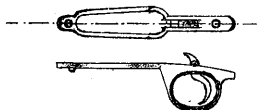


LEE MAGAZINE RIFLE.

Scale 1/8.



GUARD



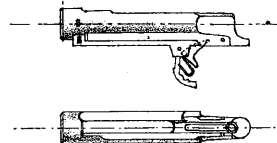
BOLT



STRIKER



BODY.



MAGAZINE.



fills the upper aperture of the magazine slot, and prevents cartridges from falling through when the arm is used as a single-loader.

The action must in all cases be closed before a magazine is inserted.

When the magazine is filled the bullet of the top cartridge is pushed into the projection L, and this keeps the other cartridges securely and firmly in their places. On withdrawing the bolt to open the action the top cartridge is slightly drawn back, and this frees the cartridges, and allows them to be fed up by the spring D.

Lee Magazine Rifle.

This rifle has a bolt action, and the principle does not differ from those already described. The magazine M is detachable, and is inserted from underneath into a slot or mortise in front of the trigger-guard.

The magazine M is of sheet-iron, and when inserted is held in its place by a magazine catch C, which engages in a notch N in the rear of the magazine; the magazine can be released by an upward pressure on the magazine catch at its lower end, where it projects inside of the trigger-guard. The cartridges are placed in the magazine one over the other in nearly a horizontal position, each slightly in advance of the one below it, rendering it impossible for anything to impinge on the caps of the cartridges. The cartridges are pressed up in front of the bolt by a magazine spring D situated in the lower part of the magazine box.

The magazine is simply a sheet-iron box of a sufficient size to hold five cartridges, but there seems to be no reason why it should not be made of larger dimensions.

The magazine must be detached before the arm can be used as a single-loader, but in a late pattern there are two notches in the magazine at N. When the magazine is only inserted as far as the first notch, the arm can only be used as a single-loader, but by pressing in the magazine to the second notch it immediately comes into play. There is a spring plate in the shoe, which is pushed aside by the insertion of the magazine, but immediately springs out on its removal. This plate nearly fills the upper aperture of the magazine slot, and prevents cartridges from falling through when the arm is used as a single-loader.

The action must in all cases be closed before a magazine is inserted.

When the magazine is filled, the bullet of the top cartridge is pushed into the projection L, and this keeps the other cartridges securely and firmly in their places. On withdrawing the bolt to open the action the top cartridge is slightly drawn back, and this frees the cartridges, and allows them to be fed up by the spring D.

The Bethel-Burton Double Magazine Rifle.

This arm has two magazines—one N in the stock under the barrel, and the other a detachable hopper on the side of the

receiver. The two magazines together when filled contain twenty cartridges; each magazine has a cut-off, thereby enabling to be used as a single-loader, when desired.

Mr. Burton sometimes substitutes for the hopper a low detachable one, and the cartridges are issued to the soldier in cheaply constructed boxes holding eight or ten; these boxes the firer inserts in this low hopper, from which the cartridges fall by gravity on to the feed carrier. The boxes, when empty, are thrown away.

Fig. 1 shows the working parts of the breech action partially in section.

Fig. 2 is a side view of the gun complete, with the hopper P attached.

"a" is the receiver; a^1 a^2 the bolt made in two pieces; e the carrier pivoted at n to the receiver, and provided with a hinged gate H to enable the magazine n to be filled. The arm e^1 of the carrier extends up into a groove in the bolt a^1 , serving to operate the carrier, prevents the bolt from being entirely withdrawn, and, in conjunction with the pin C^1 and the extractor C , to eject the empty case. The firing pin b , on which a cam piece a^3 is secured by a screw a^4 , extends through the bolt; when the bolt is pushed in, the cam engages the sear g on the trigger, the pressure of the mainspring is then thrown on the sear g , and the rear end of the bolt a^2 is free to turn. The bolt a^2 , when withdrawn, is prevented from turning by means of the pin d ; but when it is pushed in, the pin d strikes the rear end of the receiver, forces it out of a groove in the strap, and allows the bolt to turn; the sear g is kept up in position by the spiral spring g^1 .

The cut off h^1 , Fig. 2, is actuated by a simple slide which is moved forward or back by the finger; the cut off on the hopper P on the opposite side of the gun is also operated by a simple thumb piece.

To take out the bolt and carrier remove the pin n only.

REVOLVERS.

ENFIELD REVOLVER PISTOL, MARK II.

This pistol has a rebounding lock, and it differs from other patterns usually met with in its method of extracting the empty cartridge cases.

The barrel is $5\frac{1}{8}$ inches in length, and the diameter of bore and form and twist of rifling are the same as in the M.H. rifle.

The cylinder contains six chambers, and the pistol is loaded in the ordinary way.

The act of pulling the trigger cocks the pistol and fires it, and upon the release of the trigger the trigger rebounds to half-cock.

The stock is of walnut, the remaining parts of steel.

Weight of pistol, 2 lbs. $8\frac{1}{2}$ ozs.

BETHEL BURTON DOUBLE MAGAZINE RIFLE.

Fig. 1.

Fig. 1.

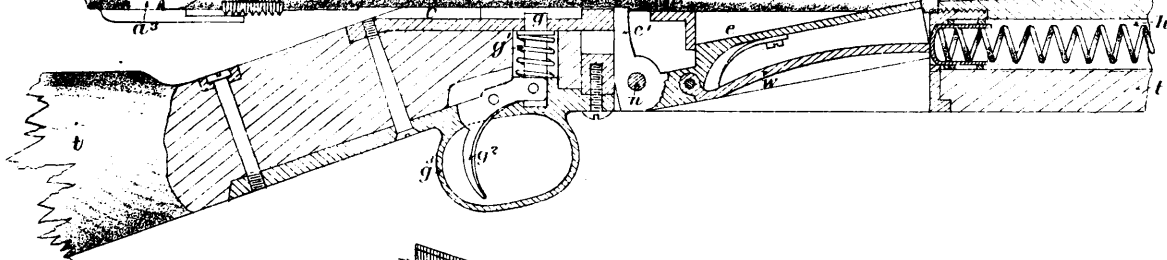
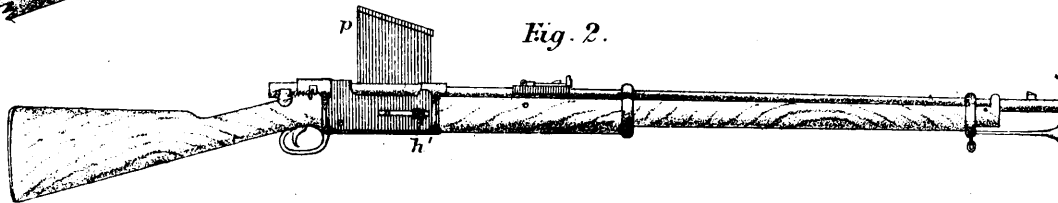


Fig. 2.



ENFIELD REVOLVER PISTOL. (MARK II.)

Scale $\frac{1}{3}$

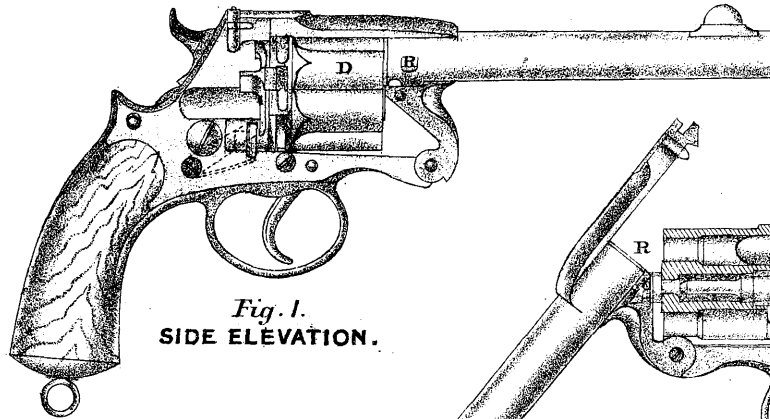


Fig. 1.
SIDE ELEVATION.

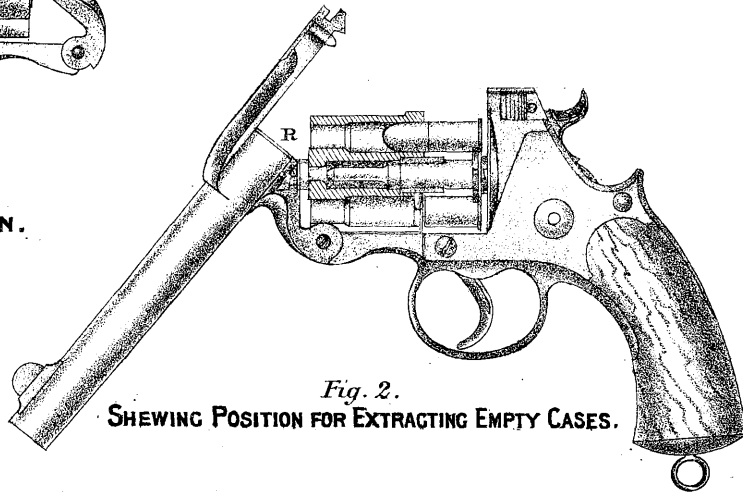
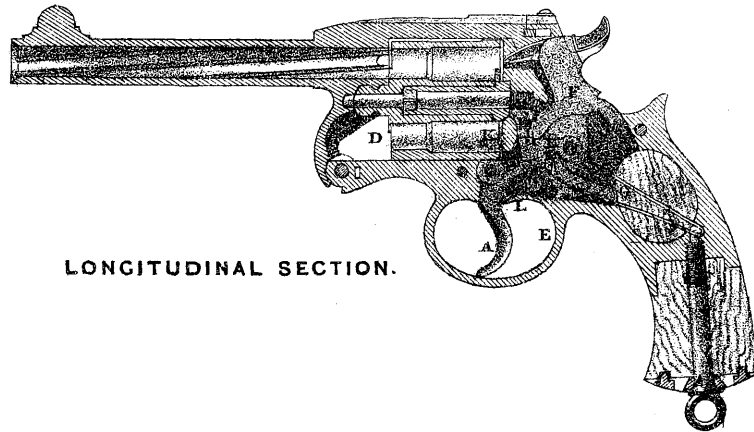


Fig. 2.
SHEWING POSITION FOR EXTRACTING EMPTY CASES.

ENFIELD REVOLVER PISTOL (MARK II.)

Scale $\frac{1}{3}$.

Fig. 3.



LONGITUDINAL SECTION.

Description of Action.

The pistol may be fired on the single-acting principle by cocking in the usual manner, a bent being provided on the hammer to engage and rest on the trigger.

For firing the pistol by automatic pull-off of trigger only, the action may be described as follows :—

The trigger A and the pawl B being connected by an axis at C, they are both carried upwards by pulling the trigger, and the pawl rotates the cylinder D by means of ratchet-teeth cut on the cylinder face near the axis pin; on the lower end of pawl B a projection or horn C is formed; this engages and begins to cock the hammer F directly the trigger is pulled, and releases it at the end of the pull.

The main-spring G, is of the common V form, the ends being shaped to act on the hammer F and lever H, the upper arm gives the hammer its striking power; the lower presses on the lever and hammer to give the rebound or half-cock position. On the lever a small swivel K is fitted to engage the cylinder and prevent a return movement when the pawl is coming down and rubbing against the face of the cylinder teeth; a small spiral spring L is attached to the trigger to act on end of pawl, and assist the trigger in returning to its position for the next shot. A knuckle is formed on the top of trigger to engage and fall into the indents on the outside of cylinder, whilst the upper end of pawl prevents it turning in the opposite direction at the moment of discharge. The shield N (Fig. 1) also exerts a pressure on the cylinder by means of its spring shown in dotted lines, and engages notches cut on the circumference of the cylinder to prevent it moving when the action is returning after firing.

To extract empty cases, the barrel catch O (Fig. 2) is drawn backwards by the thumb, and a sharp downward motion given to the pistol causes the barrel to revolve on its joint-pin, and draw the cylinder off its axis sufficiently to release the empty cases.

The ears R R, near the barrel front of cylinder, are for the purpose of opening the holster to allow the cylinder to pass.

TABLE I.—MILITARY RIFLES: LENGTHS, WEIGHTS, &c.

Rifle.	Nation.	Mechanism.	Approximate Weight with Bayonet.	Length with Bayonet.	Length of Barrel.	Grooves.		Approximate weight of 10 cartridges.
						Number.	One turn in	
			lbs. oz.	ft. in.	inches.		inches.	lbs. oz.
Berdan	Russia	Bolt ..	11 0	6 1 $\frac{1}{4}$	32 $\frac{3}{4}$	6	21	0 14 solid drawn
Gras	France	" ..	10 7 $\frac{1}{8}$	6 0 $\frac{3}{4}$	32 $\frac{3}{10}$	4	22	0 15 " "
Martini-Henry	England	Block ..	9 12	5 11 $\frac{1}{2}$	33 $\frac{3}{16}$	7	22	1 1 $\frac{1}{8}$ rolled case 1 4 solid drawn
Portugal								
Mauser	Germany ..	Bolt ..	11 12	6 0 $\frac{1}{2}$	33 $\frac{5}{8}$	4	22	0 15 " "
	Roumania							
Peabody-Martini	Servia ..	Block ..	10 8 $\frac{1}{2}$	5 9	33 $\frac{3}{16}$	5	22	1 2 $\frac{1}{8}$ " "
	Turkey ..							
	China ..							
Remington ..	Denmark	" ..	10 15	6 1	35 $\frac{3}{16}$	5	20	0 15
	Egypt ..							
	Spain ..							
	China ..							
Snider	England	" ..	10 0	6 0 $\frac{1}{2}$	39	3	78	1 0 rolled case
	Portugal							
Springfield ..	United States	" ..	10 1	5 9 $\frac{1}{2}$	32 $\frac{1}{2}$	3	22	1 1 $\frac{1}{4}$ solid drawn
Vetterli ..	Italy ..	Bolt ..	10 8	6 2	33 $\frac{7}{8}$	4	26	0 12 " "
	Switzerland							
Werndl	Austria ..	Block ..	11 0	6 0	33	6	28	0 15 " "
Experimental, 0.402	England	Block ..	—	—	—	7	16	0 17 $\frac{1}{2}$ " "
Experimental, 0.303 Magazine	England	Bolt ..	—	—	—	7	10	0 10 $\frac{1}{2}$ " "

TABLE II.—MILITARY RIFLES: VELOCITIES, &c.

System.	Calibre.	Charge.		Value of $\frac{d^2}{w}$.	Velocities.				
		Powder.	Bullet.		Muzzle.	At 500 yds.	At 1000 yds.	At 1500 yds.	At 2000 yds.
	inch.	grains.	grains.		f. s.	f. s.	f. s.	f. s.	f. s.
Berdan	0·42	77	370	3·337	1444	873	645	476	353
Gras	0·433	81	386	3·4	1493	880	646	474	350
Martini-Henry (rolled case cartridge)	0·45	85	480	2·953	1315	869	664	508	389
Martini-Henry (solid drawn case)	0·45	85	480	2·953	1350	1109	672	514	393
Mauser	0·433	75	380	3·453	1430	859	629	459	338
Peabody-Martini	0·45	85	480	2·953	1380	888	678	519	397
Remington	0·433	75	400	3·281	1340	849	631	468	350
Snider	0·577	70	480	4·855	1240	711	458	299	196
Springfield	0·45	70	500	2·835	1301	875	676	523	404
Vetterli single loader (Italy)	0·408	62	310	3·759	1430	835	595	422	304
Werndl	0·433	75	370	3·547	1439	854	620	449	328
Experimental (England)	0·402	85	384	2·945	1570	944	715	559	420
Experimental (England)	0·303	70	217	2·961	1800	1012	755	579	442

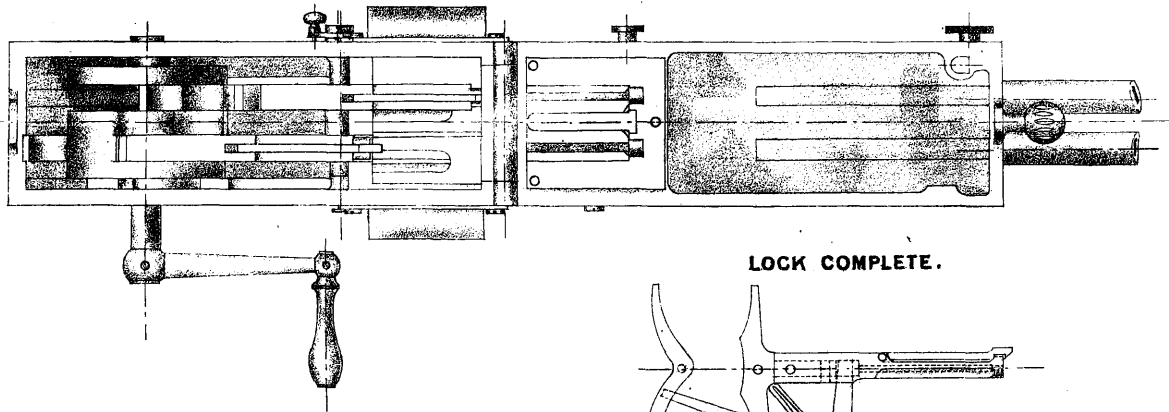
TABLE III.—MILITARY RIFLES: TRAJECTORY, TIME OF FLIGHT.

Systems.	Greatest heights of Trajectory.				Times of flight over different Ranges.			
	500 yds.	1000 yds.	1500 yds.	2000 yds.	500 yds.	1000 yds.	1500 yds.	2000 yds.
	feet.	feet.	feet.	feet.	seconds.	seconds.	seconds.	seconds.
Berdan	7·995	47·01	151·7	388·7	1·409	3·418	6·139	9·826
Gras	9·87	59·57	190·32	330·38	1·389	3·402	6·141	9·842
Martini-Henry	8·594	47·90	147·1	357·85	1·461	3·449	6·045	9·4287
Mauser	8·249	48·68	159·2	411·1	1·432	3·477	6·288	10·100
Peabody-Martini	8·097	45·395	139·77	341·67	1·4182	3·358	5·893	9·213
Remington	8·539	50·42	160·3	403·1	1·473	3·539	6·310	10·001
Snider	11·35	75·58	284·5	866·2	1·679	4·333	8·409	14·67
Springfield	8·574	46·88	142·3	343·0	1·460	3·417	5·946	9·23
Vetterli, single-loader (Italy)	8·527	52·17	176·3	469·9	1·455	3·599	6·618	10·80
Werndl	8·252	49·41	162·6	426·0	1·432	3·503	6·354	10·29
Experimental (0''·402, England)	6·704	39	122	298	—	—	—	—
Experimental (0''·303, England)	—	—	—	—	—	—	—	—

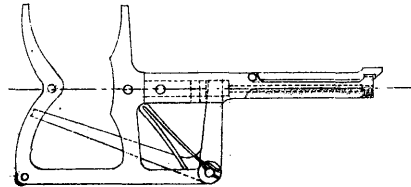
GUN GARDNER 2 BARREL.

PLAN OF ACTION

COVER OPEN.



LOCK COMPLETE.



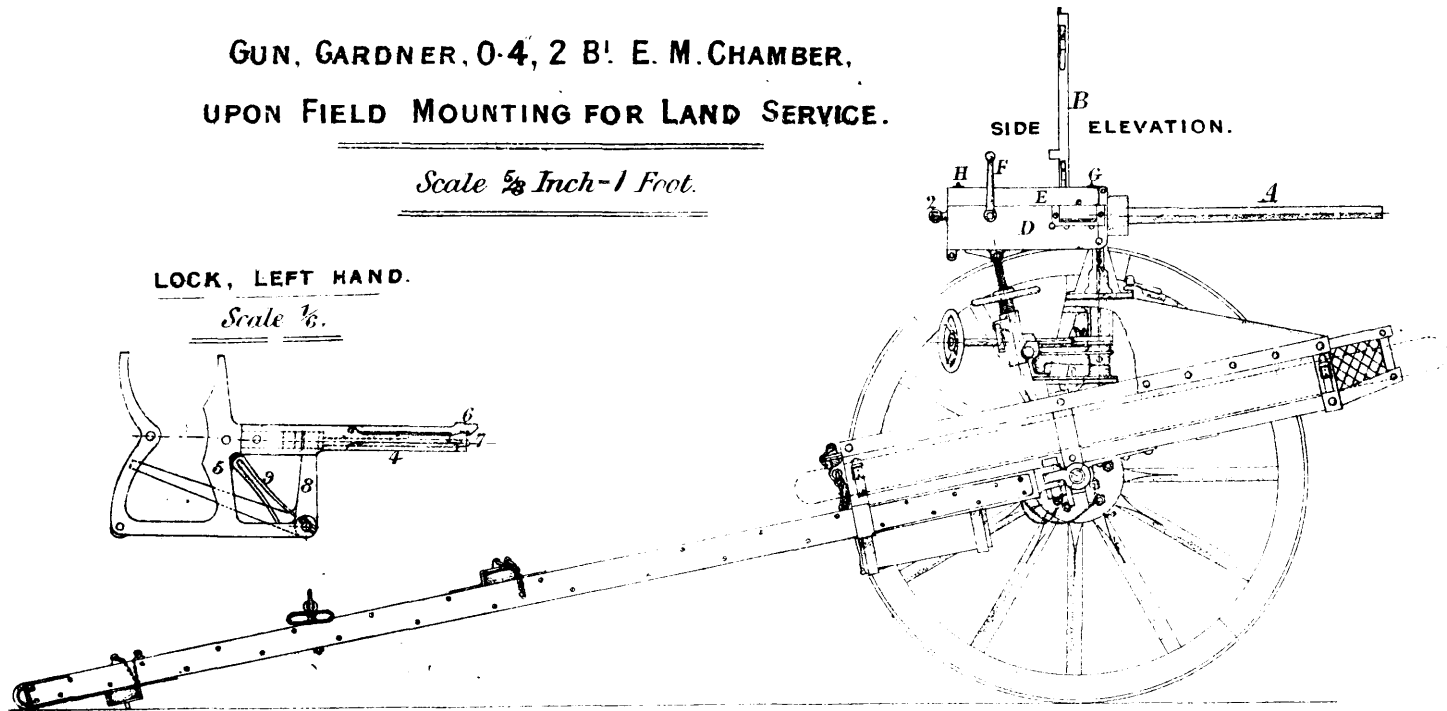
Scale 2" = 1 Foot.

GUN, GARDNER, O-4, 2 B! E. M. CHAMBER,
UPON FIELD MOUNTING FOR LAND SERVICE.

Scale $\frac{5}{8}$ Inch-1 Foot.

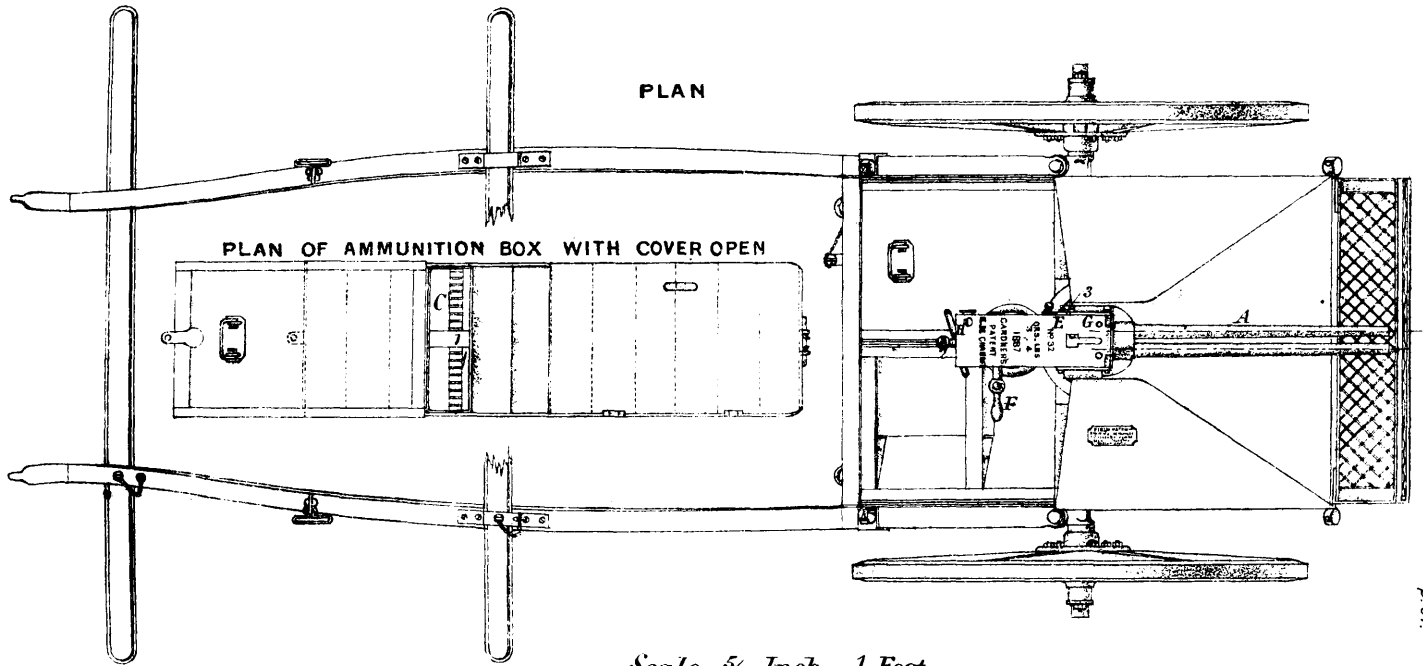
LOCK, LEFT HAND.

Scale $\frac{1}{6}$.



PLAN

PLAN OF AMMUNITION BOX WITH COVER OPEN



Scale. $\frac{5}{8}$ Inch = 1 Foot.

RIFLE CALIBRE GUNS.

GARDNER 2-BARREL, RIFLE CALIBRE.

Description.

The barrels (the axes of which lie in a horizontal plane, and are parallel to each other) are fixed in a gun-metal casing. The top of the casing is closed in by the cover, which is pivoted to the fore-end of the breech casing, and is locked down by means of the cascade screw.

In the breech casing are the locks which carry the mechanism for igniting the cartridges and extracting the cartridge cases. The locks are driven backward and forward by means of a disc crank, worked by the handle. At the forward motion the cartridge is pushed into the barrel chamber, and there held during the time of discharge, whilst during the backward motion the case is withdrawn.

The gun is fed from a vertical cartridge feeder, which is attached to the cover behind an opening, through which the cartridges fall from the feeder to the cartridge carrier.

The cartridge carrier, which is to the rear of the breech ends of the barrels, has a transverse motion for the purpose of bringing the cartridges from the opening in the cover, and delivering them opposite the right and left-hand barrels alternately, where they are in line with the lock plungers.

The cartridge feeder holds twenty-four cartridges, and is supplied during firing from wooden cartridge-holders, each holder containing twenty cartridges.

The gun is furnished with two sights, the foresight and tangent sight.

The tangent sight is marked from 0 to 2000 yards. The sighting is known as "full," that is, the foresight should fill the V in the tangent sight when taking aim, because when the tangent sight is at zero, a line from the top of the foresight to the top of the notch of the tangent sight is parallel to the axis of the barrels.

The object of this block is to enable a two-barrel gun to be used as one-barrel gun in the event of one of the barrels becoming unserviceable, without waste of ammunition.

To use it. Remove the lock from the barrel from which it is intended to discontinue the fire.

Drop the block on to the cartridge carrier, with the bevelled edge towards the centre of the gun.

Feed and fire as usual.

The same block answers for either right or left, by simply turning it end for end.

This is a flat bar, passing through the casing in front of the hammers; when the edge of the bar is turned towards the hammers, they cannot complete their forward movement; the springs are consequently kept compressed, and no cartridges can be fired, although fed through the gun; the spring handle of the bar shows when the bar is in safe or firing position.

Action.

Supposing the right-hand barrel to be just fired, the continued rotation of the handle and disc crank causes the right-hand hammer to be turned upon its axis, drawing back the firing pin and compressing the lock spring; at the same time the cartridge carrier moves over to the left, and the ejector, which has passed under the lock, rises to the left of it, forming a trough under the opening in the cover, and into this trough a cartridge falls ready for conveyance to the barrel chamber.

The crank pin now comes in contact with the butt of the lock and forces it backward, extracting the cartridge case.

The lock being fully back, the cartridge carrier moves to the right, bringing the cartridge from under the opening in the cover to a position in line with the barrel chamber, and with its rim or head between the face of the plunger and the hook of the extractor, which is pressed down by channels in the cover, at the same time the empty case has been thrown out at an opening in the side of the casing. The lock now moves forward, pushing the cartridge into the chamber, and forcing down the ejector that it may pass under the lock. The lock at this point being fully forward, supports the cartridge in the barrel chamber, whilst the hammer, being released, the firing pin flies forward and ignites the cartridge.

The right and left-hand barrels are fired alternately, the right lock advancing as the left is being withdrawn, and *vice versa*.

The cartridge carrier, which is actuated by a cam upon the disc crank, obtains its supply of cartridges from the cartridge feeder.

*Instructions for Armourers in Stripping, Assembling, and
Adjusting the Gun.*

**To remove
locks.**

See that the safety bar is in firing position open the cover and turn the crank until the right-hand crank pin is at the top; when in this position the fore-end of the plunger of the right-hand lock will be about two inches from the barrel; take hold of the plunger and raise it, at the same time moving the crank slightly; the lock will now come away; turn the left-hand crank pin to the top, and take out the left-hand lock.

**To remove
the cartridge
carrier.**

Lift up the right-hand hood, and push out the guide pins; turn the crank until the cartridge carrier is to the left, then with the fingers inserted through the discharge ports, lift out the carrier. It will be found easier to remove the cartridge carrier if both hoods are first taken from the casing, but with a little practice it may be removed without.

**To remove
safety bar.**

Lift up the right-hand hood and draw the safety bar out.

**To remove
the crank.**

Place the flat part of the spanner in the slot in the left axis pin, letting the cross-piece or screwdriver end rest upon the frame at the rear; take hold of the crank handle and give a smart backward turn; this will loosen the left axis pin; do not take it quite out until the right axis pin is loosened, which is accomplished by placing a piece of hard wood between the crank and rear end of

breech casing and turning the crank handle backwards; both axis pins being removed, the crank may be lifted out.

Remove the hoods and drive the barrel fixing pin out of casing; drive the barrels forward with a piece of hard wood and hammer. To remove the barrels.

Compress the spring by means of the hammer; place the jaws of the spanner over the spring as low as possible, this will keep the spring compressed, when the hammer is released the spring may be taken from the lock; take out the hammer; drive out the fixing pin from the plunger, and draw off the butt; take out the firing pin, drive out the fixing pin and remove extractor. If it is necessary to remove the spring from the spanner, compress the spring in a vice or between the frame and cover of the gun, when it will be left free of the spanner. Care must be taken to hold the *open* end of the spring in the vice, and *not* the turned end. To strip a lock.

All locks should be taken out, oiled and tested monthly.

N.B.—All pins without heads are to be driven out FROM THE LEFT.

Reverse the foregoing operations, taking care in replacing locks to have the crank pins in the same position as directed for stripping, and that the end of the hammer is under the crank and *not* in the opening in the disc; see that the locks are placed right and left as marked. To assemble gun.

May be caused by a weak lock-spring; the weight of spring may be tested with a wire and spring balance; it should require a pressure of not less than 17 lbs. to press the point of the firing pin back slightly. Missfires may also occur if oil be allowed to corrode round the firing pin, or if the point of the firing pin is worn flat. Missfires.

Should any cases of non-extraction occur, owing to the extractor cutting through the head of the cartridge, draw back the lock and drive out the empty case, with the cleaning rod inserted from the muzzle. Sometimes, owing to a hang-fire, the head of the cartridge case may be blown off, leaving the cylindrical part in the chamber; in this case take out the lock and introduce the clearing plug into the breech; turn the plug with the ratchet handle until the threaded part obtains a fair hold in the cartridge case, then withdraw the clearing plug. If any difficulty is experienced in withdrawing it, a few light blows struck on the handle of the plug (close down to the bend) with a hammer or screw-driver, will readily remove it. If any difficulty is experienced in removing the shell from the clearing plug when it is taken out, compress the cartridge case in a vice, or between the frame and cover of the gun in the corner of the hinge, then take the spanner and turn the clearing plug to the left by the nut at the end, when the cartridge case will readily come off. Non-extraction.

A jam may occur after a hang-fire by the next cartridge being driven forward into the chamber, which is already occupied by the cylindrical part of the previous cartridge case. When this happens cut off the supply of cartridges, and remove the feeder; open the cover, turn back the crank handle, and remove any cartridges from the carrier, take out the lock and drive back the jammed cartridge with the cleaning rod, then use the clearing plug as before directed if the previous cartridge case should still remain in the chamber. Jams.

To replace a barrel. The spare barrel is interchangeable as regards diameter, should the fixing pin be found difficult to enter, the groove in the barrel may be eased away with a round file until the pin goes home : copy the chamfer on the breech end of the barrel from the old one.

Cleaning gun. When cleaning the gun, turpentine or oil is to be used. On no account may emery cloth or any cutting substance be allowed. In oiling, before assembling, use rangoon oil sparingly; oil the parts all over, but do not put on enough to allow it to run into drops and clog.

It is *very* important that the barrel chambers should be kept clean; they should be oiled immediately after firing ceases.

When the gun is not loaded, the crank handle must *not* be turned until the safety bar is placed at safe position; neglect of this will cause serious damage to the chambers.

THE THREE-BARREL NORDENFELT RIFLE CALIBRE MACHINE GUN.

Gun. The gun consists of a rectangular frame of gun metal, the rear part of which forms a box containing the various parts of the mechanism. The front part of the box is open at the bottom to allow the empty cartridges to fall out of the gun. The top of the box is provided with a cover, hinged to the front side, and secured by means of a lock. The cover opens towards the front, and has openings at the top to allow the cartridges to enter into the gun from the magazine or distributor which is placed on the top.

The two sides of this frame box project towards the front, and, adjoining there, form the supports for the barrels, their muzzles passing through this projecting frame, and their breech ends being secured in the front side of the frame box.

Mechanism. The principal parts of the mechanism are :—

- a.* Hand Lever.
- b.* Action Lever.
- c.* Action Block.
- d.* Breech Block.
- e.* Cartridge Carrier.

a. The hand lever, which is one with the action pin, is placed in a bearing in the under plate of the frame box and sets the mechanism in motion.

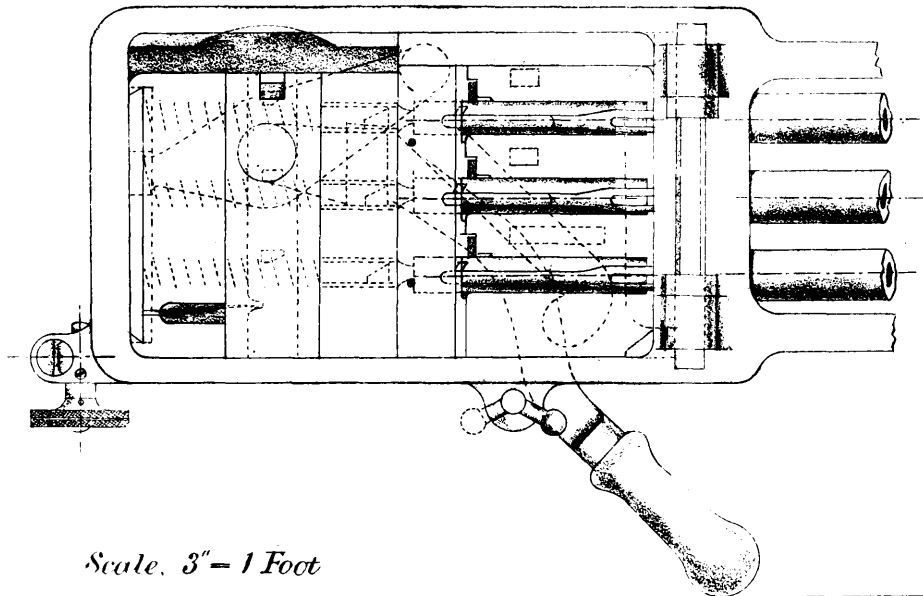
b. The action lever is jointed to the action pin, and has a friction roller at one end, which works in a cam groove in the breech block, and the other end acts in a slot in the action block and gives it a transverse motion.

c. The action block has only transverse motion. In it are three slots for the breech pieces to pass through. The plate of the breech block passes underneath. In the solid part, between the slots, chambers are bored for the lock springs and hammers, and in rear is a plate or spring bar, movable in a groove, which retains the springs. The hammers have each a T shaped projection. Through the middle part of the action

GUN NORDENFELT. 3 BARREL.

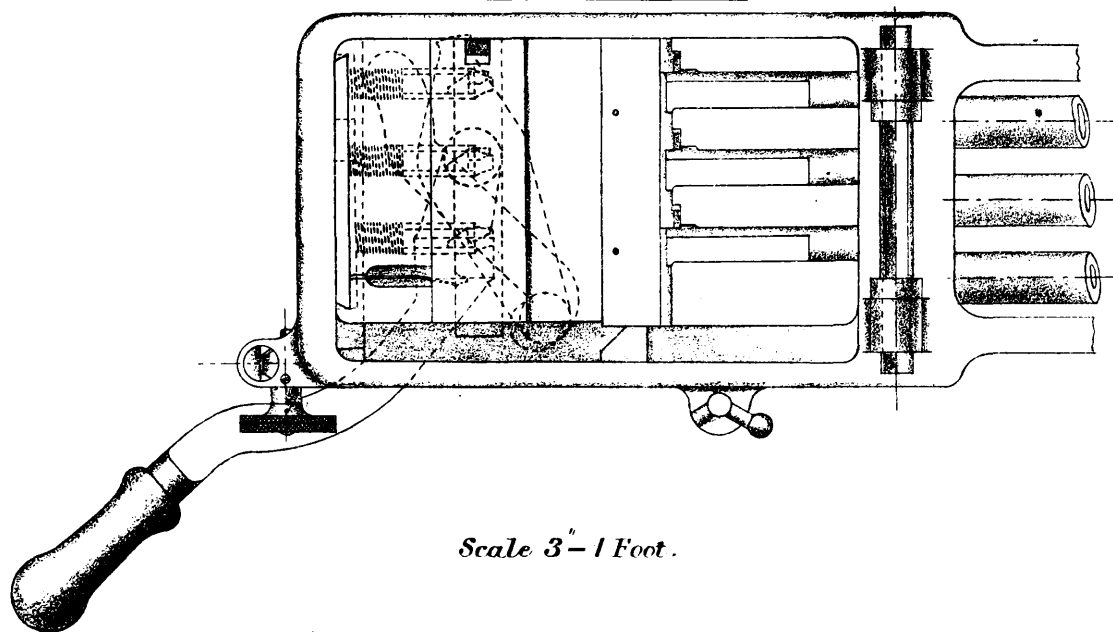
POSITION OF ACTION FOR FIRING, AND EXTRACTING.

COVER REMOVED.



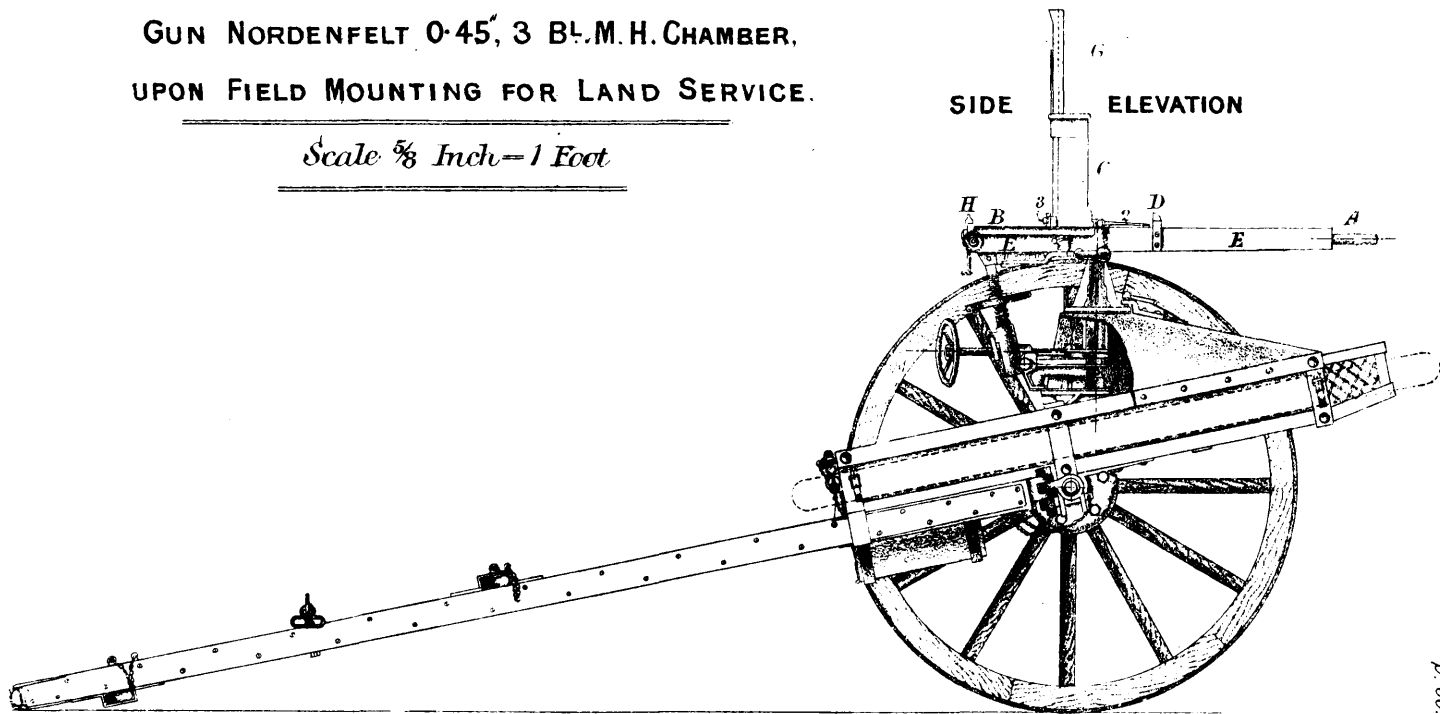
Scale, 3" = 1 Foot

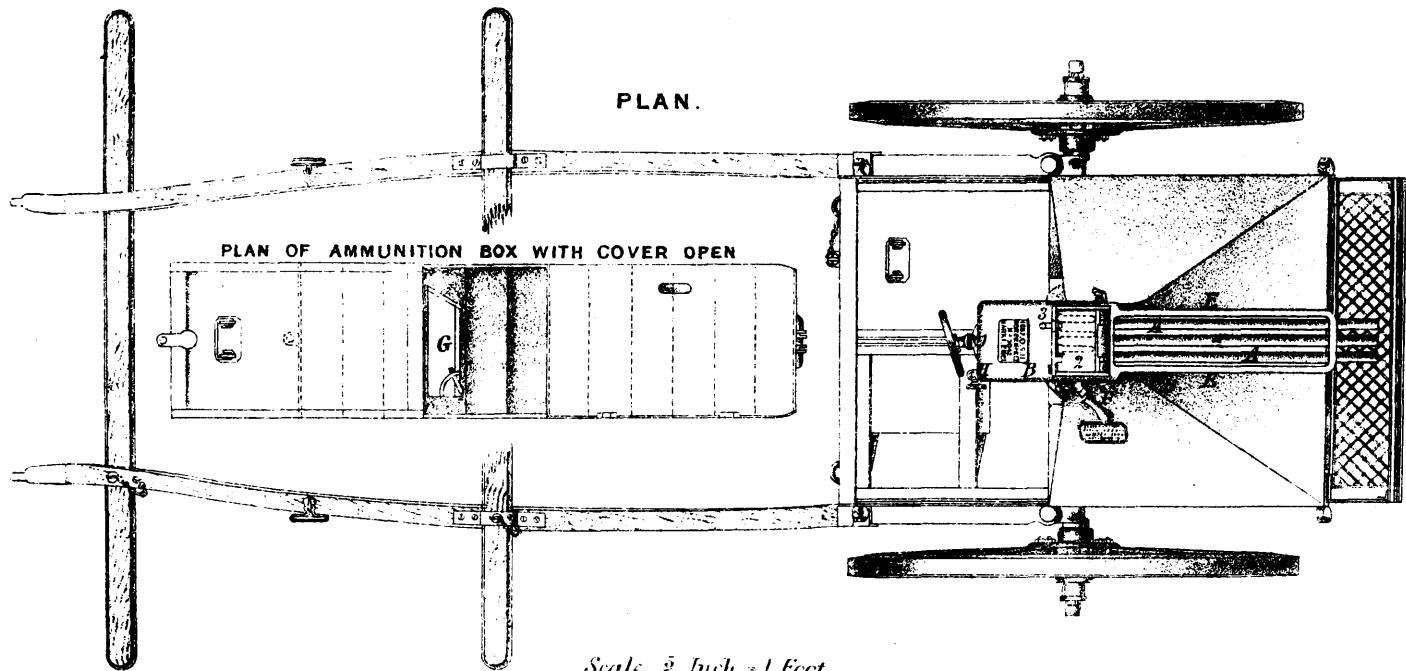
GUN NORDENFELT 3 BARREL .
POSITION OF ACTION FOR LOADING.
(Cover Removed.)



GUN NORDENFELT 0-45, 3 BL.M.H. CHAMBER,
UPON FIELD MOUNTING FOR LAND SERVICE.

Scale $\frac{5}{8}$ Inch = 1 Foot





PLAN.

PLAN OF AMMUNITION BOX WITH COVER OPEN

Scale $\frac{3}{8}$ Inch = 1 Foot

block a channel passes from right to left, for the reception of the trigger comb, which is acted upon by a small spring. On the under part of the trigger comb are three lugs. The trigger comb being kept to the right by the spring, retains the hammers, since corresponding lugs on them have been forced behind the lugs on the trigger comb. The trigger comb projects to the right of the action block, and is forced against the right side of the frame box by the action block moving to the right, and the trigger comb is thus forced to the left, releasing the hammers.

d. The breech block consists of a plate made in one, with three breech pieces or plungers containing firing pins and claw extractors. On the under surface of this is the cam slot in which the action lever friction roller works, affording to the breech block longitudinal motion only. On the upper surface of this plate are three studs, which act on the lower T projections of the hammers, forcing them back and compressing the lock springs. A lug on each side of the breech piece acts upon corresponding lugs in the cartridge carrier.

e. The cartridge carrier receives the requisite transverse movement by the lugs on the breech block. It has no longitudinal movement. It is made of gun metal (whereas the other parts of the mechanism are made of steel), and is so constructed that it retains the cartridges dropping into it from the distributor on the cover, but allows the empty cartridges to fall through when they are extracted from the barrels.

Action of the Mechanism.

The action of the mechanism is as follows:—Supposing the hand lever to be in its most forward position and the gun just fired—

1st. The hand lever moves to the rear, and the rear end of the action lever carries the action block to the left. Lever moved back.

2nd. The openings in the action block for the breech pieces being in a line with them, the action lever roller working in the breech plate cam slot carries the breech block to the rear; at the same time the empty cartridge cases are withdrawn, which drop to the ground through the holes in the cartridge carrier.

3rd. The studs on the upper surface of the breech plate catch the lower part of the hammer T projections, force the hammers back and against the bevelled edges of the trigger comb teeth; the trigger comb is then moved against its spring to the left until the hammers are clear, when the spring carries the trigger comb back to its normal position, with the teeth in front of the hammers. At the same time the lock springs are compressed and the cartridge carrier is brought to the left, until the pockets come opposite the holes in the cover, when fresh cartridges drop in. The hand lever has now reached its farthest position to the rear.

1st. The carrier block is moved to the right and the three fresh cartridges are thus placed in front of the barrels: the breech block is then carried forward and the cartridges are pushed into their respective barrels. Lever moved forward.

2nd. The cartridges being quite home, the action block is moved to the right and the hammers are thus brought directly behind their respective firing pins ; at the same instant the projecting part of the trigger comb is carried against the framework, forcing the trigger comb to the left, and thus freeing each hammer in turn, which, flying forward, strike the firing pins and fire the cartridges. The solid part of the action block being behind the breech pieces, locks the mechanism and transmits the pressure from the exploding cartridges to the solid frame.

Feeding the Gun with Cartridges.

This is effected by means of a "distributor," a "feed slide" and "feed boxes." The distributor is constructed of steel plates, with the exception of the rear face and guides, which are of gun-metal. It is placed on the gun on the top of the cover, over the carrier block, where it remains during the firing, and is secured in position by means of a spring lock or catch.

The "distributor" has a separate compartment for each barrel, and on the rear face of each compartment is a guide, which holds the cartridges by the rims of their bases. The cartridge lies in an inclined position, with the bullet slightly raised and touching the front inner face of the distributor. The cartridges are retained in the distributor, until required, by means of a catch running the whole of its width in rear of the bottom. This catch can be thrown in and out of action by a handle on the left side of the distributor.

The "feed slide" is of gun-metal, and is fitted with three guides, corresponding to those on the rear face of the distributor. It is placed on the top of the distributor, where it is secured by means of a spring catch.

The "feed boxes" are made of paper strengthened by canvas, the interior of each box is divided into three rows of compartments, corresponding to the guides in the feed slide, each compartment contains a cartridge, which stands on its bullet, with its base projecting beyond the top of the box, which latter is closed by means of a movable cover.

Manipulation of the feed.

The manipulation of the feed is as follows:—

The empty distributor is fixed in its place, and the feed slide secured on the top. The man working the feed being on the left of the gun, takes a full feed box in his left hand, removes the cover with his right, turning it so as to bring the flat against the bases of the cartridges, which prevents the cartridges falling out of their compartments in the feed box ; he then places the bases of the lower cartridges in the guides of the feed slide, and with his left hand draws the feed box down in front of the guides of the feed slide, the cartridges will remain attached to the guides by their bases, and will fall steadily down into their respective compartments in the distributor. The empty feed box is now placed on one side. Then if continuous fire is required, the operation is repeated with a full feed box, as soon as all the cartridges in the guides have disappeared in the distributor. When the catch of the distributor is released, a cartridge for each

barrel falls on to the cartridge carrier, the others continuing to supply their places, the rapidity of supply being regulated by the movement of the cartridge carrier.

By means of the catch on the distributor, it can be removed from the gun, even when containing cartridges, without risk of the cartridges falling out.

To Dismount and Mount the Mechanism.

1st.—Open the cover and move the hand lever to its rear position. To dismount the mechanism.

2nd.—Lift out the cartridge cover.

3rd.—Lift out the action block and the breech block together.

4th.—Disengage the action lever from the action pin, and remove it.

5th.—Remove the hand lever.

Replace the various parts in the reverse order to that in which they were removed :— To mount the mechanism.

1st.—Put the hand lever in its place.

2nd.—Join the action lever to the pin of the hand lever.

3rd.—Drop the breech block into its place, so that the friction roller on the action lever enters the groove on the lower plate of the breech block.

4th.—Move the hand lever forward and place the action block in rear of the breech block.

5th.—Move the hand lever to its rear position and put in the cartridge carrier.

6th.—Lower and secure the cover.

Remove the action block and slide the spring bar out of its groove. The springs and hammers are then free to be taken out and changed ; they are replaced in a similar manner. To change a lock spring or a hammer.

Remove the breech block, lift up the rear end of the extractor until the lug on the rear end is clear of the recess into which it fits ; force the extractor forward and it is free to be changed. To change an extractor or a firing pin.

The firing pin is also now free.

To replace an extractor : place the claws of the extractor close to the front of the breech piece, press down the front of the extractor, having seen that the firing pin is fully forward, then push the extractor forward until the lug on its rear end drops into its recess.

Instructions for keeping the Gun in Working Order.

The mechanism, barrels, chambers, and every part of the gun should be kept free from rust and Slightly oiled.

The mechanism should, if possible, be cleaned and oiled every morning. To perform this in an efficient manner proceed as follows :—

Dismount the mechanism, clean off all clogged oil. Clean and very lightly oil all movable parts and the surfaces on which they move ; see that the hammers and firing pins move freely in their respective channels, and that the lock springs, extractors, &c., are in perfect order. Mount the mechanism, work the mechanism

by means of the hand lever, and ascertain that all parts work perfectly smoothly, if not, some of the surfaces are not sufficiently clean and these should be attended to.

Remarks on the Working of the Gun.

The following may possibly occur during practice with this gun, and in case of such occurrence the action detailed will prove efficacious.

Misfires.

In case of repeated misfires—

If the caps have not been struck, it is probable that in working the gun the hand lever has sometimes not been moved backwards as far as it will go, in which case the gun has not been cocked, or that the hand lever has not been moved forward as far as it will go, in which case one or more of the hammers have not been released. In the case, therefore, of the caps not being struck, the working of the gun should be attended to.

If the caps have been insufficiently struck, a lock spring, hammer head, or a firing pin is probably broken. These should, therefore be examined and the broken part changed.

If the cap has been fairly struck, but has not fired the powder, the ammunition is defective and must be changed.

**Working of
the gun
obstructed.**

In case the movement of the hand lever is stopped by any obstruction, no violence should on any account be used, but the handle should be gently moved backwards and forwards once or twice as far as it will go, when the obstruction will probably be cleared away.

If, however, the obstruction is caused by an extractor failing to act, the empty cartridge case will remain in the chamber, and will prevent the loaded cartridge from entering. When this occurs examine the extractor, and if necessary change it, and force the empty cartridge case out of the chamber by means of the cleaning rod, using it from the muzzle.

If, however, time will not admit of the foregoing, the row of cartridges corresponding to the obstructed barrel must be removed from the feed boxes; the firing can then be continued with the remaining barrels. If the obstruction is caused by an extractor breaking, proceed as in the case of an extractor failing to act.

If the obstruction is such as to prevent the hand lever from being moved, and the cause of the obstruction is unknown, put the hand underneath and remove any fired cases that may possibly hang in the carrier. If the obstruction is not thus cleared, open the cover and ascertain the cause of the obstruction, and then remove it.

Cease firing.

When the practice with the gun is finished the cover should be opened, to ascertain that no cartridges remain in the gun, if there are any they should be removed; the cover is then closed and the hand lever pushed forward as far as it will go, and the hand lever catch let down. If, however, there should not be time to perform the foregoing, let down the hand lever catch, which will prevent the lever being moved forward sufficiently far to fire any cartridges that may remain in the gun.

SIDE ELEVATION .

Fig.1.

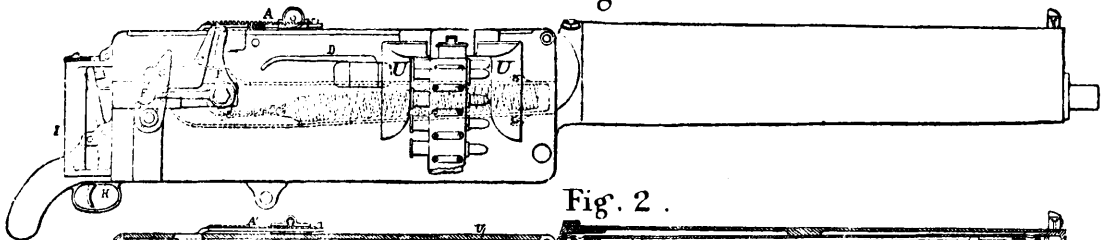
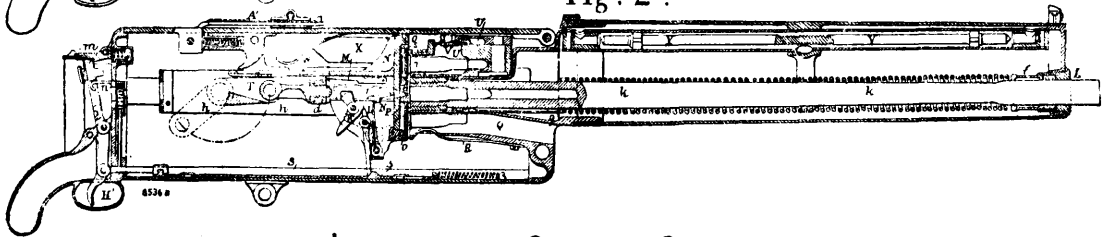


Fig. 2 .



LONGITUDINAL CENTRAL SECTION .

THE MAXIM AUTOMATIC GUN.

This gun consists of two parts, the recoiling portion and the non-recoiling portion. The non-recoiling portion is mounted on trunnions, and is provided with handles for aiming and a trigger for firing; to it, also, is attached the elevating and depressing gear, the sights, and so forth. Inside this portion is mounted the recoiling portion, Plate 2, arranged in such a manner that the recoil when firing moves it back through a distance of 1 in.; the force of the recoil being absorbed by the spiral spring, and in cocking the hammer.

Plate I., Fig. 1, shows the outside or non-recoiling portion of the gun; all parts shown in this view remain stationary at the time of firing, with the exception of the crank B E F. This crank forms part of the recoiling portion, and is connected with the bolt, Plate 3. A represents the sight; I the aiming handles, used also as receptacles for oil; H the trigger; U U the feed box.

Plate I., Fig. 2, shows a longitudinal central section of the gun with all the parts in the firing position. The lock employed is very similar to that used in the old-fashioned single-barrel pistol, namely, a firing-pin, a main spring, a hammer, and a sear. All these parts are mounted in the lock or bolt N N N.

The operation of firing is as follows. When the trigger H¹ is pulled the rod S S is drawn backwards, and with it the lower end of the sear L; this movement of the sear releases the hammer K, when the main spring throws the firing-pin J violently forward, striking the primer and exploding the cartridge. The recoil resulting from this explosion causes all the movable parts to slide backwards through a distance of 1 in.; the projecting arm B is brought in violent contact with the stationary point of resistance C, and rolling on it carries the crank arm over its dead point; the force is then transferred to the crank (the barrel and its extension returning to the firing position), the effect of which is to forcibly rotate the crankshaft and to cause the crank handle F to strike the buffer spring D.

This motion of the crank draws back the bolt sufficiently to draw the empty cartridge case from the barrel, and a loaded cartridge from the feed-box U. As the bolt moves backwards, the sliding piece O drops down partly by its own weight and partly by the action of the spring W, thus bringing the loaded cartridge in line with the barrel, and the empty case in line with the discharge pipe Q. The turning of the crank-arm T into the position shown by the dotted lines, not only unlocks the breech and draws the bolt away from the barrel, but it also cocks the hammer by bringing the part d in contact with an arm or extension on the hammer.

The same action of recoiling extends the spiral spring shown in dotted lines, winds the chain about a small fusee also shown in dotted lines, so that when the crank handle F is resting on the buffer D, the spiral spring is not only extended 1 in. by the recoil of the barrel, but the winding of the chain on the fusee

causes a still further elongation. Thus, when the crank handle F has been brought to state of rest at D, the action of the spiral spring is to first pull the barrel and other recoiling portions home into the firing position, and then to rotate the crankshaft also back into the firing position, the same spring performing both functions. As the crank is brought back into the firing position, it strikes the piece G in such a manner as to bring the handle to a dead stop, the movable piece G being constructed so as to prevent all rebounding.

When the bolt has again returned into the firing position, the connecting-rod strikes the top or safety sear M, disengages it from the firing-pin J, when if the trigger H¹ be pulled or be held in a pulled position the gun will again fire. The vertical sliding piece O is moved upwards as the breech is closed, engaging a new cartridge in the feed-box U, and at the same time leaving the empty case in the tube Q.

The feeding of the cartridges is accomplished in the following manner: The backward motion of the recoiling portion at the instant of firing, causes pawls attached to the slide V to engage another cartridge in the belt, and their return into firing position moves the belt into the gun, bringing a new cartridge in front of the sliding piece O O O; stationary pieces X attached to the non-recoiling portion, determine the exact path described by the slide O. The slide O carries with it a small catch s, and also a spring P, the object of these two pieces being to keep the cartridges in their proper places in the slide. The water jacket is provided with a tube in which slides freely to and fro the rod Y. If the gun be fired at elevation, this rod slides backwards, closes up the water passage at the lower end of the tube, and opens a passage for steam at the highest portion; this prevents the escape of water.

Again, if the gun is fired at depression, this rod slides forward, preventing the escape of water and opening a passage for the steam at the highest point. The spiral spring around the barrel is for the purpose of keeping the two stuffing boxes at each end of the barrel tight; *m* is a safety catch arranged in such a manner that when it is turned outward in the position shown in the engraving, it is quite impossible to pull the trigger; *n* shows a small shutter for closing the hole in the rear end of the rectangular box; by moving this shutter downwards the barrel may be inspected and cleaned from the rear.

Plate II. shows the recoiling portion of the gun, consisting of the barrel, its extension, the crank, and the lock. This in reality is the gun proper; the other portion may be considered as the carriage on which the gun operates. The engraving shows the position of the parts when the breech is opened.

Plate III. represents an external view of the bolt. It will be observed by this that the handling of the loaded cartridge and the extraction of the empty case is effected by firmly seizing the cartridge by both sides of the head, there being no spring extractor used. Very nearly all the machinery in the gun is contained in this one piece, which is very small in size. Each gun is provided with two complete bolts, which are interchange-

Plate II.

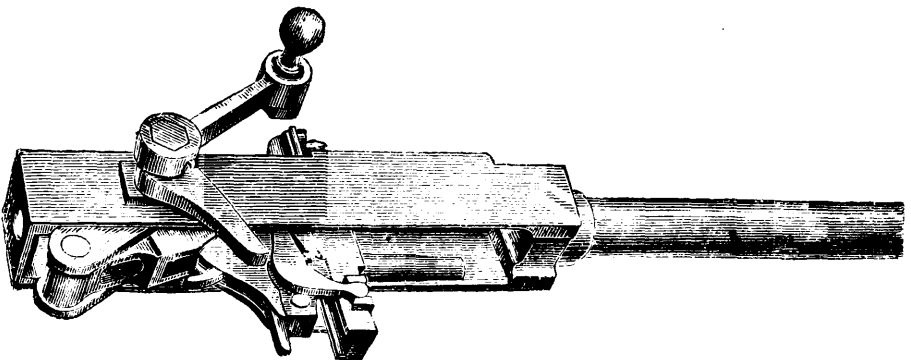


Plate III.

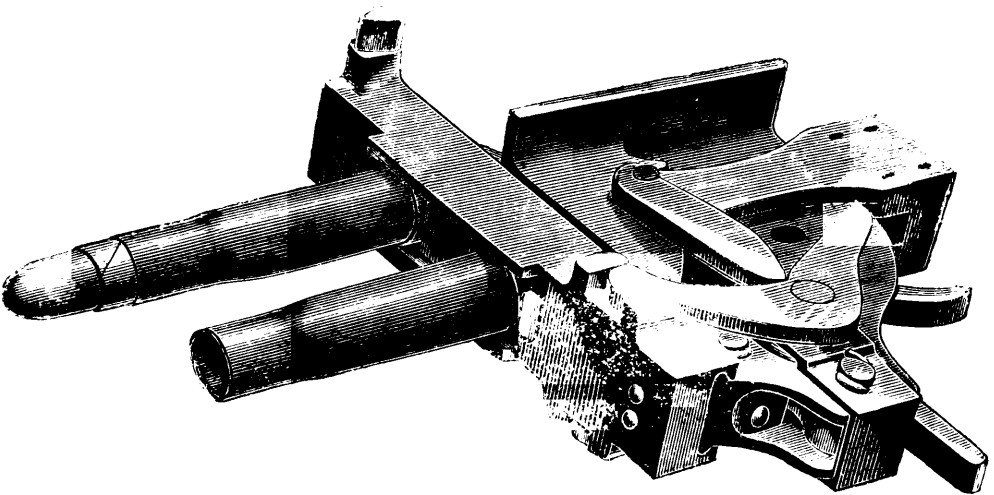


Plate IV.

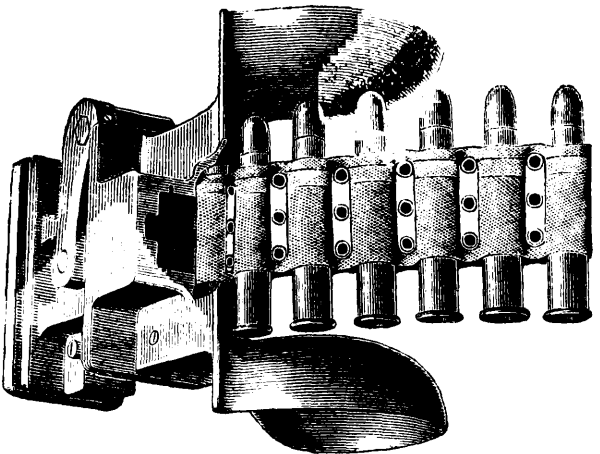


Plate V.

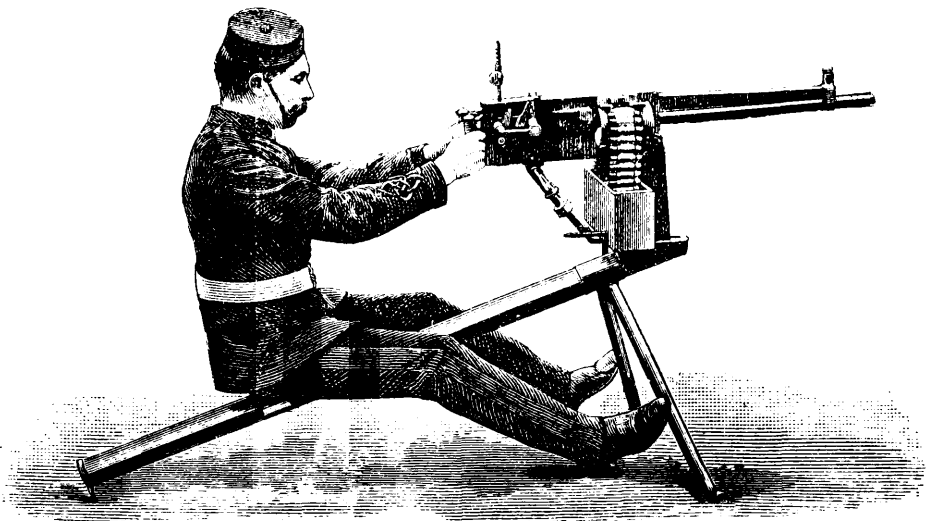
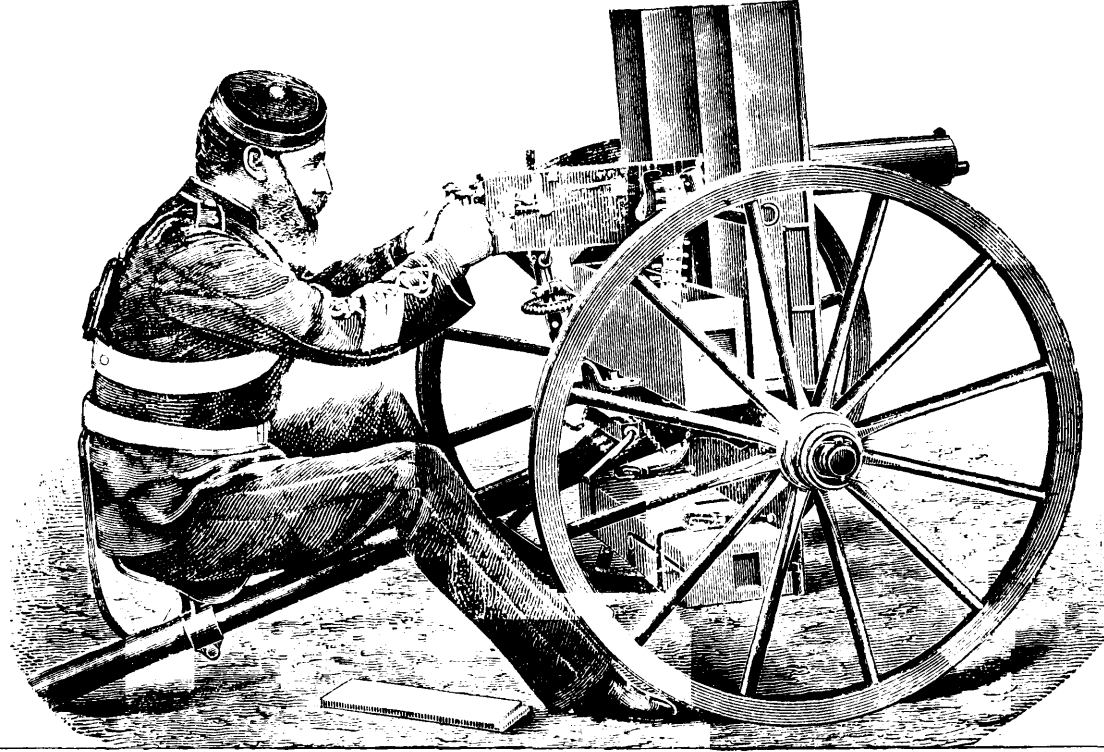


Plate VI.



able. The bolt may be removed from the gun and a new one supplied in its place in about five seconds. As this is the only part of the gun which stands any danger of breaking or of being disarranged, it will be seen that the machinery of the gun is practically in duplicate.

Plate IV. shows the feed-box. The cartridges are placed in a band formed by two pieces of tape connected together by eyelets and brass straps, and the band is made thick at the edge next the bullets by being folded over a piece of cord, so that the cartridges may lie even. The reciprocating action of the barrel operates the lever shown at the top of the engraving in such a manner as to draw the cartridges into position one by one.

Plate V. shows the gun mounted on a tripod.

Plate VI. shows the gun mounted on wheels.