when Nehemiah prepared to rebuild the walls of Jerusalem an Ammonite was foremost in opposition (Neh. ii. 10,19, iv. 1-3).[1] True to their antecedents, the Ammonites, with some of the neighbouring tribes, did their utmost to resist and check the revival of the Jewish power under Judas Maccabaeus (1 Macc. v. 6; cf. Jos. *Ant. Jud.* xii. 8. 1.). The last notice of them is in Justin Martyr (*Dial. cum Tryph.* § 119), where it is affirmed that they were still a numerous people. The few Ammonite names that have been preserved (Nahash, Hanun, and those mentioned above, Zelek in 2 Sam. xxiii. 37 is textually uncertain) testify, in harmony with other considerations, that their language was Semitic, closely allied to Hebrew and to the language of the Moabites. Their national deity was Molech or Milcon. (See Moloch.) (S. A. C.)

AMMONIUS GRAMMATICUS, the supposed author of a treatise entitled Περὶ ὁμοίων καὶ διαφόρων λέξεων (*On the Differences of Synonymous Expressions*), of whom nothing is known. He was formerly identified with an Egyptian priest who, after the destruction of the pagan temple at Alexandria (389), fled to Constantinople, where he became the tutor of the ecclesiastical historian Socrates. But it seems more probable that the real author was Herennius Philo of Byblus, who was born during the reign of Nero and lived till the reign of Hadrian, and that the treatise in its present form is a revision prepared by a later Byzantine editor, whose name may have been Ammonius.

Text by Valckenaer, 1739, Schäfer, 1822; Kopp, *De Ammonii . . . Distinctionibus Synonymicis*, 1883.

AMMONIUS HERMIAE (5th century A.D.), Greek philosopher, the son of Hermias or Hermeias, a fellow-pupil of Proclus. He taught at Alexandria, and had among his scholars Asclepius, John Philoponus, Damascius and Simplicius. His commentaries on Plato and Ptolemy are lost. Those on Aristotle are all that remain of his reputedly numerous writings. Of the commentaries we have—(1) one on the *Isagoge* of Porphyry (Venice, 1500 fol.); (2) one on the *Categories* (Venice, 1503 fol.), the authenticity of which is doubted by Brandis; (3) one on the *De Interpretatione* (Venice, 1503 fol.). They are printed in Brandis's scholia to Aristotle, forming the fourth volume of the Berlin *Aristotle*; they are also edited (1891–1899) in A. Busse's *Commentaria in Aristot. Graeca*. The special section on fate was published separately by J. C. Orelli, *Alex. Aphrod.*, *Ammonii, et aliorum de Fato quae supersunt* (Zürich, 1824). A life of Aristotle, ascribed to Ammonius, but with more accuracy to John Philoponus, is often prefixed to editions of Aristotle. It has been printed separately, with Latin translation and scholia, at Leiden, 1621, at Helmstadt, 1666, and at Paris, 1850. Other commentaries on the *Topics* and the first six books of the *Metaphysics* still exist in manuscript. Of the value of the logical writings of Ammonius there are various opinions. K. Prantl speaks of them with great, but hardly merited, contempt.

For a list of his works see J. A. Fabricius, *Bibliotheca Graeca*, v. 704-707; C. A. Brandis, *Über d. Reihenf. d. Bücher d. Aristot. Org.*, 283 f.; K. Prantl, *Gesch. d. Logik*, i. 642.

AMMONIUS SACCAS (3rd century A.D.), Greek philosopher of Alexandria, often called the founder of the neo-Platonic school. Of humble origin, he appears to have earned a livelihood as a porter; hence his nickname of "Sack-bearer" (Σακκᾶς, for σακκοφόρος). The details of his life are unknown, insomuch that he has frequently been confused with a Christian philosopher of the same name. Eusebius (*Church History*, vi. 19), who is followed by Jerome, asserts that he was born a Christian, remained faithful to Christianity throughout his life, and even produced two works called *The Harmony of Moses and Jesus* and *The Diatessaron, or Harmony of the Four Gospels*, which is said by some to exist in a Latin version by Victor, bishop of Capua. Porphyry, quoted by Eusebius, *ib.* vi. 19. 6, however, says that he apostatized in later life and left no writings behind him. There seems no reason, therefore, to doubt that Eusebius is here referring to the Christian philosopher. After long study and meditation, Ammonius opened a school of philosophy in Alexandria. His principal pupils were Herennius, the two Origens, Cassius Longinus and Plotinus. As he designedly wrote nothing, and, with the aid of his pupils, kept his views secret, after the manner of the Pythagoreans, his philosophy must be inferred mainly from the writings of Plotinus. As Zeller points out, however, there is reason to think that his doctrines were rather those of the earlier Platonists than those of Plotinus. Hierocles, writing in the 5th century A.D., states that his fundamental doctrine was an eclecticism, derived from a critical study of Plato and Aristotle. His admirers credited him with having reconciled the quarrels of the two great schools. His death is variously given between A.D. 240 and 245. See Neo-Platonism, Origen.

Bibliography.—C. Rösler, *De commentitiis philosophiae Ammoniaceae fraudibus et noxis* (Tübingen, 1786); L. J. Dehaut, *Essai historique sur la vie et la doctrine d' Ammonius Saccas* (Brussels, 1836); E. Zeller, "Ammonius Saccas und Plotinus," *Arch. f. Gesch. d. Philos.* vii., 1894, pp. 295-312; E. Vacherot, *Hist. crit. de l'école d'Alexandrie* (Paris, 1846); T. Whittaker, *The Neo-platonists* (Camb., 1901); Eusebius, *Hist. Eccles.*, trans. A. C. M'Giffert (Oxford and New York, 1890), notes on passages quoted above.

AMMUNITION, a military term (derived, through the French, from Lat. *munire*, to provide), for consumable stores used in attack or defence, such as rifle cartridges, cartridges, projectiles, igniting tubes and primers for ordnance, &c.

The components of ammunition intended for rifles and ordnance may be divided into (*a*) explosives and propellants (see Explosives and Gunpowder), (*b*) projectiles of all kinds, and (*c*) cartridges. The military classification of explosives differs somewhat from that of the Explosives Act 1875, but, broadly speaking, they are divided into two groups. The first of these comprises explosives in bulk, made-up cartridges for cannon, and filled quick-firing cartridges; Group II. contains small-arm cartridges, fuzes, primers, tubes, filled shells (fuzed or unfuzed), &c. Each group is subdivided, and arrangements are made for storing certain divisions of Group I. in a magazine in separate compartments. All the divisions of Group II. are, and the remaining divisions of Group I. (comprising wet gun-cotton, picric acid and Q.F. cartridges) may be, stored in ammunition stores.

These general conditions apply to the *storage of ammunition in fortresses*. Here the positions for the magazine and ammunition stores are so chosen as to afford the best means of protection from an enemy's fire. Huge earth parapets cover these buildings, which are further strengthened, where possible, by traverses protecting the entrances. For the purpose of filling, emptying and examining cannon cartridges and shell, a laboratory is generally provided at some distance from the magazine. The various stores for explosives are classified into those under magazine conditions (viz. magazines, laboratories and cartridge stores) and those with which these restrictions need not be observed (viz. ammunition and shell stores). The interior walls of a magazine are lined and the floors laid so that there may be no exposed iron or steel. At the entrance there is a lobby or barrier, inside which persons about to enter the magazine change their clothes for a special suit, and their boots for a pair made without nails. In an ammunition or shell store these precautions need not be taken except where the shell store and the adjacent cartridge store have a common entrance; persons entering may do so in their ordinary clothes. A large work may have a main magazine and several subsidiary magazines, from which the stock of cartridges is renewed in the cartridge stores attached to each group of guns or in the expense cartridge stores and cartridge recesses. The same applies to main ammunition stores which supply the shell stores, expense stores and recesses.

The supply of ammunition may be divided roughly into (*a*) that

[1] The allusions in Jer. xlix. 1-6; Zeph. ii. 8-11; Ezek. xxi. 28-32; Judg. xi. 12-28, have been taken to refer to an Ammonite occupation of Israelite territory after the deportation of the east Jordanic Israelites in 734, but more probably belong to a later event. The name Chephar-Ammoni (in Benjamin; Josh. xviii. 24) seems to imply that the "village" became a settlement of "Ammonites." Some light is thrown upon the obscure history of the post-exile period by the references to the mixed marriages which aroused the reforming zeal of Ezra and culminated in the exclusion of Ammon and Moab from the religious community—on the ground of incidents which were ascribed to the time of the "exodus" (Deut. xxiii. 3 sqq.; Ezr. ix. 1 sqq.; Neh. xiii. 1 sqq.).

for guns forming the movable armament, (*b*) that for guns placed in permanent positions. The movable armament will consist of guns and howitzers of small and medium calibre, and it is necessary to arrange suitable expense cartridge stores and shell stores in close proximity to the available positions. They can generally be constructed to form part of the permanent work in the projected face of traverses or other strong formations, and should be arranged for a twenty-four hours' supply of ammunition. These stores are refilled from the main magazine every night under cover of darkness. Light railways join the various positions. The guns mounted in permanent emplacements are divided into groups of two or three guns each, and usually each group will require but one calibre of ammunition. A cartridge store, shell store and a general store, all well ventilated, are arranged for the especial service of such a group of guns. In the cartridge store the cylinders containing the cartridges are so placed and labelled that the required charge, whether reduced or full, can be immediately selected. In the shell store also for the same reason the common shell are separated from the armour-piercing or shrapnel. Each nature of projectile is painted in a distinctive manner to render identification easy. The fuzes, tubes, &c., are placed in the general store with the tools and accessories belonging to the guns. The gun group is distinguished by some letter and the guns of the group by numerals; thus, $\frac{A}{1}$ is No. 1 gun of group A. The magazine and shell stores are also indicated by the group letter, and so that mistakes, even by those unaccustomed to the fort, may be avoided, the passages are pointed out by finger posts and direction boards. For the immediate service of each gun a few cartridges and projectiles are stored in small receptacles—called cartridge and shell recesses respectively—built in the parapet as near the gun position as practicable. In some cases a limited number of projectiles may be placed close underneath the parapet if this is conveniently situated near the breech of the gun and not exposed to hostile fire.

In order to supply the ammunition sufficiently rapidly for the efficient service of modern guns, hydraulic, electric or hand-power hoists are employed to raise the cartridges and shell from

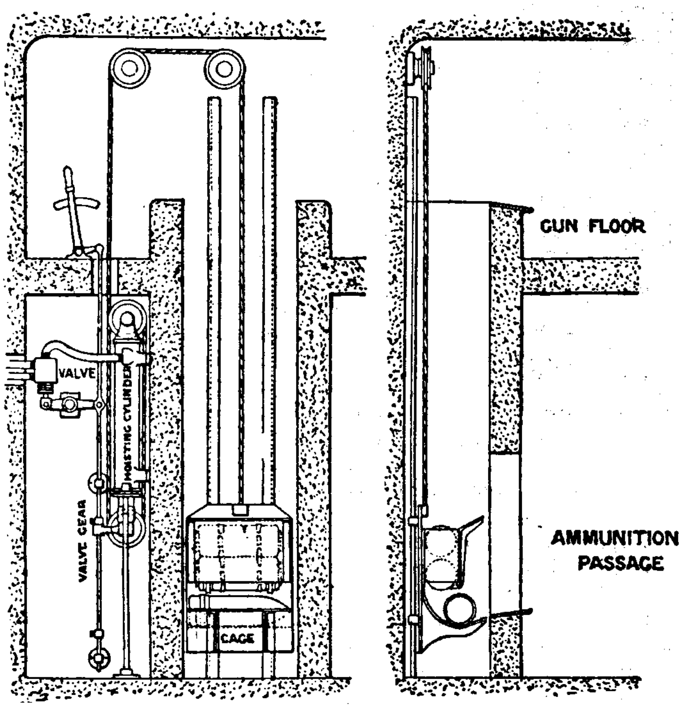


FIG. 1.—Ammunition Hoist.

the cartridge store and shell store to the gun floor, whence they are transferred to a derrick or loading tray attached to the mounting for loading the gun.

Projectiles for B.L. guns above 6-in. calibre are stored in shell stores ready filled and fuzed standing on their bases, except shrapnel and high-explosive shell, which are fuzed only when about to be used. Smaller sizes of shells are laid on their sides in layers, each layer pointing in the opposite direction to the one below to prevent injury to the driving bands. Cartridges are stored in brass corrugated cases or in zinc cylinders. The corrugated cases are stacked in layers in the magazine with the mouth of the case towards a passage between the stacks, so that it can be opened and the cartridges removed and transferred to a leather case when required for transport to the gun. Cylinders are stacked, when possible, vertically one above the other. The charges are sent to the gun in these cylinders, and provision is made for the rapid removal of the empty cylinders.

The number and nature of rounds allotted to any fortress depends on questions of policy and location, the degrees of resistance the nature of the works and *personnel* could reasonably be expected to give, and finally on the nature of the armament. That is to say, for guns of large calibre three hundred to four hundred rounds per gun might be sufficient, while for light Q.F. guns it might amount to one thousand or more rounds per gun. (A. G. H.)

Supply of ammunition in the field.

With every successive improvement in military arms there has necessarily been a corresponding modification in the method of supplying ammunition and in the quantity required to be supplied. When hand-to-hand weapons were the principal implements of battle, there was, of course, no such need, but even in the middle ages the archers and crossbowmen had to replenish the shafts and bolts expended in action, and during a siege stone bullets of great size, as well as heavy arrows, were freely used. The missiles of those days were, however, interchangeable, and at the battle of Towton (1461) the commander of the Yorkist archers, by inducing the enemy to waste his arrows, secured a double supply of ammunition for his own men. This interchangeability of war material was even possible for many centuries after the invention of firearms. At the battle of Liegnitz (1760) a general officer was specially commissioned by Frederick the Great to pack up and send away, for Prussian use, all the muskets and ammunition left on the field of battle by the defeated Austrians. Captured material is, of course, utilized whenever possible, at the present time, and in the Chino-Japanese War the Japanese went so far as to prepare beforehand spare parts for the Chinese guns they expected to capture (Wei-Hai-Wei, 1895), but it is rare to find a modern army trusting to captures for arms and ammunition; almost the only instance of the practice is that of the Chilean civil war of 1891, in which the army of one belligerent was almost totally dependent upon this means of replenishing stores of arms and cartridges. But what was possible with weapons of comparatively rough make is no longer to be thought of in the case of modern arms. The Lee-Metford bullet of ·303 in. diameter can scarcely be used in a rifle of smaller calibre, and in general the minute accuracy of parts in modern weapons makes interchangeability almost impossible. Further, owing to the rapidity with which, in modern arms, ammunition is expended, and the fact that, as battles are fought at longer ranges than formerly, more shots have to be fired in order to inflict heavy losses, it is necessary that the reserves of ammunition should be as close as possible to the troops who have to use them. This was always the case even with the older firearms, as, owing to the great weight of the ammunition, the soldier could carry but few rounds on his person. Nevertheless it is only within the past seventy years that there has grown up the elaborate system of ammunition supply which now prevails in all regularly organized armies. That which is described in the present article is the British, as laid down in the official *Combined Training* (1905) and other manuals. The new system designed for stronger divisions, and others, vary only in details and nomenclature.

Infantry.—The infantry soldier generally carries, in pouches, bandoliers, &c., one hundred rounds of small-arms ammunition (S.A.A.), and it is usual to supplement this, when an action is imminent, from the regimental reserve (see below). It is to be noticed that every reduction in the calibre of the rifle means an increase in the number of rounds carried. One hundred rounds of the Martini-Henry ammunition weighed 10lb 10 oz.; the same weight gives 155 with ·303 ammunition (incl.charges), and if a ·256 calibre is adopted the number of rounds will be still greater. It is, relatively, a matter of indifference that the reserves of ammunition include more rounds than formerly; it is of the highest importance that the soldier should, as far as possible, be independent of fresh supplies, because the bringing up of ammunition to troops closely engaged is laborious and costly in lives. The *regimental reserves* are carried in S.A.A. carts and on pack animals. Of the former each battalion has six, of the latter eight. The six carts are distributed, one as reserve to the machine gun, three as reserve to the battalion itself, and two as part of the *brigade reserve*, which consists therefore of eight carts. The brigade reserve communicates directly with the brigade ammunition columns of the artillery (see below). The eight pack animals follow the eight companies of their battalion. These, with two out of the three battalion carts, endeavour to keep close to the firing line, the remaining cart being with the reserve companies. Men also are employed as carriers, and this duty is so onerous that picked men only are detailed. Gallantry displayed in bringing up ammunition is considered indeed to justify special rewards. The amount of S.A.A. in regimental charge is 100 rounds in the possession of each soldier, 2000 to 2200 on each pack animal, and 16,000 to 17,600 in each of four carts, with, in addition, about 4000 rounds with the machine gun and 16,000 more in the fifth cart.

Artillery.—The many vehicles which accompany batteries (see ARTILLERY) carry a large quantity of ammunition, and with the contents of two wagons and the limber each gun may be considered as well supplied, more especially as fresh rounds can be brought up with relatively small risk, owing to the long range at which artillery fights and the use of cover. Each brigade of artillery has its own *ammunition column*, from which it draws its reserve in the first instance.

Ammunition Columns.—An ammunition column consists of military vehicles carrying gun and S.A. ammunition for the combatant unit to which the column belongs. Thus the ammunition columns of a division, forming part of the brigades of field artillery, carry reserve ammunition for the guns, the machine guns of the infantry and the rifles of all arms. Generally speaking, the ammunition column of each of the artillery brigades furnishes spare ammunition for its own batteries and for one of the brigades of infantry. All ammunition columns are officered and manned by the Royal Artillery. They are not reserved exclusively to their own brigades, divisions, &c., but may be called upon to furnish ammunition to any unit requiring it during an action. The officers and men of the R.A. employed with the ammunition column are, as a matter of course, immediately available to replace casualties in the batteries. Teams, wagons and *matériel* generally are also available for the same purpose. The horse artillery, howitzer and heavy brigades of artillery have each their own ammunition columns, organized in much the same way and performing similar duties. The ammunition column of the heavy brigade is divisible into three sections, so that the three batteries, if operating independently, have each a section at hand to replenish the ammunition expended. The horse artillery brigade ammunition columns carry, besides S.A.A. for all corps troops other than artillery, the reserve of pom-pom ammunition. In action these columns are on the battlefield itself. Some miles to the rear are the divisional and corps troops columns, which on the one hand replenish the empty wagons of the columns in front, and on the other draw fresh supplies from the depots on the line of communication. These also are in artillery charge; a divisional column is detailed to each division (*i.e.* to replenish each set of brigade ammunition columns), and the corps troops column supplies the columns attached to the heavy, howitzer and horse artillery brigades. The ammunition thus carried includes ordinarily seven or eight kinds at least. S.A.A., field, horse, howitzer and heavy gun shrapnel, howitzer and heavy gun lyddite shells, cartridges for the four different guns employed and pom-pom cartridges for the cavalry,—in all twelve distinct types of stores would be carried for a complete army corps. Consequently the rounds of each kind in charge of each ammunition column must vary in accordance with the work expected of the combatant unit to which it belongs. Thus pom-pom ammunition is out of place in the brigade ammunition columns of field artillery, and S.A.A. is relatively unnecessary in that attached to a heavy artillery brigade. Under these circumstances a column may be unable to meet the particular wants of troops engaged in the vicinity; for instance, a cavalry regiment would send in vain to a heavy artillery ammunition section for pom-pom cartridges. The point to be observed in this is that the fewer the natures of weapons used, the more certain is the ammunition supply. (C. F. A.)

Shot.

The first projectiles fired from cannon were the darts and stone shot which had been in use with older weapons. These darts ("garros") had iron heads or were of iron wrapped with leather to fit the bore of small guns, and continued in use up to nearly the end of the 16th century. Spherical stone shot were chosen on account of cheapness; forged iron, bronze and lead balls were tried, but the expense prevented their general adoption. Further, as the heavy metal shot necessitated the use of a correspondingly large propelling charge, too great a demand was made on the strength of the feeble guns of the period. Stone shot being one-third the weight of those of iron the powder charge was reduced in proportion, and this also effected an economy. Both iron and stone shot were occasionally covered with lead, probably to preserve the interior of the bore of the gun. Cast iron, while known in the 14th century, was not sufficiently common to be much used for the manufacture of shot, although small ones were made about that time. They were used more frequently at the latter part of the following century. Towards the end of the 16th century nearly all shot were of iron, but stone shot were still used with guns called Petrieroes (hence the name) or Patararoes, for attacking weak targets like ships at short range.

Case shot are very nearly as ancient as spherical shot. They can be traced back to the early part of the 15th century, and they have practically retained their original form up to the present date. They are intended for use at close quarters when a volley of small shot is required. With field guns they are not of much use at ranges exceeding about four hundred yards; those for heavy guns are effective up to one thousand yards. In the earlier forms lead or iron shot were packed in wood casks or in canvas bags tied up with twine like the later quilted shot. In the present (fig. 2) type small shot are placed in a cylindrical case of sheet iron, with iron ends, one end being provided with handles. For small guns the bullets are made of lead and antimony—like shrapnel bullets—while for larger calibres they are of cast iron weighing from two ounces to three and a half pounds each.

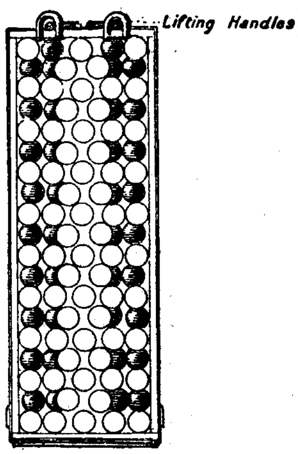


FIG. 2.—Case Shot.

Grape shot is now obsolete. It consisted generally of three tiers of cast-iron balls separated by iron plates and held in place by an iron bolt which passed through the centre of the plates.

There was also another type called *quilted shot* which consisted of a number of small shot in a canvas covering tied up by rope. *Chain shot*, in the days of sailing ships, was much in favour as a means of destroying rigging. Two spherical shot were fastened together by a short length of chain. On leaving the gun they began gyrating around each other and made a formidable missile.

Red-hot shot were invented in 1579 by Stephen Batory, king of Poland. They were used with great effect by the English during the siege of Gibraltar, especially on the 13th of September 1782, when the French floating batteries were destroyed, together with a large part of the Spanish fleet. *Martin's shell* was a modified form; here a cast-iron shell was filled with molten cast iron and immediately fired. On striking the side of a ship the shell broke up, freeing the still molten iron, which set fire to the vessel.

Rotation.—Projectiles intended for R.M.L. guns were at first fitted with a number of gun-metal studs arranged around them in a spiral manner corresponding to the twist of rifling. This was defective, as it allowed, as in the old smooth-bore guns, the powder gas to escape by the clearance (called "windage") between the projectile and the bore, with a consequent loss of efficiency; it also quickly eroded the bore of the larger guns. Later the rotation was effected by a cupped copper disc called a "gas check" attached to the base end of the projectile. The powder gas pressure expanded the rim of the gas check into the rifling grooves and prevented the escape of gas; it also firmly fixed the gas check to the projectile, thus causing it to rotate. A more regular and efficient action of the powder gas was thus ensured, with a corresponding greater range and an improvement in accuracy. With the earlier Armstrong (R.B.L.) guns the projectiles were coated with lead (the late Lord Armstrong's system), the lead being forced through the rifling grooves by the pressure of the exploded powder gas. The lead coating is, however, too soft with the higher velocities of modern B.L. guns. Mr Vavasseur, C.B., devised the plan of fitting by hydraulic pressure a copper "driving band" into a groove cut around the body of the projectile. This is now universal. It not only fulfils the purpose of rotating the projectile, but renders possible the use of large charges of slow-burning explosive. The copper band, on being forced through the gun, gives rise to considerable resistance, which allows the propelling charge to burn properly and thus to exert its enormous force on the projectile.

The laws which govern the designs of projectiles are not well defined. Certain formulae are used which give the thickness of the walls of the shell for a known chamber pressure in the gun, and for a particular stress on the material of the shell. The exact proportions of the shell depend, however, greatly on experimental knowledge.

Armour-piercing Shot and Shell.—On the introduction of iron ships it was found that the ordinary cast-iron projectile readily pierced the thin plating, and in order to protect the vital parts of the vessel wrought-iron armour of considerable thickness was placed on the sides. It then became necessary to produce a projectile which would pierce this armour. This was effected by Sir W. Palliser, who invented a method of hardening the head of the pointed cast-iron shot. By casting the projectile point downwards and forming the head in an iron mould, the hot metal was suddenly chilled and became intensely hard, while the remainder of the mould being formed of sand allowed the metal to cool slowly and the body of the shot to be made tough.

These shot proved very effective against wrought-iron armour, but were not serviceable against compound and steel armour. A new departure had, therefore, to be made, and forged steel shot with points hardened by water, &c., took the place of the Palliser shot. At first these forged steel shot were made of ordinary carbon steel, but as armour improved in quality the projectiles followed suit, and, for the attack of the latest type of cemented steel armour, the projectile is formed of steel—either forged or cast—containing both nickel and chromium. Tungsten steel has also been used with success.

Armour-piercing shot or shell are generally cast from a special mixture of chrome steel melted in pots; they are afterwards forged into shape. The shell is then thoroughly annealed, the core bored and the exterior turned up in the lathe. The shell is finished in a similar manner to others described below. The final or tempering treatment is very important, but details are kept strictly secret. It consists in hardening the head of the projectile and tempering it in a special manner, the rear portion being reduced in hardness so as to render it tough. The cavity of these projectiles is capable of receiving a small bursting charge of about 2 % of the weight of the complete projectile, and when this is used the projectile is called an *armour-piercing shell*. The shell, whether fuzed or unfuzed, will burst on striking a medium thickness of armour. Armour-piercing shells, having a bursting charge of about 3 % of the weight of the complete projectile, are now often fitted with a soft steel cap (fig. 3) for the perforation of

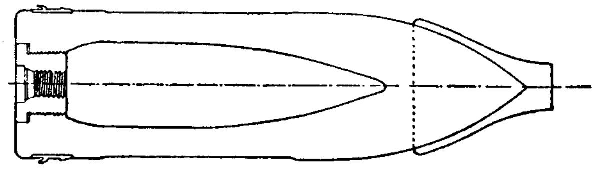


Fig. 3.—Capped A.P. Shell.

hard steel armour. For the theory of the action of the cap see ARMOUR PLATES.

Even with these improvements the projectile cannot, with a reasonable velocity, be relied upon to pierce one calibre in thickness of modern cemented steel armour.

Shell.

Explosive shells do not appear to have been in general use before the middle of the 16th century. About that time hollow balls of stone or cast iron were fired from mortars. The balls were nearly filled with gunpowder and the remaining space with a slow-burning composition. This plan was unsatisfactory, as the composition was not always ignited by the flash from the discharge of the gun, and moreover the amount of composition to burn a stipulated time could not easily be gauged. The shell was, therefore, fitted with a hollow forged iron or copper plug, filled with slow-burning powder. It was impossible to ignite with certainty this primitive fuze simply by firing the gun; the fuze was consequently first ignited and the gun fired immediately afterwards. This entailed the use of a mortar or a very short piece, so that the fuze could be easily reached from the muzzle without unduly endangering the gunner. Cast-iron spherical common shell (fig. 4) were in use up to 1871. For guns they were latterly fitted with a wooden disc called a *sabot*, attached by a copper rivet, intended to keep the fuze central when loading. They were also supposed to reduce the rebounding tendency of the shell as it travelled along the bore on discharge. Mortar shell (fig. 5) were not fitted with sabots.

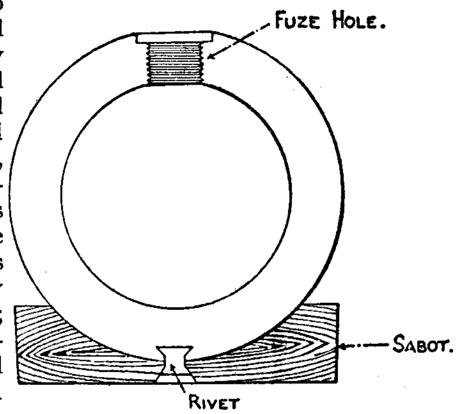


Fig. 4.—Spherical Common Shell.

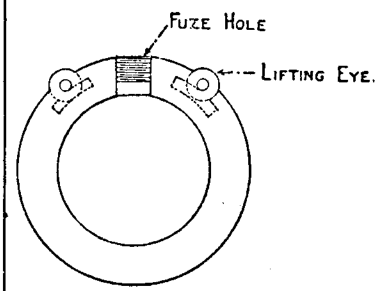


Fig. 5.—Mortar Shell.

Cast iron held its own as the most convenient material for projectiles up to recent years, steel supplanting it, first for projectiles intended for piercing armour, and afterwards for common shell for high-velocity guns where the shock of discharge has been found too severe for cast iron.

Common shell is essentially a material destructor. Filled with ordinary gunpowder, the larger natures are formidable projectiles for the attack of fortifications and the unarmoured portions of warships. On bursting they break up into somewhat large pieces, which carry destruction forward to some distance from the point of burst. For the attack of buildings common shell are superior to shrapnel and they are used to attack troops posted behind cover where it is impossible for shrapnel to reach them; their effect against troops is, however, generally insignificant. When filled with lyddite, melinite, &c., they are called high-explosive (H.E.) shell (see below). Common shell for modern high-velocity guns may be made of cast steel or forged steel; those made of cast iron are now generally made for practice, as they are found to break up on impact, even against earthworks, before the fuze has time to act; the bursting charge is, therefore, not ignited or only ignited after the shell has broken up, the effect of the bursting charge being lost in either case. So long as the shell is strong enough to resist the shocks of discharge and impact against earth or thin steel plates, it should be designed to contain as large a bursting charge as possible and to break up into a large number of medium-sized pieces. Their effect between decks is generally more far-reaching than lyddite shell, but the purely local effect is less. Light structures, which, at a short distance from the point of burst, successfully resist lyddite shell and confine the effect of the explosion, may be destroyed by the shower of heavy pieces produced by the burst of a large common shell.

To prevent the premature explosion of the shell, by the friction of the grains of powder on discharge, it is heated and coated internally with a thick lacquer, which on cooling presents a smooth surface. Besides this the bursting charge of all shell of 4-in. calibre and upwards (also with all other natures except shrapnel) is contained in a flannel or canvas bag. The bag is inserted through the fuze hole and the bursting charge of pebble and fine grain powder gradually poured in. The shell is tapped on the outside by a wood mallet to settle the powder down. When all the powder has been got in, the neck of the bag is tied and pushed through the fuze hole. A few small shalloon primer bags, filled with seven drams of fine grain powder, are then inserted to fill up the shell and carry the flash from the fuze through the burster bag.

In the United States specially long common shell called *torpedo shell*, about 4·7 calibres in length, are employed with the coast artillery 12-in. mortars. They were made of cast steel, but owing to a premature explosion in a mortar, supposed to be due to weakness of the shell, they are now made of forged steel. The weight of the usual projectile for this mortar is 850 lb. The torpedo shell, however, weighs 1000 lb and contains 137 lb of high explosive; it is not intended for piercing armour but for producing a powerful explosion on the armoured deck of a warship. The compression, and consequent generation of heat on discharge of the charge in these long shell, render them liable to premature explosion if fired with high velocities. Some inventors have, therefore, sought to overcome this by dividing the shell transversely into compartments and so making each portion of the charge comparatively short.

Cast-steel common shell (fig. 6) are cast in sand moulds head downwards from steel of the required composition to give the proper tenacity. A large head, which is subsequently removed, is cast on the base to give solidity and soundness to the castings. The castings are annealed by placing them in a furnace or oven until red hot, then allowing them to cool gradually. The process of casting is very similar to that for the old cast-iron common shell, which, however, were cast base downwards. The steel castings after being annealed are dressed and carefully examined for defects. The exterior of the body is generally ground by an emery wheel or turned in a lathe; the groove for the driving band is also turned and the fuze hole fitted with a gun-metal bush. Forged-steel common shell are made from solid steel billets. These are heated to redness and shaped by a series of punches which force the heated metal through steel dies by hydraulic pressure. If the shell is intended for a nose fuze the base end is shaped by the press and the head subsequently formed by a properly shaped die, or, in the case of small shell, the head can, when red hot, be spun up in a lathe by a properly formed tool. For a base fuze shell the head is produced by the punches and dies, and the base is subsequently formed by pressing in the metal to the desired shape. The shell is then completed as described above.

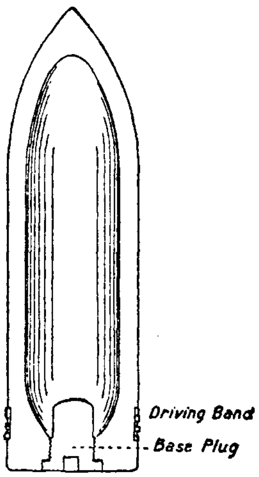


FIG. 6.—Pointed Common Shell (cast steel).

High-explosive shell (fig. 7), as used in the English service, are simply forged-steel common shell filled with lyddite and having a special nose fuze and exploder. The base end of lyddite shell is made solid to prevent the possibility of the gas pressure in the gun producing a premature explosion. In filling the shell great precautions are necessary to prevent the melted lyddite (picric acid) from coming in contact with certain materials such as combinations of lead, soda, &c., which produce sensitive picrates. The shell are consequently painted externally with a special non-lead paint and lacquered inside with special lacquer. The picric acid is melted in an oven, the temperature being carefully limited. The melted material is poured into the shell by means of a bronze funnel, which also forms the space for the exploder of picric powder. On cooling, the material solidifies into a dense, hard mass (density 1·6), in which state it is called *lyddite*. The fuze on striking ignites the exploder and in turn the lyddite. When properly detonated a dense black smoke is produced and the projectile is broken up into small pieces, some of which are almost of the fineness of grains of sand. The radius of the explosion is about 25 yds., but the local effect is intense, and hence on light structures in a confined space the destruction is complete. The shell is only of use against thin plates; against modern armour it is ineffective. When detonation has not been complete, as sometimes happens with small shells, the smoke is yellowish and the pieces of the exploded shell are as large as when a powder burster is used.

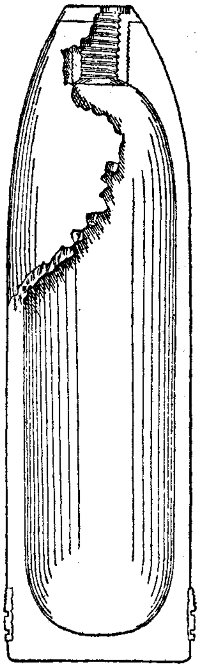


FIG. 7.—Lyddite Shell (forged steel).

The French high-explosive shell *obus torpille* or *obus à mélinite* was adopted in 1886. The *mélinite* was originally filled into the ordinary cast-iron common shell (*obus ordinaire*) with thick walls, but soon afterwards a forged-steel thin-walled shell (*obus allongé*) was introduced. To explode the shell a steel receptacle (called a *gaîne*) is screwed into the nose of the shell. It is filled with explosive and fitted with a detonator which is exploded by a percussion fuze. Except for the means adopted to ensure detonation this shell is practically the same as the lyddite shell.

Picric acid in some form or other is used in nearly all countries for filling high-explosive shell. In some the explosive is melted and poured into cardboard cases instead of being poured directly into the shell. The cases are placed in the shell either by the head of the shell unscrewing from the body or by a removable base plug. The French *mélinite* and the Italian *pertite* are believed to be forms of picric acid. Russia and the United States use compressed wet gun-cotton (density 1·2) as the charge for their high-explosive shell. The gun-cotton is packed in a thin zinc or copper case and is placed in the shell either by the head or base of the shell being removable. The gun-cotton is detonated by a powerful exploder, the form of which differs in each country. Ammonal is also used in high-explosive shell, but owing to its light density it is not in great favour. For field-gun and other small high-explosive shells, ordinary smokeless powder is often used.

Double shell is a term given to a common shell which was made abnormally long, so as to receive a large bursting charge. They were intended to be fired with a reduced charge at short range. They are now practically obsolete; their place with modern B.L. guns has been taken by high-explosive shell. *Star shell* are intended for illuminating the enemy's position. They are very similar to shrapnel shell, composition stars made up in cylindrical paper cases taking the place of the bullets. The shell on bursting, blows off the head and scatters the ignited stars. This shell is only supplied to mountain guns and howitzers, and takes the place of the older types of illuminating shell, viz. the *ground light ball* and the *parachute light ball*.

Hand grenades were used at the assault of entrenchments or in boat attacks. Although generally regarded as obsolete, they were much used by the Japanese at the siege of Port Arthur, 1904. In the British service they were small, thin, spherical common shell weighing 3 ℔ for land service and 6 ℔ for sea service, filled with powder. They were fitted with a small wood time fuze to burn 7·5 seconds. The grenade was held in the hand and

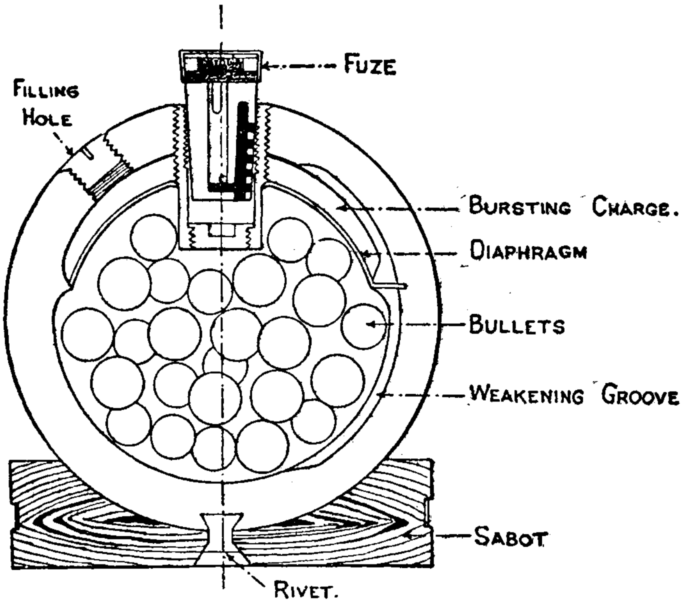


FIG. 8.—Boxer Shrapnel.

the fuze lighted by a port-fire. It was then thrown some 20 to 30 yds. at the enemy's works or boats. Sometimes a number were fired from a mortar at an elevation of about 30° so that none should strike the ground too near the mortar. New types of grenades filled with high explosives detonated by a percussion fuze have been produced of late years, and it is probable that they will be again introduced into most countries.

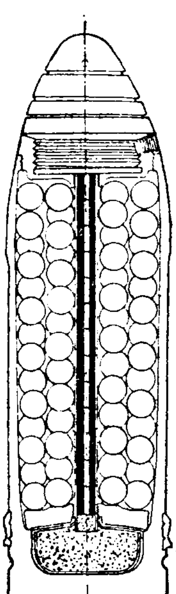
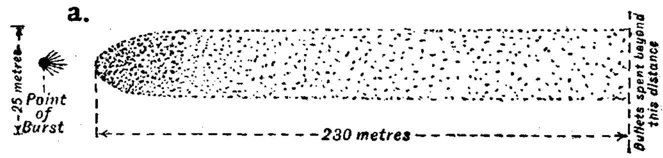


FIG. 9.—Shrapnel Shell.

Shrapnel shell were invented by Lieutenant (afterwards Lieutenant-General) Henry Shrapnel, R.A. (1761–1842), in 1784. They were spherical common shell with lead bullets mixed with the bursting charge. Although far superior to common shell in man-killing effect, their action was not altogether satisfactory, as the shell on bursting projected the bullets in all directions, and there was a liability of premature explosion. In order to overcome these defects Colonel Boxer, R.A., separated the bullets from the bursting charge by a sheet-iron diaphragm—hence the name of "diaphragm shell" (fig. 8). The bullets were hardened by the addition of antimony, and, as the bursting charge was small, the shell was weakened by four grooves made inside the shell extending from the fuze hole to the opposite side.

With rifled guns the form of the shell altered, but its character remained. The body of the shell was still made of cast iron with a cavity at the base for the bursting charge; on this was placed a thick steel diaphragm with a hollow brass tube which communicated the flash from the nose fuze to the bursting charge. The body was filled with hard lead bullets, and a wood head covered with sheet iron or steel surmounted it and carried the fuze. By making the body of toughened steel (fig. 9) and by slightly reducing the diameter of the bullets, the number of bullets contained was much increased. In the older field shrapnel, bullets of 18 and 34 to the ℔ were used; for later patterns see



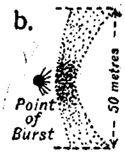


FIG. 10.

table in ORDNANCE: *Field Equipments*. Thus with the cast-iron body the percentage of useful weight, *i.e.* the proportion of the weight of the bullets to the total weight of the shell, was from 26 to 28 %, while with modern steel shell it is from 47 to 53 %. The limit of the forward effect of shrapnel at effective range is about 300 yds. and the extent of front covered 25 yds.

[Fig. 10 shows in plan the different effects of (*a*) shrapnel and of (*b*) high-explosive, burst in the air with a time fuze in the usual way. It will be seen that the shrapnel bullets sweep an area of about 250 yds. by 30 yds., half the bullets falling on the first 50 yds. of the beaten zone. With the high-explosive shell, however, the fragments strike the ground closer to the point of burst and beat a shallow, but broad, area of ground (about 7 yds. by 55 yds.). These areas show the calculated performance of the German field gun (96 N.A.), firing at a range of 3300 yds. In the case of the high-explosive shell, the concussion of the burst is highly dangerous, quite apart from the actual distribution of the fragments of the shell.]

The term "*shooting shrapnel*" is given to certain howitzer shrapnel, which are designed to contain a large bursting charge for the purpose of considerably augmenting the velocity of the bullets when the shell bursts.

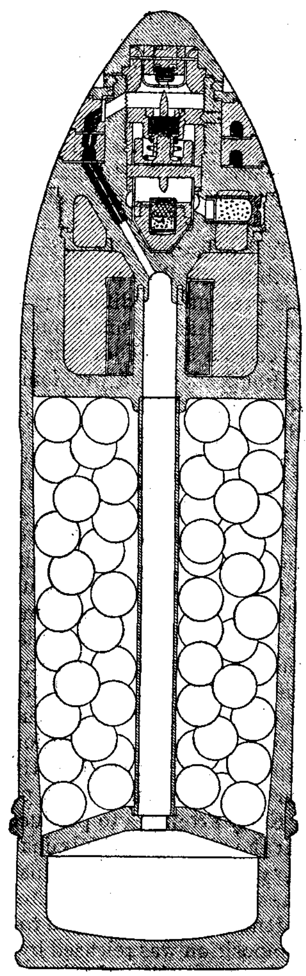


FIG. 11.—High-Explosive Shrapnel (Ehrhardt).

High-explosive shell of a compound type have also lately appeared. Messrs Krupp have made a kind of ring shell with a steel body; a central tube conveys the flash from the fuze to a base magazine containing a smoke-producing charge, while surrounding the central tube is a bursting charge of ordinary smokeless nitro-powder. A shrapnel on somewhat similar lines has been made by Ehrhardt; in form (fig. 11) it is an ordinary shrapnel with base burster, but near the head is a second magazine filled with a high-explosive charge; this is attached to the end of the fuze and is so arranged that when the shell is burst as time shrapnel the flash from the fuze passes clear of the high-explosive magazine and ignites only the base magazine, the bullets being blown out in the usual manner. When, however, the fuze acts on graze, the percussion part detonates the high-explosive charge and the bullets are blown out sideways and thus reach men behind shields, &c. (fig. 10). There is some loss of bullet capacity in this shell, and it appears likely that the bullets will be materially deformed when detonation occurs; the advantages may, however, counterbalance their objections.

Segment and *ring shell* are varieties of shrapnel, the interior of the shell being built up of cast-iron segments or rings (which break up into segments) about a tinned-iron cylinder which formed the magazine of the shell. The shell was completed by a cast-iron body formed around the segments or rings. The German army in 1870 employed ring shell almost exclusively against the French. The French found that common shell (*obus ordinaire*) when made of cast iron broke up on bursting into a small number of irregularly shaped pieces, and in order to obtain a systematic fragmentation for small shells they adopted a variety of projectiles of the segment and shrapnel types. With the improvements made latterly these have become obsolete, and the French system does not now materially differ from that employed in England and other countries. The old shell are, however, of sufficient interest to be enumerated; thus the "double-walled shell" (*obus à double paroi*) was built up of two shells, the internal portion had a cylindrical chamber for the bursting charge, but on the outside it was so shaped as to break up into well-defined pieces; the external portion of the shell was cast around the internal part, and also broke up into a number of pieces; this shell was liable to premature explosion. The *obus à couronnes de balles* (1879) was practically a segment shell with cast-iron balls in lieu of segments; thin iron partitions separated each layer, and the balls were flattened where they came in contact with the plates. The *obus à balles libres*, adopted in 1880, were of the same type, but there were no separating plates. The *obus à anneaux* was simply a ring shell of the same type as used in England. The *obus à mitraille* adopted in 1883 for field and siege guns had a cast-iron disc for its base with the body built up of segments and steel balls; a hollow ogival head surmounted this and a thin steel envelope bound all together. The head was filled with powder and fitted with a fuze; on explosion the head burst and rupturing the envelope set free the balls and segments.

It is of importance in firing shrapnel shell that the position of the burst shall be plainly seen. With the larger patterns of shell this presents no difficulty, but with the shrapnel for field guns which contain a small bursting charge only, and at long range in certain states of the atmosphere, the difficulty becomes pronounced. The problem has been solved in some cases by packing the bullets in fine grain black powder (instead of resin) and compressing both bullets and powder in order to prevent the generation of heat when the bullets set back on the discharge of the gun. In Germany a mixture of red amorphous phosphorus and fine grain powder is used for the same purpose and produces a dense white cloud of smoke. In Russia a mixture of magnesium and antimony sulphide is used.

Fuzes.—The fuzes first used were short iron or copper tubes filled with slow-burning composition. They were roughly screwed on the exterior to fit a similar thread in the fuze hole of the shell. There was no means of regulating the length of time of burning, but later, about the end of the 17th century, the fuze case was made of paper or wood, so that, by boring a hole through the outer casing into the composition, the fuze could be made to burn approximately for a given time before exploding the shell—or the fuze could be cut to the correct length for the same purpose.

Early attempts to produce percussion fuzes were unsuccessful, but the discovery of fulminate of mercury in 1799 finally afforded the means of attaining this object. Some fifty years, however, elapsed before a satisfactory fuze was made. This was the Pettman fuze, in which a roughened ball covered with detonating composition was released by the discharge of the gun. When the shell hit any object, the ball struck against the interior walls of the fuze, the composition was exploded and thence the bursting charge of the shell. At present there are three types of percussion fuzes—(1) those which depend on the gas pressure in the gun setting the pellet of the fuze free—this type is necessarily a base fuze; (2) those which rely on the shock of discharge or the rotation of the shell setting the pellet free, as in various kinds of nose and base fuzes; (3) those relying on direct impact with the object.

The British base percussion fuze (fig. 12) illustrates type (1). In this, before firing, the needle pellet is held back by a central spindle with a pressure plate attached to its rear end. For additional safety a centrifugal bolt is added which is released by the rotation of the shell. On discharge, the gas pressure pushes the pressure plate in, the central spindle is carried forward with it and unlocks the centrifugal bolt; this is withdrawn by the rotation of the shell, and the needle pellet is then free to move forward and explode the detonating cap when the shell strikes.

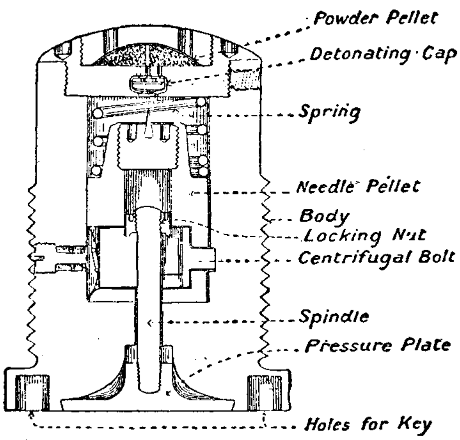


FIG. 12.—Base Percussion Fuze.

Type (2) is that usually adopted in small base fuzes and in the percussion part of "time and percussion" fuzes. Here the ferrule, on shock of discharge, moves back relatively to the percussion pellet by collapsing the stirrup spring; this leaves the pellet free to move forward, on the shell striking, and its detonator to strike the needle fixed in the fuze body. A spiral spring prevents any movement of the pellet during flight.

The direct-action or impact fuzes of type (3) are very simple (see fig. 13 of direct-action fuze). They are made of such a strength that during discharge nothing happens, but on striking an object the needle disc is crushed in and the needle explodes the detonating composition and thence the powder.

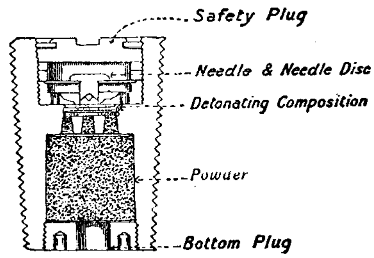


FIG. 13.—Direct-Action Percussion Fuze.

The action of all time fuzes is started by the discharge of the gun. By this the pellet strikes the detonator and so ignites a length of slow-burning composition which is pressed into a wood tube or into a channel formed in a metal ring. To regulate the time of burning of the wood fuze, a hole is bored through into the composition as before stated, so that when it has burnt down to this hole one of the side channels filled with powder is ignited and explodes the shell. Wood fuzes are now only used for R.M.L. guns.

With modern long-burning fuzes (fig. 14), two composition time rings are used. The lower of these rings is made movable so that it can be turned to bring any desired place over a hole in the body of the fuze, which is filled with powder and communicates with the magazine. On the gun being fired the detonator is exploded and its flash ignites the upper time ring. This burns round to a passage made in the lower ring, when the lower ring begins to burn and continues to do so until the channel to the magazine is reached. The gases from the ignited composition escape from an external hole made in each time ring.

Mechanical time fuzes depending on the rotation of the shell to give a regular motion to clockwork have been tried, but so far no practicable form of these fuzes has been found.

It is important that all fuzes should be rigidly guarded against dampness, which tends to lengthen their time of burning; hence they are protected either by being kept in hermetically sealed tins holding one or more fuzes, or by some similar means.

Tubes and Primers.—In ancient times various devices were adopted to ignite the charge. Small guns were fired by thrusting a hot wire down the vent into the charge, or slow-burning powder was poured down the vent and ignited by a hot wire.

Later the priming powder was ignited by a piece of slow match held in a lint-stock (often called linstock). About A.D. 1700 this was effected by means of a port-fire (this was a paper case about

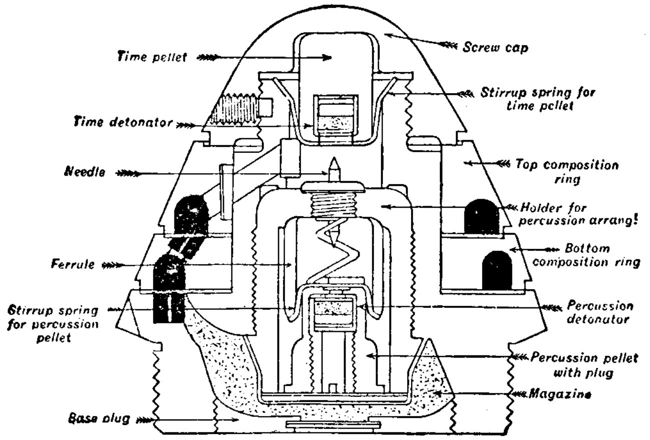


FIG. 14.—Fuze, Time and Percussion, No. 80, Mk. I.

16 in. long filled with slow-burning composition which burnt rather more than 1 in. per minute). Later again the charge was exploded by paper tubes (sometimes called Dutch tubes) filled with powder and placed in the vent and ignited by a port-fire. In comparatively modern times friction tubes have been used, while in the latest patterns percussion or electric tubes are employed.

In most B.L. guns it is essential to stop the erosion of the metal of the vent by preventing the escape of gas through it when the gun is fired. For this purpose the charges in such guns are ignited by "vent-sealing tubes." For M.L. guns and small B.L. guns radially vented, especially those using black powder, the amount of erosion in the vent is not so serious. The charge is fired by ordinary friction tubes, which are blown away by the escape of gas through the vent. In all guns axially vented, vent-sealing tubes, which are not blown out, must be employed so that the men serving the gun may not be injured.

The common friction tube is a copper tube, driven with powder, having at the upper end a short branch (called a nib piece) at right angles. This branch is filled with friction composition in which a friction bar is embedded. On the friction bar being sharply pulled out, by means of a lanyard, the composition is ignited and sets fire to the powder in the long tube; the flash is conveyed through the vent and explodes the gun charge. For

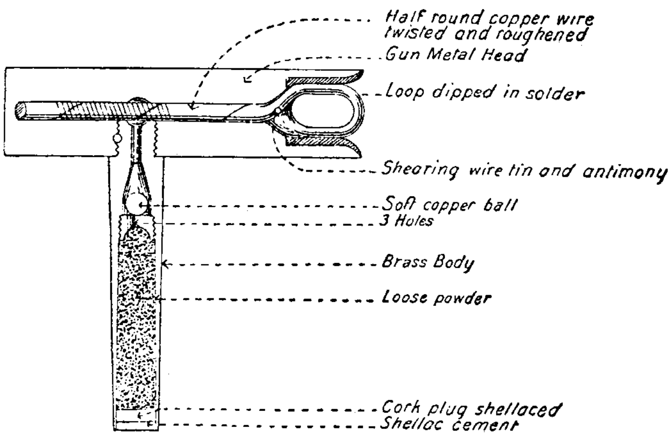


FIG. 15.—T-headed Friction Tube.

naval purposes, in order that the sailors should not be cut about the face or hurt their feet, tubes of quill instead of copper were used. If friction tubes are employed when cordite or other smokeless powder charges are used, the erosion of the vent is very rapid unless the escape of the gas is prevented; in this case T-headed tubes (fig. 15) are used. They are similar in action to the ordinary type, but are fixed to the vent by the head fitting a bayonet joint formed with the vent. The explosion blows a small

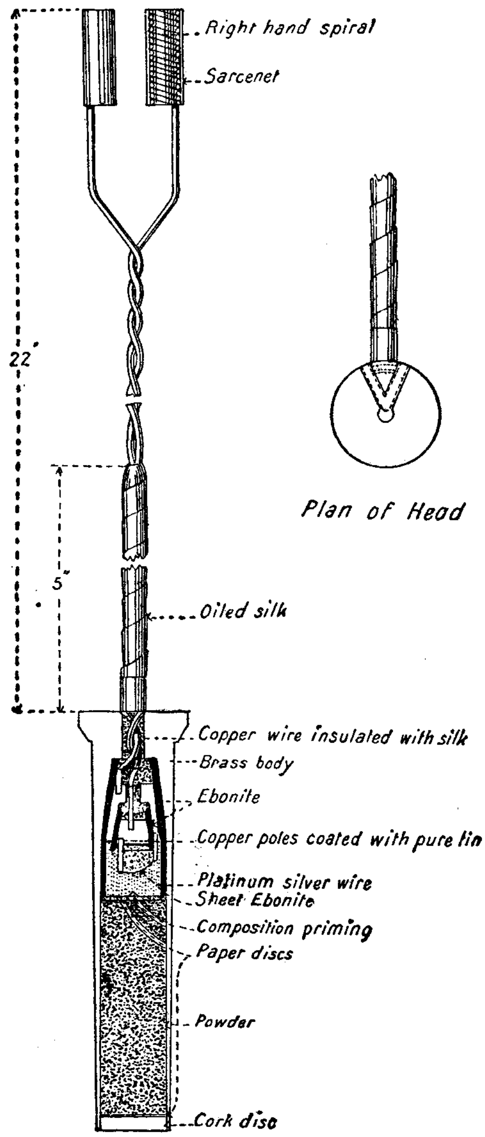


FIG. 16.—Electric Tube.

ball upwards and blocks the coned hole at the top of the tube and so prevents any rush of gas.

The vent-sealing tube accurately fits into a chamber formed at the end of the vent, and is held in place by the gun lock or some similar means. The force of the explosion expands the tube against the walls of its chamber, while the internal structure of the tube renders it gas-tight, any escape of gas through the vent being thus prevented.

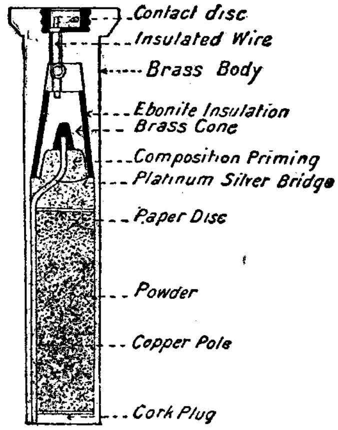


FIG. 17.—Wireless Tube.

In the English service electric tubes (in the United States called "primers") are mostly used, but percussion or friction tubes are in most favour on the continent, and electric tubes are seldom or never used. There are two types of electric tube, one with long wires (fig. 16) for joining up with the electric circuit and the other without external wires. The first type has two insulated wires led into the interior and attached to two insulated brass cones which are connected by a wire "bridge" of platinum silver. This bridge is surrounded by a priming composition of gun-cotton dust and mealed powder and the remainder of the tube is filled with powder. On an electric current passing, the bridge is heated to incandescence and ignites the priming composition.

In the wireless tube (fig. 17) the lock of the gun makes the electric contact with an insulated disc in the head of the tube. This disc is connected by an insulated wire to a brass cone, also insulated, the bridge being formed from an edge of the cone to a brass wire which is soldered to the mouth of the tube. Priming composition surrounds the bridge and the tube is filled with powder. The electric circuit passes from the gun lock to the disc, thence through the bridge to the body of the tube, returning through the metal of the gun and mounting.

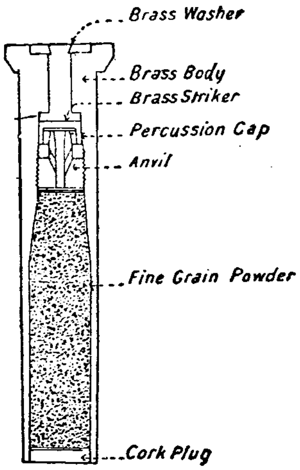


FIG. 18.—Primer.

The percussion tube (fig. 18) has a similarly shaped body to the wireless electric tube, but the internal construction differs; it is fitted with a striker, below which is a percussion cap on a hollow brass anvil, and the tube is filled with powder.

With Q.F. guns (that is, strictly, those using metallic cartridge cases) the case itself is fitted with the igniting medium; in England these are called primers. For small guns the case contains a percussion primer, usually a copper cap filled with a chlorate mixture and resting against an anvil. The striker of the gun strikes the cap and fires the mixture. For larger guns an electric primer (fig. 19) is used, the internal construction and action of which are precisely similar to the wireless tube already described; the exterior is screwed for the case. For percussion

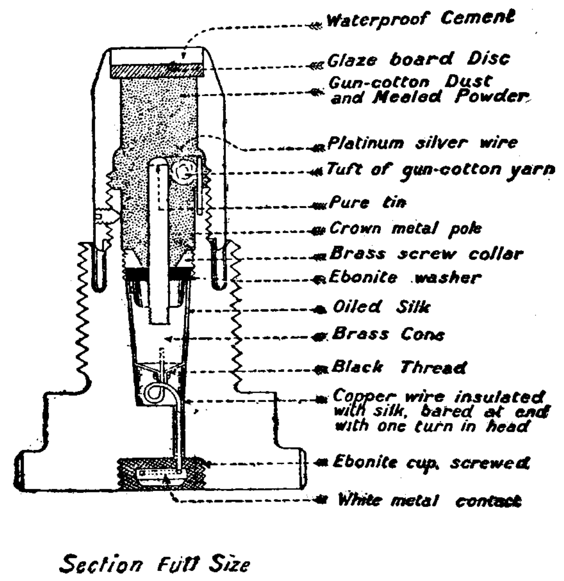


FIG. 19.—Electric Primer.

firing an ordinary percussion tube is placed in an adapter screwed into the case. In some foreign services a combined electric and percussion primer is used; the action of this will be understood from fig. 20.

Cartridges. The first cartridges for cannon were made up of gunpowder packed in a paper bag or case. For many years after the introduction of cannon the powder was introduced into the bore by means of a scoop-shaped ladle fixed to the end of a long stave. The ladle was made of the same diameter as the shot, and it had a definite length so that it was filled once for the charging of small guns but for larger guns the ladle had to be filled twice or even thrice. The rule was to make the powder charge the same weight as that of the shot.

Cartridges made up in paper or canvas bags were afterwards used in forts at night-time or on board ship, so that the guns could be more rapidly loaded and with less risk than by using a ladle. Before loading, a piece of the paper or canvas covering had to be cut open immediately under the vent; after the shot had been rammed home the vent was filled with powder from a priming horn, and the gun was then fired by means of a hot iron, quick match or port-fire.

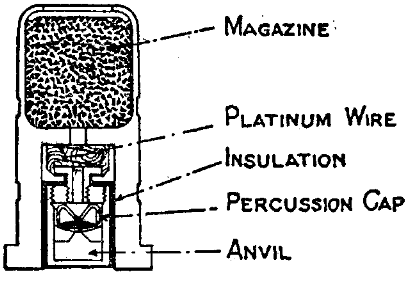


FIG. 20.—Combined Primer.

The ancient breech-loading guns were not so difficult to load, as the powder chamber of the gun was removable and was charged by simply filling it up with powder and ramming a wad on top to prevent the escape of the powder.

Paper, canvas and similar materials are particularly liable to smoulder after the gun has been fired, hence the necessity of well sponging the piece. Even with this precaution accidents often occurred owing to a cartridge being ignited by the still glowing débris of the previous round. In order to prevent this, bags of non-smouldering material, such as flannel, serge or silk cloth are used; combustible material such as woven gun-cotton cloth has also been tried, but there are certain disadvantages attending this.

All smokeless powders are somewhat difficult to ignite in a gun, so that in order to prevent hang-fires every cartridge has a primer or igniter, of ordinary fine grain gunpowder, placed so as to intercept the flash from the tube; the outside of the bag containing this igniter is made of shalloon, to allow the flash to penetrate with ease. The charge for heavy guns (above 6 in.) is made up in separate cartridges containing half and quarter charges, both for convenience of handling, and to allow of a reduced charge being used.

The cartridges are made of a bundle of cordite, or other smokeless powder, tightly tied with silk, placed in a silk cloth bag with the primer or igniter stitched on the unclosed end; the exterior is taped with silk cloth tape so as to form a stiff cartridge. For

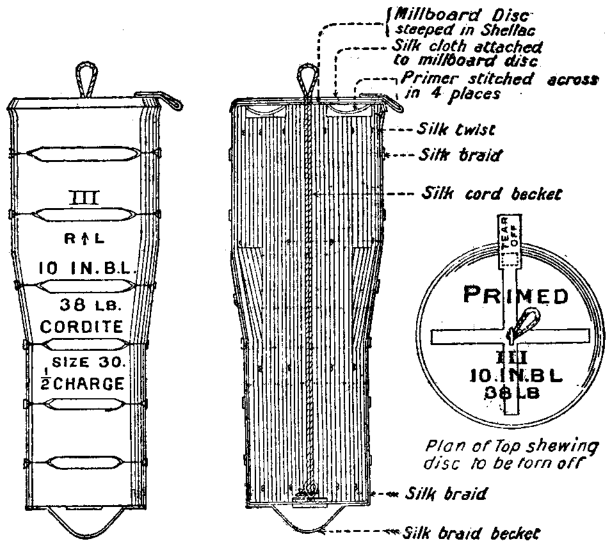


FIG. 21.—10-inch B.L. Gun Cartridge.

some of the longer guns, the exterior of the cartridge is conveniently made of a coned shape, the coned form being produced by building up layers outside a cylindrical core. In these large cartridges a silk cord becket runs up the centre with a loop at the top for handling (fig. 21).

For howitzers, variable charges are used, and are made up so that the weight can be readily altered. The following typical instance (fig. 22) will serve to show the general method of making

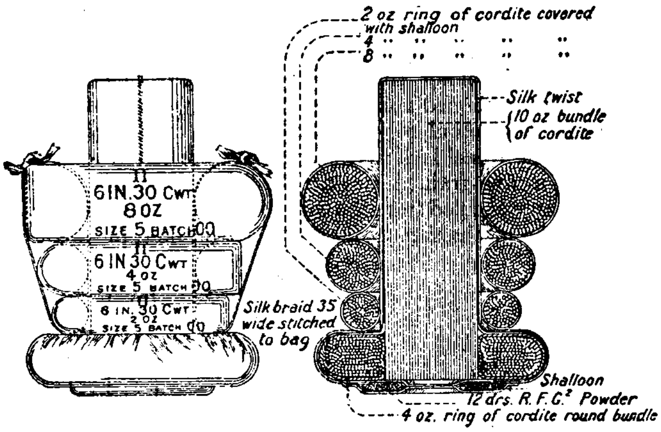


FIG. 22.—6-inch B.L. Howitzer Cartridge.

up such charges, whether for B.L. or Q.F. howitzers. Small size cordite is used, and the charge is formed of a mushroom-shaped core, made up in a shalloon bag; on the stalk, so as to be easily removed, three rings of cordite are placed. The bottom of the core contains the primer, and the rings can be attached to the core by two silk braids. The weight of the rings is graduated so that by detaching one or more the varying charges required can be obtained.

For quick-firing guns the charge is contained in a brass case to which is fitted a primer for igniting the charge. This case is

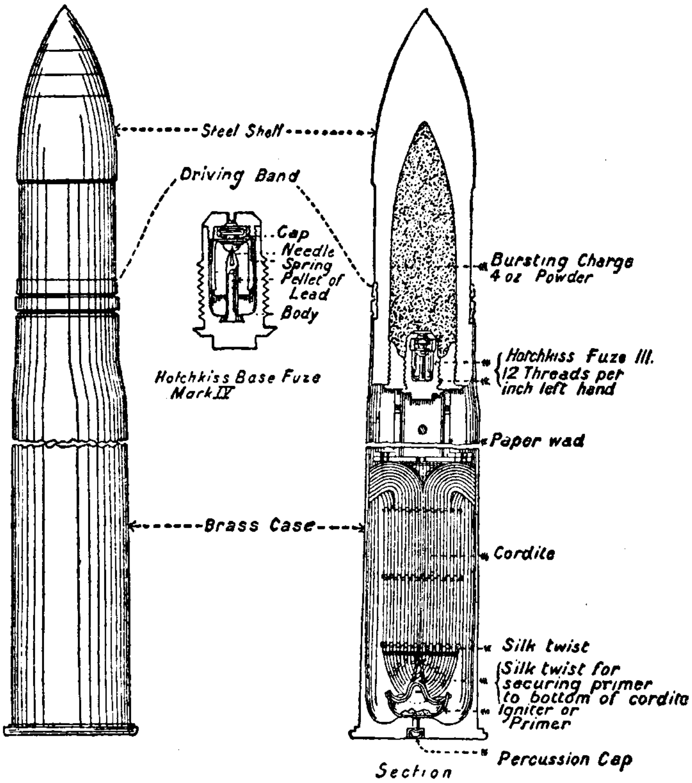


FIG. 23.—6-pr. Q.F. Cartridge.

inserted into the gun, and when fired slightly expands and tightly fits the chamber of the gun, thus acting as an obturator and preventing any escape of gas from the breech. This class of ammunition is especially useful for the smaller calibres of guns, such as 3-pr., 6-pr. and field guns, but Messrs Krupp also employ metallic cartridge cases for the largest type of gun, probably on account of the known difficulty of ensuring trustworthy obturation by any other means practicable with sliding wedge guns.

The charges for these cases are made up in a very similar manner to those already described for B.L. guns. Where necessary, distance pieces formed of *papier-mâché* tubes and felt wads are used to fill up the space in the case and so prevent any movement of the charge. The mouth of the case is closed either by the base end of the projectile (fig. 23), in which case it is called "fixed ammunition" or "simultaneous loading ammunition," or by a metallic cap (fig. 24), when it is called "separate loading ammunition," the projectile and charge being thus loaded by separate operations. (A. G. H.)

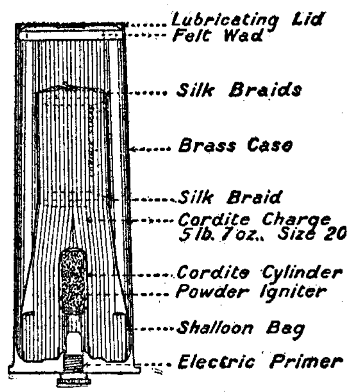


FIG. 24.—4·7-inch Q.F. Cartridge (greatly reduced scale).

Small-arms ammunition.

The Bullet.— The original musket bullet was a spherical leaden ball two sizes smaller than the bore, wrapped in a loosely fitting paper patch which formed the cartridge. The loading was, therefore, easy with the old smooth-bore Brown Bess and similar military muskets. The original muzzle-loading rifle, on the other hand, with a closely fitting ball to take the grooves, was loaded with difficulty, particularly when foul, and for this reason was not generally used for military purposes.

In 1826 Delirque, a French infantry officer, invented a breech with abrupt shoulders on which the spherical bullet was rammed down until it expanded and filled the grooves. The objection in this case was that the deformed bullet had an erratic flight. The Brunswick rifle, introduced into the British army in the reign of William IV., fired a spherical bullet weighing 557 grs. with a belt to fit the grooves. The rifle was not easily loaded, and soon fouled. In 1835 W. Greener produced a new expansive bullet, an oval ball, a diameter and a half in length, with a flat end, perforated, in which a cast metallic taper plug was inserted. The explosion of the charge drove the plug home, expanded the bullet, filled the grooves and prevented windage. A trial of the Greener bullet in August 1835, at Tynemouth, by a party of the 60th (now King's Royal) Rifles, proved successful. The range and accuracy of the rifle were retained, while the loading proved as easy as with a smooth-bore musket. The invention was, however, rejected by the military authorities on the ground that the bullet was a compound one. In 1852 the government awarded Minié, a Frenchman, £20,000 for a bullet of the same principle, adopted into the British service. Subsequently, in 1857, Greener was also awarded £1000 for "the first public suggestion of the principle of expansion, commonly called the Minié principle, in 1836." The Minié bullet contained an iron cup in a cavity in the base of the bullet. The form of the bullet was subsequently changed from conoidal to cylindro-conoidal, with a hemispherical iron cup. This bullet was used in the Enfield rifle introduced into the British army in 1855. It weighed 530 grs., and was made up into cartridges and lubricated as for the Minié rifle. A boxwood plug to the bullet was also used. The bullet used in the breech-loading Martini-Henry rifle, adopted by the British government in 1871 in succession to the Snider-Enfield rifle, weighed 480 grs., and was fired from an Eley-Boxer cartridge-case with a wad of wax lubrication at the base of the bullet.

Between 1854 and 1857 Sir Joseph Whitworth conducted a long series of rifle experiments, and proved, among other points, the advantages of a smaller bore and, in particular, of an elongated bullet. The Whitworth bullet was made to fit the grooves of the rifle mechanically. The Whitworth rifle was never adopted by the government, although it was used extensively for match purposes and target practice between 1857 and 1866, when it was gradually superseded by Metford's system mentioned below.

The next important change in the history of the rifle bullet occurred in 1883, when Major Rubin, director of the Swiss Laboratory at Thun, invented the small-calibre rifle, one of whose essential features was the employment of an elongated compound bullet, with a leaden core in a copper envelope. About 1862 and later, W. E. Metford had carried out an exhaustive series of experiments on bullets and rifling, and had invented the important system of light rifling with increasing spiral, and a hardened bullet. The combined result of the above inventions was that in December 1888 the Lee-Metford small-bore ·303 rifle, Mark I., was finally adopted for the British army. The latest development of this rifle is now known as the ·303 Lee-Enfield, which fires a long, thin, nickel-covered, leaden-cored bullet 1·25 in. long, weighing only 215 grs., while the Martini-Henry bullet, 1·27 in. in length and ·45 in. in diameter, weighed 480 grs.

The adoption of the smaller elongated bullet, necessitated by the smaller calibre of the rifle, entailed some definite disadvantages. The lighter bullet is more affected by wind. Its greater relative length to diameter necessitates a sharper pitch of rifling in order properly to revolve the bullet (one turn in 10 in. for the ·303 rifle as compared with one turn in 22 in. for the Martini-Henry). This, in its turn, necessitates a hard nickel envelope for the leaden bullet in order to prevent its "stripping," or being forced through the barrel without rotation. The general result is that, while the enveloped bullet has a much higher penetrative power than one of lead only, it does not usually inflict so severe a wound, nor has it such a stunning effect as the old lead bullet. It cuts a small clean hole, but does not deform. This fact is of some military importance, as, for example, in warfare with savages, in which the chief danger is usually a rush of large numbers at close quarters. The advantages, however, of the smaller calibre and the lighter bullet and ammunition are considered to outweigh the disadvantages, and they have been universally adopted for all military rifles.

Bullets for target and sporting-rifles have, in the main, followed, or occasionally preceded, the line of progress of military rifle bullets. In 1861 Henry introduced a modification of the grooving of the cylindrical Whitworth bullet, and in 1864 and 1865 the Rigby mechanically fitting bullet was used with success at the National Rifle Association meeting, and in the second stage of the Queen's prize. The bullets of sporting rifles, and particularly those of Express rifles, are often lighter than military bullets, and made with hollow points to ensure the expansion of the projectile on or after impact. The size and shape of the hollow in the point vary according to the purpose required and the nature of the game hunted. If greater penetration is needed, the leaden bullet is hardened with mercury or tin, or the military nickel-coated bullet is used with the small-bore, smokeless-powder rifles. Explosive bullets filled with detonating powder were at one time used in Express and large-bore rifles for large game. The use of these bullets is now practically abandoned owing to their uncertainty of action and the danger involved in handling them. Their use in warfare is prohibited by international law.

The nickel-covered bullet, when used in a modern small-bore rifle for sporting purposes, is made into an expanding bullet, either by leaving the leaden core uncovered at the nose of the bullet, with or without a hollow point, or by cutting transverse or longitudinal nicks of varying depth in the point or circumference of the bullet.

A cone-shaped sharp-pointed bullet, named the Spitzer bullet, has been tried in the United States under the auspices of the Ordnance Department, in a Springfield rifle, which is practically identical with the British service ·303 Lee-Enfield. This bullet is lighter than the Lee-Enfield bullet (150 grs. as against 215 grs.), and when fired with a heavier charge of powder (51 grs. as against 31 grs.) gives, it is claimed, better results in muzzle-velocity, trajectory, deflexion from wind and wear and tear of rifling, than the present universally used cylinder-shaped bullet. In 1906 details of its prototype, the German "S" bullet (*Spitzgeschoss*), and of the French "D" bullet, were published.

The Cartridge.—The original cartridge for military small arms dates from 1586. It consisted of a charge of powder and a bullet in a paper envelope. This cartridge was used with the muzzle-loading military firearm, the base of the cartridge being ripped or bitten off by the soldier, the powder poured into the barrel, and the bullet then rammed home. Before the invention of the fire-lock or flint-lock, about 1635, the priming was originally put into the pan of the wheel-lock and snaphance muskets from a flask containing a fine-grained powder called serpentine powder. Later the pan was filled from the cartridge above described before loading. The mechanism of the flint-lock musket, in which the

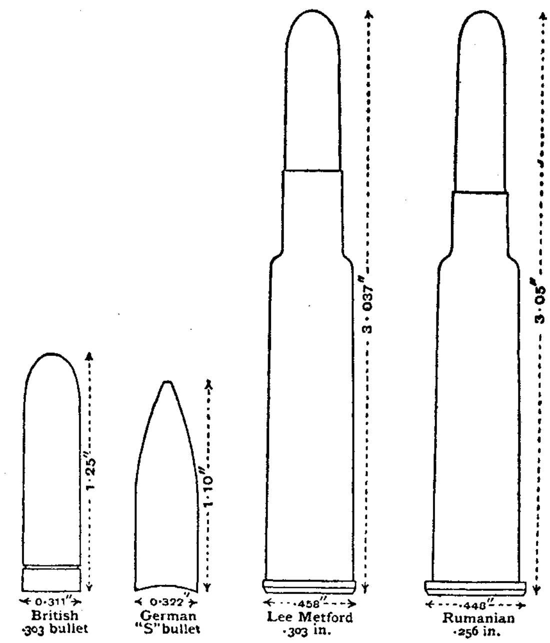


FIG. 25.

pan was covered by the furrowed steel struck by the flint, rendered this method of priming unnecessary, as, in loading, a portion of the charge of powder passed from the barrel through the vent into the pan, where it was held by the cover and hammer.

The next important advance in the method of ignition was the introduction of the copper percussion cap. This was only generally applied to the British military musket (the Brown Bess) in 1842, a quarter of a century after the invention of percussion powder and after an elaborate government test at Woolwich in 1834. The invention which made the percussion cap possible was patented by the Rev. A. J. Forsyth in 1807, and consisted of priming with a fulminating powder made of chlorate of potash, sulphur and charcoal, which exploded by concussion. This invention was gradually developed, and used, first in a steel cap, and then in a copper cap, by various gunmakers and private individuals before coming into general military use nearly thirty years later. The alteration of the military flint-lock to the percussion musket was easily accomplished by replacing the powder pan by a perforated nipple, and by replacing the cock or hammer which held the flint by a smaller hammer with a hollow to fit on the nipple when released by the trigger. On the nipple was placed the copper cap containing the detonating composition, now made of three parts of chlorate of potash, two of fulminate of mercury and one of powdered glass. The detonating cap thus invented and adopted, brought about the invention of the modern cartridge case, and rendered possible the general adoption of the breech-loading principle for all varieties of rifles, shot guns and pistols. Probably no invention connected with firearms has wrought such changes in the principle of gun construction as those effected by the expansive cartridge case. This invention has completely revolutionized the art of gunmaking, has been successfully applied to all descriptions of firearms, and has produced a new and important industry—that of cartridge manufacture.

Its essential feature is the prevention of all escape of gas at the breech when the weapon is fired, by means of an expansive cartridge case containing its own means of ignition. Previous to this invention shot guns and sporting rifles were loaded by means of powder flasks and shot flasks, bullets, wads and copper caps, all carried separately. The earliest efficient modern cartridge case was the pin-fire, patented, according to some authorities, by Houiller, a Paris gunsmith, in 1847; and, according to others, by Lefaucheux, also a Paris gunsmith, in or about 1850. It consisted of thin weak shell made of brass and paper which expanded by the force of the explosion, fitted perfectly into the barrel, and thus formed an efficient gas check. A small percussion cap was placed in the middle of the base of the cartridge, and was exploded by means of a brass pin projecting from the side and struck by the hammer. This pin also afforded the means of extracting the cartridge case. This cartridge was introduced in England by Lang, of Cockspur Street, London, about 1855.

The central-fire cartridge was introduced into England in 1861 by Daw. It is said to have been the invention of Pottet of Paris, improved upon by Schneider, and gave rise to much litigation in respect of its patent rights. Daw was subsequently defeated in his control of the patents by Eley Bros. In this cartridge the cap in the centre of the cartridge base is detonated by a striker passing through the standing breech to the inner face, the cartridge case being withdrawn, or, in the most modern weapons, ejected by a sliding extractor fitted to the breech end of the barrel, which catches the rim of the base of the cartridge.

This is practically the modern cartridge case now in universal use. In the case of shot guns it has been gradually improved in small details. The cases are made either of paper of various qualities with brass bases, or entirely of thin brass. The wadding between powder and shot has been thickened and improved in quality; and the end of the cartridge case is now made to fit more perfectly into the breech chamber. These cartridges vary in size from 32 bore up to 4 bore for shoulder guns. They are also made as small as ·410 and ·360 gauge: their length varies from $1\frac{3}{4}$ in. to 4 in. Cartridges for punt guns are usually $1\frac{1}{2}$ in. in diameter and $9\frac{3}{4}$ in. in length.

In the case of military rifles the breech-loading cartridge case was first adopted in principle by the Prussians about 1841 in the needle-gun (*q.v.*) breech-loader. In this a conical bullet rested on a thick wad, behind which was the powder, the whole being enclosed in strong lubricated paper. The detonator was in the hinder surface of the wad, and fired by a needle driven forward from the breech, through the base of the cartridge and through the powder, by the action of a spiral spring set free by the pulling of the trigger.

In 1867 the British war office adopted the Eley-Boxer metallic central-fire cartridge case in the Enfield rifles, which were converted to breech-loaders on the Snider principle. This consisted of a block opening on a hinge, thus forming a false breech against which the cartridge rested. The detonating cap was in the base of the cartridge, and was exploded by a striker passing through the breech block. Other European powers adopted breech-loading military rifles from 1866 to 1868, with paper instead of metallic cartridge cases. The original Eley-Boxer cartridge case was made of thin coiled brass. Later the solid-drawn, central-fire cartridge case, made of one entire solid piece of tough hard metal, an alloy of copper, &c., with a solid head of thicker metal, has been generally substituted.

Central-fire cartridges with solid-drawn metallic cases containing their own means of ignition are now universally used in all modern varieties of military and sporting rifles and pistols. There is great variety in the length and diameter of cartridges for the different kinds and calibres of rifles and pistols. Those for military rifles vary from 2·2 in. to 2·25 in. in length, and from ·256 to ·315 gauge. For sporting rifles from $2\frac{1}{4}$ in. to $3\frac{1}{2}$ in. in length, and through numerous gauges from ·256 in. to ·600 in. For revolvers, pistols, rook and rabbit rifles, and for Morris tubes, cartridges vary from ·22 in. to ·301 in. in gauge. All miniature cartridges with light charges are made for breech adapters to enable ·303 military rifles to be used on miniature rifle ranges. All the above cartridges are central-fire. Rim-fire cartridges for rifles, revolvers and pistols vary from ·22 in. to ·56 in. gauge according to the weapon for which they are required. The cartridge for the British war office miniature rifle is ·22 calibre, with 5 grs. of powder and a bullet weighing 40 grs. Most modern military rifles are supplied with clip or charger loading arrangements, whereby the magazine is filled with the required number of cartridges in one motion. A clip is simply a case of cartridges which is dropped into the magazine; a charger is a strip of metal holding the bases of the cartridges, and is placed over the magazine, the cartridges being pressed out into the latter. Both clips and chargers, being consumable stores, may be considered as ammunition. (H. S.-K.)

AMNESTY (from the Gr. ἀμνηστία, oblivion), an act of grace by which the supreme power in a state restores those who may have been guilty of any offence against it to the position of innocent persons. It includes more than pardon, inasmuch as it obliterates all legal remembrance of the offence. Amnesties, which may be granted by the crown alone, or by act of parliament, were formerly usual on coronations and similar occasions, but are chiefly exercised towards associations of political criminals, and are sometimes granted absolutely, though more frequently there are certain specified exceptions. Thus, in the case of the earliest recorded amnesty, that of Thrasybulus at Athens, the thirty tyrants and a few others were expressly excluded from its operation; and the amnesty proclaimed on the restoration of Charles II. did not extend to those who had taken part in the execution of his father. Other celebrated amnesties are that proclaimed by Napoleon on the 13th of March 1815, from which thirteen eminent persons, including Talleyrand, were excepted; the Prussian amnesty of the 10th of August 1840; the general amnesty proclaimed by the emperor Francis Joseph of Austria in 1857; the general amnesty granted by President Johnson after the Civil War in 1868; and the French amnesty of 1905. The last act of amnesty passed in Great Britain was that of 1747, which proclaimed a pardon to those who had taken part in the second Jacobite rebellion.

AMOEBA, the Greek equivalent of the name "Amibe" given by Bery St Vincent to the Proteus animalcule of earlier naturalists, used as a quasi-popular term for any simple naked protist the sole external organs of which are pseudopodia, *i.e.* temporary outgrowths of the clearer outer layer of the soft protoplasmic body. It is also used as a generic name, and in its present limitations by E. Penard includes only those the pseudopodia of which are constantly changing, blunt outgrowths. In the former wider sense, amoebae are found in sluggish waters, fresh and salt, all over the world; they readily make their appearance in infusions putrefying after infection from aerially carried germs, and the leucocytes or colourless blood corpuscles of Metazoa are essentially amoebae in their structure and behaviour. The protoplasm of the individual is divided into a centrally placed body, the nucleus, of relatively stable shape, and the cytoplasm, itself divided into an outer, clearer ectoplasm ("ectosarc") and an inner, more granular endoplasm ("endosarc"), passing into one another. The movements of amoebae are of several kinds. (1) The amoeba may grow out irregularly into blunt lobes, the pseudopodia, some being emitted while others are retracted, and so may advance in any direction by the emission of pseudopodia thitherward, and the enlargement of these by the passage of the organism into them. (2) Again, it may advance by a sort of rolling: the lower surface, or that in contact with the substratum over or under which it is passing, is viscid and adheres to the substratum, the superficial dorsal layer passing forward and bending over to the ventral side; whilst the converse action takes place at the hinder end; (3) or again, the pseudopodia, when long, well marked and relatively permanent, may serve as actual limbs on which the body is supported and on which it moves. In the outgrowth of a pseudopod the process may take