internal regulations the legislature has left the company free to adopt whatever terms of association it chooses. It has furnished in the schedule to the Companies Act 1862 (Table A), a model or specimen set of regulations, but their adoption, wholly or in part, is optional; only if a company does not register articles of its own these statutory regulations are to apply. When, as is commonly the case, a company decides to have articles of its own framing, such articles must be expressed in separate paragraphs, numbered arithmetically, and signed by the subscribers of the memorandum of association. They must also be printed, stamped like a deed, and attested. When so perfected, they are to be delivered, with the memorandum of association, to the registrar of joint stock companies, who is to retain and register them. The articles of association thereupon become a public document, which any person may inspect on payment of a fee of one shilling. This has important consequences, because every person dealing with the company is presumed to be acquainted with its constitution, and to have read its articles. The articles, also, upon registration, bind the company and its members to the same extent as if each member had subscribed his name and affixed his seal to them. (See also MEMORANDUM OF ASSOCIATION; COMPANY; INCORPORATION.)

In the United States, articles of association are any instrument in writing which sets forth the purposes, the terms and conditions upon which a body of persons have united for the prosecution of a joint enterprise. When this instrument is duly executed and filed, the law gives it the force and effects of a charter of incorporation.

ARTICULATA, a zoological name now obsolete, applied by Cuvier to animals, such as insects and worms, in which the body displays a jointed structure. (See ARTHROPODA.)

ARTICULATION (from Lat. *articulare*, to divide into joints), the act of joining together; in anatomy the junction of the bones (see JOINTS); in botany the point of attachment and separation of the deciduous parts of a plant, such as a leaf. The word is also used for division into distinct parts, as of human speech by words or syllables.

ARTILLERY (the O. Fr. *artiller*, to equip with engines of war, probably comes from Late Lat. *articulum*, dim. of *ars*, art, cf. "engine" from *ingenium*, or of *artus*, joint), a term originally applied to all engines for discharging missiles, and in this sense used in English in the early 17th century. In a more restricted sense, artillery has come to mean all firearms not carried and used by hand, and also the *personnel* and organization by which the power of such weapons is wielded. It is, however, not usual to class *machine guns* (*q.v.*) as artillery. The present article deals with the development and contemporary state of the artillery arm in land warfare, in respect of its organization, *personnel* and special or "formal" employment. For the *matériel*—the guns, their carriages and their ammunition—see ORDNANCE and AMMUNITION. For *ballistics*, see that heading, and for the work of artillery in combination with the other arms, see TACTICS.

Artillery, as distinct from ordnance, is usually classified in accordance with the functions it has to perform. The simplest division is that into *mobile* and *immobile* artillery, the former being concerned with the handling of all weapons so mounted as to be capable of more or less easy movement from place to place, the latter with that of weapons which are installed in fixed positions. Mobile artillery is subdivided, again chiefly in respect of its employment, into *horse* and *field* batteries, *heavy field* or *position* artillery, *field howitzers*, *mountain artillery* and *siege trains*, adapted to every kind of terrain in which field troops may be employed, and work they may have to do. Immobile artillery is used in fixed positions of all kinds, and above all in permanent fortifications; it cannot, therefore, be classified as above, inasmuch as the *raison d'être*, and consequently the armament of one fort or battery may be totally distinct from that of another. "Fortress," "Garrison" and "Foot" artillery are the usual names for this branch. The dividing line, indeed, in the case of the heavier weapons, varies with circumstances; guns of position may remain on their ground while elaborate fortifications grow up around them, or the deficiencies of a field army in artillery may be made good from the *matériel*, more frequently still from the *personnel*, of the fortress artillery. Thus it may happen that mobile artillery becomes immobile and vice versa. But under normal circumstances the principle of classification indicated is maintained in all organized military forces.

HISTORICAL SKETCH

1. *Early Artillery.*—Mechanical appliances for throwing projectiles were produced early in the history of organized warfare, and "engines invented by cunning men to shoot arrows and great stones" are mentioned in the Old Testament. These were continually improved, and, under the various names of *catapulta*, *balista*, *onager*, *trébuchet*, &c., were employed throughout the ancient and medieval periods of warfare. The machines finally produced were very powerful, and, even when a propelling agent so strong as gunpowder was discovered and applied, the supersession of the older weapons was not effected suddenly nor without considerable opposition. The date of the first employment of cannon cannot be established with any certainty, but there is good evidence to show that the Germans used guns at the siege of Cividale in Italy (1331). The terms of a commission given (1414) by Henry V. to his *magister operationum, ingeniarum, et gunnarum ac aliarum ordinationum*, one Nicholas Merbury, show that the organization of artillery establishments was grafted upon that which was already in existence for the service of the old-fashioned machines. Previously to this it is recorded that of some 340 men forming the ordnance establishment of Edward III. in 1344 only 12 were artillerymen and gunners. Two years later, at Creçy, it is said, the English brought guns into the open field for the first time. At the siege of Harfleur (1415) the ordnance establishment included 25 "master gunners" and 50 "servitour gunners." The "gunner" appears to have been the captain of the gun, with general charge of the guns and stores, and the special duty of laying and firing the piece in action.

2. *The Beginnings of Field Artillery.*—It is clear, from such evidence as we possess, that the chief and almost the only use of guns at this time was to batter the walls of fortifications, and it is not until later in the 15th century that their employment in the field became general (see also CAVALRY). The introduction of field artillery may be attributed to John Žižka, and it was in his Hussite wars (1419–1424) that the *Wagenburg*, a term of more general application, but taken here as denoting a cart or vehicle armed with several small guns, came into prominence. This device allowed a relatively high manœuvring power to be attained, and it is found occasionally in European wars two centuries later, as for instance at Wimpfen in 1622 and Cropredy Bridge in 1644. In an act of attainder passed by the Lancastrian party against the Yorkists (1459), it is stated that the latter were "traiterously ranged in bataill . . . their cartes with gonnes set before their batailles" (Rot. Parl. 38 Henry VI., v. 348). In the London fighting of 1460, small guns were used to clear the streets, heavy ordnance to batter the walls of the Tower. The battle of Lose Coat Field (1469) was decided almost entirely by Edward IV.'s field guns, while at Blackheath (1497) "some cornets of horse, and bandes of foot, and good store of artillery wheeling about" were sent to "put themselves beyond" the rebel camp (Bacon, *Henry VII.*). The greatest example of artillery work in the 15th century was the siege of Constantinople in 1453, at which the Turks used a large force of artillery, and in particular some monster pieces, some of which survived to engage a British squadron in 1807, when a stone shot weighing some 700 lb cut the mainmast of Admiral (Sir) J. T. Duckworth's flagship in two, and another killed and wounded sixty men. For siege purposes the new weapon was indeed highly effective, and the castles of rebellious barons were easily knocked to pieces by the prince who owned, or succeeded in borrowing, a few pieces of ordnance (cf. Carlyle, *Frederick the Great*, book iii. chap. i.).

3. *The 16th Century.*—In the Italian wars waged by Charles

VIII., Louis XII. and Francis I. of France, artillery played a most conspicuous part, both in siege and field warfare. Indeed, cannon did excellent service in the field before hand firearms attained any considerable importance. At Ravenna (1512) and Marignan (1515) field artillery did great execution, and at the latter battle "the French artillery played a new and distinguished part, not only by protecting the centre of the army from the charges of the Swiss phalanxes, and causing them excessive loss, but also by rapidly taking up such positions from time to time . . . as enabled the guns to play upon the flanks of the attacking columns" (Chesney, *Observations on Firearms*, 1852). In this connexion it must, however, be observed that, when the arquebus and other small arms became really efficient (about 1525), less is heard of this small and handy field artillery, which had hitherto been the only means of breaking up the heavy masses of the hostile pikemen. We have seen that artillery was not ignored in England; but, in view of the splendid and unique efficiency of the archers, there was no great opportunity of developing the new arm. In the time of Henry VIII., the ordnance in use in the field consisted in the main of heavy *culverins* and other guns of position, and of lighter field pieces, termed *sakers*, *falcons*, &c. It is to be noticed that already the lightest pieces had disappeared, the smallest of the above being a 2-pounder. In the earlier days of field artillery, the artillery train was a miscellaneous congeries of pontoon, supply, baggage and tool wagons, heavy ordnance and light guns in carts. With the development of infantry fire the use of the last-named weapons died out, and it is largely due to this fact that "artillery" came to imply cumbrous and immobile guns of position. Little is, therefore, heard of smart manœuvring, such as that at Marignan, during the latter part of the 16th century. The guns now usually come into action in advance of the troops, but, from their want of mobility, could neither accompany a farther advance nor protect a retreat, and they were generally captured and recaptured with every changing phase of the fight. Great progress was in the meanwhile made in the adaptation of ordnance to the attack and defence of fortresses and, in particular, vertical fire came into vogue. A great Turkish gun, carrying a 600-lb stone shot, was used in the siege of Constantinople, apparently in this way, since Gibbon records that at the range of a mile the shot buried itself a fathom deep in earth, a fact which implies that a high angle of elevation was given. In the celebrated siege of Malta in 1565 artillery played a conspicuous part.

4. *The Thirty Years' War.*—Such, in its broadest outlines, is the history of artillery work during the first three centuries of its existence. Whilst the material had undergone a very considerable improvement, the organization remained almost unchanged, and the tactical employment of guns had become restricted, owing to their slowness and difficulty of movement on the march and immobility in action. In wars of the type of the War of Dutch Independence and the earlier part of the Thirty Years' War, this heavy artillery naturally remained useful enough, and the *Wagenburg* had given place to the musketry initiated by the Spaniards at Bicocca and Pavia, which since 1525 had steadily improved and developed. It is not, therefore, until the appearance of a captain whose secret of success was vigour and mobility that the first serious attempt was made to produce field artillery in the proper sense of the word, that is, a gun of good power, and at the same time so mounted as to be capable of rapid movement. The "carte with gonnes" had been, as is the modern machine gun, a mechanical concentration of musketry rather than a piece of artillery. Maurice of Nassau, indeed, helped to develop the field gun, and the French had invented the limber, but Gustavus Adolphus was the first to give artillery its true position on the battlefield. At the first battle of Breitenfeld (1631) Gustavus had twelve heavy and forty-two light guns engaged, as against Tilly's heavy 24-pounders, which were naturally far too cumbrous for field work. At the Lech (1632) Gustavus seems to have obtained a local superiority over his opponent owing to the handiness of his field artillery even more than by its fire-power. At Lützen (1632) he had sixty guns to Wallenstein's twenty-one. His field pieces were not the celebrated "leather" guns (which were indeed a mere makeshift used in Gustavus' Polish wars) but iron 4-pounders. These were distributed amongst the infantry units, and thus began the system of "battalion guns" which survived in the armies of Europe long after the conditions requiring it had vanished. The object of thus dispersing the guns was doubtless to ensure in the first place more certain co-operation between the two arms, and in the second to exercise a military supervision over the lighter and more useful field pieces which it was as yet impossible to exercise over the *personnel* of the heavy artillery.

5. *Personnel and Classification.*—More than 300 years after the first employment of ordnance, the men working the guns and the transport drivers were still civilians. The actual commander of the artillery was indeed, both in Germany and in England, usually a soldier, and Lennart Torstensson, the commander of Gustavus' artillery, became a brilliant and successful general. But the transport and the drivers were still hired, and even the gunners were chiefly concerned for the safety of their pieces, the latter being often the property, not of the king waging war, but of some "master gunner" whose services he had secured, and the latter's apprentices were usually in entire charge of the material. These civilian "artists," as they were termed, owed no more duty to the prince than any other employés, and even Gustavus, it would appear, made no great improvement in the matter of the reorganization of artillery trains. Soldiers as drivers do not appear until 150 years later, and in the meanwhile companies of "firelocks" and "fusiliers" (*q.v.*) came into existence, as much to prevent the gunners and drivers from running away as to protect them from the enemy. A further cause of difficulties, in England at any rate, was the age of the "gunners." In the reign of Elizabeth, some of the Tower gunners were over ninety years of age. Complaints as to the inefficiency of these men are frequent in the years preceding the English Civil War. Gustavus, however, has the merit of being the first to make the broad classification of artillery, as mobile or non-mobile, which has since been almost universally in force. In his time the 12-pounder was the heaviest gun classed as mobile, and the "feildpeece" *par excellence* was the 9-pounder or *demi-culverin*. After the death of Gustavus at Lützen (1632), his principles came universally into practice, and amongst them were those of the employment of field artillery.

6. *The English Civil War.*—Even in the English Civil War (Great Rebellion), in which artillery was hampered by the previous neglect of a century, its field work was not often contemptible, and on occasion the arm did excellent service. But in the campaigns of this war, fought out by men whose most ardent desire was to decide the quarrel swiftly, the marching and manœuvring were unusually rapid. The consequence of this was that the guns were sometimes either late in arriving, as at Edgehill, or absent altogether, as at Preston. The *rôle* of guns was further reduced by the fact that there were few fortresses to be reduced, and country houses, however strong, rarely required to be battered by a siege train. The New Model army usually sent for siege guns only when they were needed for particular service. On such occasions, indeed, the heavy ordnance did its work so quickly and effectually that the assault often took place one or two days after the guns had opened fire. Cromwell in his sieges made great use of shells, 12-inch and even larger mortars being employed. The castle of Devizes, which had successfully resisted the Parliamentary battering guns, succumbed at once to vertical fire. It does not, however, appear certain that there was any separation of field from siege ordnance, although the Swedish system was followed in almost all military matters.

7. *Artillery Progress, 1660–1740.*—Cromwell's practice of relegating heavy guns to the rear, except when a serious siege operation was in view, and in very rapid movements leaving even the field pieces far behind, was followed to some extent in the campaigns of the age of Louis XIV. The number of ammunition wagons, and above all of horses, required for each gun was four or five times as great as that required even for a modern quick-firer. In the days of Turenne heavy guns were much employed,

as the campaigns of the French were directed as a rule to the methodical conquest of territory and fortified towns. Similarly, Marlborough, working amidst the fortresses of the Netherlands in 1706, had over 100 pieces of artillery (of which 60 were mortars) to a force of some 11,000 men, or about 9 pieces per 1000 men. On the other hand, in his celebrated march to the Danube in 1704, he had but few guns, and the allied armies at Blenheim brought into the field only 1 piece per 1000 men. At Oudenarde "from the *rapidity of the march* . . . the battle was fought with little aid from artillery on either side" (Coxe, *Marlborough*). There was less need now than ever before for rapid manœuvres of mobile artillery, since the pike finally disappeared from the scene about 1700, and infantry fire-power had become the decisive factor in battles. In the meantime, artillery was gradually ceasing to be the province of the skilled workman, and assuming its position as an arm of the military service. In the 17th century, when armies were as a rule raised only "for the war," and disbanded at the conclusion of hostilities, there had been no very pressing need for the maintenance in peace of an expensive *personnel* and material. Gunners therefore remained, as civilians, outside the regular administration of the forces, until the general adoption of the "standing army" principle in the last years of the century (see ARMY). From this time steps were taken, in all countries, to organize the artillery as a military force. After various attempts had been made, the "Royal Regiment of Artillery" came into existence in England in 1716. It is, however, stated that the English artillery did not "begin to assume a military appearance until the Flanders campaigns" of the War of the Austrian Succession. Even in the War of American Independence a dispute arose as to whether a general officer, whose regimental service had been in the Royal Artillery, was entitled to command troops of all arms, and the artillery drivers were not actually soldiers until 1793 at the earliest. French artillery officers received military rank only in 1732.

8. *Artillery in the Wars of Frederick the Great.*—By the time of Frederick the Great's first wars, artillery had thus been divided into (*a*) those guns moving with an army in the field, and (*b*) those which were either wholly stationary or were called upon only when a siege was expected. The *personnel* was gradually becoming more efficient and more amenable to discipline; the transport arrangements, however, remained in a backward state. Siege and fortress artillery was now organized and employed in accordance with the system of the "formal attack" as finally developed by Vauban. For details of this, as involving the tactical procedure of artillery in the attack and defence of fortresses, the reader is referred to FORTIFICATION AND SIEGECRAFT. We are concerned here more especially with the progress of field artillery. The part played by this arm began now to vary according to the circumstances of each action, and the "moral" support of guns was calculated as a factor in the dispositions. In the early Silesian wars, heavy or reserve guns protected the deployment of the army and endeavoured to prepare for the subsequent advance by firing upon the hostile troops; the battalion guns remained close to the infantry, accompanied its movements and assisted in the fire fight. Their support was not without value, and the heavy guns often provoked the enemy into a premature advance, as at Mollwitz. But the infantry or the cavalry forced the decision. It has been mentioned that with the final disappearance of the pike, about 1700, infantry fire-power ruled the battlefield. Throughout the 18th century, it will be found, when the infantry is equal to its work the guns have only a subordinate part in the fighting of pitched battles. At Kunersdorf (1759) the first dashing charge of the Prussian grenadiers captured 72 guns from the Russian army. Later the total of captured ordnance reached 180, yet the Russians, then almost wholly in flight, were not cut to pieces, for only a few light guns of the Prussian army could get to the front; their heavy pieces, though twelve horses were harnessed to each, never came into action. This example will serve to illustrate the difference between the artillery of 1760 and that of fifty years later. According to Tempelhof, who was present, Kunersdorf was the finest opportunity for field artillery that he had ever seen. Yet the field artillery of the 18th century was, if anything, more powerful than that of Napoleon's time; it was the want of mobility alone which prevented the Prussians from turning to good account an opportunity fully as favourable as that of the German artillery at Sedan. That Frederick made more use of his guns in the later campaigns of the Seven Years' War is accounted for by the fact that his infantry and cavalry were no longer capable of forcing a decision, and also by changes in the general character of the operations. These were fought in and about broken country and entrenched positions, and the mobility of the other arms sank to that of the artillery. Thus power came to the front again, and the heavier weapons regained their former supremacy. In a *bataille rangée* in the open field the proportion of guns to men had been, in 1741, 2 per 1000. At Leuthen (1757) heavy fortress guns were brought to the front for a special purpose. At Kunersdorf the proportion was 4 and 5 per 1000 men, with what degree of effectiveness we have seen. In the later campaigns the Austrian artillery, which was, throughout the Seven Years' War, the best in Europe, placed its numerous and powerful ordnance (an "amphitheatre of 400 guns," as Frederick said) in long lines of field works. The combination of guns and obstacles was almost invariably too formidable to offer the slightest chance of a successful assault. It was at this stage that Frederick, in 1759, introduced horse artillery to keep pace with the movements of cavalry, a proof, if proof were needed, of the inability of the field artillery to manœuvre. The field howitzer, the weapon *par excellence* for the attack of field works, has never perhaps been more extensively employed than it was by the Prussians at that time. At Burkersdorf (1762) Frederick placed 45 howitzers in one battery. In those days the mobile artillery was always formed in groups or "batteries" of from 10 to 20 pieces. England too was certainly abreast of other countries in the organization of the field artillery arm. About the middle of the 18th century the guns in use consisted of 24-pounders, 12-pounders, 6-pounders and 3-pounders. The guns were divided into "brigades" of four, five and six guns respectively, and began to be separated into "heavy" and "light" brigades. Each field gun was drawn by four horses, the two leaders being ridden by artillerymen, and had 100 rounds of shot and 30 rounds of grape. The British artillery distinguished itself in the latter part of the Seven Years' War. Foreign critics praised its lightness, its elegance and the good quality of its materials. At Marburg (1760) "the English artillery could not have been better served; it followed the enemy with such vivacity, and maintained its fire so well, that it was impossible for the latter to re-form," says Tempelhof, the Prussian artillery officer who records the lost opportunity of Kunersdorf. The merits and the faults of the artillery had been made clear, and nowhere was the lesson taken to heart more than in France, where General Gribeauval, a French officer who had served in the war with the Austrian artillery, initiated reforms which in the end led to the artillery triumphs of the Napoleonic era. While Frederick had endeavoured to employ, as profitably as possible, the existing heavy equipments, Gribeauval sought improvement in other directions.

9. *Gribeauval's Reforms.*—At the commencement of the 18th century, French artillery had made but little progress. The carriages and wagons were driven by wagoners on foot, and on the field of battle the guns were dragged about by ropes or remained stationary. Towards the middle of the century some improvements were made. Field guns and carriages were lightened, and the guns separated into brigades. Siege carriages were introduced. From 1765 onwards, however, Gribeauval strove to build up a complete system both of *personnel* and *matériel*, creating a distinct *matériel* for field, siege, garrison and coast artillery. Alive to the vital importance of mobility for field artillery, he dismissed to other branches all pieces of greater calibre than 12-pounders, and reduced the weight of those retained. His reforms were resisted, and for a time successfully; but in 1776 he became first inspector-general of artillery, and was able to put his ideas into force. The field artillery of the new system included 4-pounder regimental guns,

and for the reserve 8- and 12-pounders, with 6-inch howitzers. For siege and garrison service Gribeauval adopted the 16-pounder and 12-pounder guns, 8-inch howitzer and 10-inch mortar, 12-, 10- and 8-inch mortars being introduced in 1785.

The carriages were constructed on a uniform model and technically improved. The horses were harnessed in pairs, instead of in file as formerly, but the manner in which the teams were driven remained much the same. The *prolong* (a sort of tow-rope) was introduced, to unite the trail of the gun and the limber in slow retiring movements. Siege carriages differed from those of field artillery only in details. Gribeauval also introduced new carriages for garrison and coast service. The great step made was in a uniform construction being adopted for all *matériel*, and in making the parts interchangeable so far as possible. In 1765 the *personnel* of the French artillery was reorganized. The corps or reserve artillery was organized in divisions of eight guns. The battery or division was thus made a unit, with guns, munitions and gunners complete, the horses and drivers being added at a later date. Horse artillery was introduced into the French army in 1791. The last step was made in 1800, when the establishment of a driver corps of soldiers put an end to the old system of horsing by contract.

10. *British Artillery, 1793–1815.*—Meanwhile the numbers of the English artillery had increased to nearly 4000 men. For some five centuries the word "artillery" in England meant entirely garrison artillery; the field artillery only existed in time of war. When war broke out, a train of artillery was organized, consisting of a certain number of field (or siege) guns, manned by garrison gunners; and when peace was proclaimed the train was disbanded, the *matériel* being returned into store, and the gunners reverting to some fort or stronghold. In 1793 the British artillery was anything but efficient. Guns were still dispersed among the infantry, mobility had declined again since the Seven Years' War, and the American war had been fought out by the other arms. The drivers were mere carters on foot with long whips, and the whole field equipment was scarcely able to break from a foot-pace. Prior to the Peninsular War, however, the exertions of an able officer, Major Spearman, had done much to bring about improvement. Horse artillery had been introduced in 1793, and the driver corps established in 1794. Battalion guns were abolished in 1802, and field "brigades of six guns" were formed, horse artillery batteries being styled "troops." Military drivers were introduced, and the horses teamed in pairs. The drivers were mounted on the near horses, the gunners either rode the off horses or were carried on the limbers and wagons. The equipment was lightened, and a new system of manœuvres introduced. A troop of horse artillery and a field brigade each had five guns and one howitzer. The "driver corps," raised in 1794, was divided into troops, the addition of one of which to a company of foot artillery converted it into a field brigade. The horse artillery possessed both drivers and horses, and required very limited assistance from the driver corps.

11. *French Revolutionary Wars.*—During the long wars of the French Revolution and Empire the artillery of the field army by degrees became field artillery as we know it to-day. The development of musketry in the 16th century had taken the work of preparing an assault out of the hands of the gunners. *Per contra*, the decadence of infantry fire-power in the latter part of the Seven Years' War had reinstated the artillery arm. A similar decadence of the infantry arm was destined to produce, in 1807, artillery predominance, but this time with an important difference, viz. *mobility*, and when mobility is thus achieved we have the first modern field artillery. The new tactics of the French in the Revolutionary wars, forced upon them by circumstances, involved an almost complete abandonment of the fire-tactics of Frederick's day, and the need for artillery was, from the first fight at Valmy onwards, so obvious that its moral support was demanded even in the outpost line of the new French armies. St Cyr (*Armies of the Rhine*, p. 112) quotes a case in which "right in the very farthest outpost line" the original 4-pounder guns were replaced by 8-, 16-, and in the end by 24-pounders. The cardinal principle of massing batteries was not, indeed, forgotten, notwithstanding the weakness of raw levies. But though, as we have seen, the *matériel* had already been greatly improved, and the artillery was less affected by the Revolution than other arms of the service, circumstances were against it, and we rarely find examples of artillery work in the Revolutionary wars which show any great improvement upon older methods. The field guns were however, at last organized in batteries each complete in itself, as mentioned above. The battalion gun disappeared; it was a relic of days in which it was thought advisable, both for other reasons and also because the short range of guns forbade any attempt at concentration of fire from several positions at one target, to have some force of artillery at any point that might be threatened. Though it was officially retained in the regulations of the French army, "officers and men combined to reject it" (Rouquerol, *Q. F. Field Artillery*, p. 121), and its last appearances, in 1809 and in 1813, were due merely to an endeavour on the part of Napoleon to give cohesion thereby to the battalions of raw soldiers which then constituted his army. But, with the development of mobility, it was probably found that sufficient guns could be taken to any threatened point, and no one had ever denied the principle of massed batteries, although, in practice, dispersion had been thought to be unavoidable.

12. *Napoleon's Artillery Tactics.*—During the war the French artillery steadily improved in manœuvring power. But many years elapsed before perfection was attained. Meanwhile, the infantry, handled without regard to losses in every fight, had in consequence deteriorated. The final production of the field artillery battle, usually dated as from the battle of Friedland (June 14, 1807), therefore saved the situation for the French. Henceforward Napoleon's battles depend for their success on an "artillery preparation," the like of which had never been seen. Napoleon's own maxim illustrates the typical tactics of 1807–1815. "When once the *mêlée* has begun," he says, "the man who is clever enough to bring up an unexpected force of artillery, without the enemy knowing it, is sure to carry the day." The guns no longer "prepared" the infantry advance by slowly disintegrating the hostile forces. Still less was it their business merely to cover a deployment. On the contrary, they now went in to the closest ranges and, by actually *annihilating* a portion of the enemy's line with case-shot fire, "covered" the assault so effectively that columns of cavalry and infantry reached the gap thus created without striking a blow. It is unnecessary to give examples. Every one of Napoleon's later battles illustrates the principle. The most famous case is that of the great battery of 100 guns at Wagram (*q.v.*) which preceded the final attack of the centre. When Napoleon at Leipzig saw the allied guns forming up in long lines to prepare the assault, he exclaimed, "At last they have learned something." This "case-shot preparation," of course, involved a high degree of efficiency in manœuvre, as the guns had to gallop forward far in front of the infantry. The want of this quality had retarded the development of field artillery for 300 years, during which it had only been important relatively to the occasional inferiority of other troops. After Napoleon's time the art of tactics became the art of *combining the three arms*.

13. *Artillery, 1815–1865.*—Henceforward, therefore, the history of artillery becomes the history of its technical effectiveness, particularly in relation to infantry fire, and of improvements or modifications in the method of putting well-recognized principles into action. Infantry fire, however, being more variable in its effectiveness than that of artillery, the period 1815–1870 saw many changes in the relations of the two arms. In the time of Napoleon, infantry fire never equalled that of the Seven Years' War, and after the period of the great wars the musket was less and less effectively used. Economy was, however, practised to excess in every army of Europe during the period 1815–1850, and even if there had been great battles at this time, the artillery, which was maintained on a minimum strength of guns, men and horses, would not have repeated the exploits of Sénarmont and Drouot in the Napoleonic wars. The principle was well understood, but under such conditions the practice was impossible. It was at this stage that the general

introduction of the rifled musket put an end, once for all, to the artillery tactics of the smooth-bore days. Infantry, armed with a far-ranging rifle, as in the American Civil War, kept the guns beyond case-shot range, compelling them to use only round shot or common shell. In that war, therefore, attacking infantry met, on reaching close quarters, not regiments already broken by a *feu d'enfer*, but the full force of the defenders' artillery and infantry, both arms fresh and unshaken, and the full volume of their case shot and musketry. At Fredericksburg the Federal infantry attacked, unsupported by a single field piece; at Gettysburg the Federal artillery general Hunt was able to reserve his ammunition to meet Lee's assault, although the infantry of his own side was meanwhile subjected to the fire of 137 Confederate guns. Thus, in both these cases the assault became one of infantry against unshaken infantry and artillery. On many occasions, indeed, the batteries on either side went into close ranges, as the traditions of the old United States army dictated, but their losses were then totally out of proportion to their effectiveness. Indeed, the increased range at which battles were now fought, and the ineffectiveness of the projectiles necessarily used by the artillery at these ranges, so far neutralized even rifled guns that artillery generals could speak of "idle cannonades" as the "besetting sin" of some commanders.

14. *The Franco-German War, 1870–71.*—In the next great war, that of 1866 (Bohemia), guns were present on both sides in great numbers, the average for both sides being three guns per 1000 men. Artillery, however, played but a small part in the Prussian attacks, this being due to the inadequate training then afforded, and also to the mixture of rifled guns and smooth-bores in their armament. In Prussia, however, the exertions of General v. Hindersin, the improvement of the *matériel*, and above all the better tactical training of the batteries, were rewarded four years later by success on the battlefield almost as decisive as Napoleon's. In 1870 the French artillery was invariably defeated by that of the Germans, who were then free to turn their attention to the hostile infantry. At first, indeed, the German infantry was too impatient to wait until the victorious artillery had prepared the way for them by disintegrating the opposing line of riflemen. Thus the attack of the Prussian Guards at St Privat (August 18, 1870) melted away before the unbroken fire-power of the French, as had that of the Federals at Fredericksburg and that of the Confederates at Gettysburg. But such experiences taught the German infantry commanders the necessity of patience, and at Sedan the French army was enveloped by the fire of nearly 600 guns, which did their work so thoroughly that the Germans annihilated the Imperial army at the cost of only 5 % of casualties.

15. *Results of the War.*—The tactical lessons of the war, so far as field artillery is concerned, may be briefly summarized as (*a*) employment of great masses of guns; (*b*) forward position of guns in the order of march, in order to bring them into action as quickly as possible; (*c*) the so-called "artillery duel," in which the assailant subdues the enemy's artillery fire; and (*d*) when this is achieved, and not before, the thorough preparation of all infantry attacks by artillery bombardment. This theory of field artillery action has not, even with the almost revolutionary improvements of the present period, entirely lost its value, and it may be studied in detail in the well-known work of von Schell, *Taktik der Feldartillerie* (1877), later translated into English by Major-General Sir A. E. Turner (*Tactics of Field Artillery*, 1900). In one important matter, however, the precepts of Schell and his contemporaries no longer hold good. "It is absolutely necessary that the object of the infantry's attack should be cannonaded before it advances. To accomplish this, sufficient time should be given to the artillery, and on no account should the infantry be ordered to advance until the fire of the guns has produced the desired effect." This, the direct outcome of the slaughter at St Privat, represents the best possibilities of breechloading guns with common shell—no more than a slow disintegration of the enemy's power of resistance by a thorough and lengthy "artillery preparation." Against troops sheltered behind works (as in the Russo-Turkish War of 1877–78) the common shell usually failed to give satisfactory results, if for no other reason, because the "preparation" consumed an inordinate time, and in any case the hostile artillery had first of all to be subdued in the artillery duel.

16. *Quick-firing Field Guns.*—In 1891, a work by General Wille of the German army (*The Field Gun of the Future*) and in 1892 another by Colonel Langlois of the French service (*Field Artillery with the other Arms*) foreshadowed many revolutionary changes in *matériel* and tactics which have now taken place. The new ideas spread rapidly, and the quick-firing gun came by degrees to be used in every army. The original designs have been greatly improved upon (see ORDNANCE: *Field artillery equipments*), but the principles of these designs have not undergone serious modification. These are, briefly, the mechanical absorption of the recoil, by means of brakes or buffers, and the development of "time shrapnel" as the projectile of field artillery. The absorption of recoil of itself permits of a higher rate of fire, since the gun does not require to be run up and relaid after every shot. Formerly such an advantage was illusory (since aim could not be taken through the thick bank of smoke produced by rapid fire), but the introduction of smokeless powder removed this objection. Artillerists, no longer handicapped, at once turned their attention to the increase of the rate of fire. At the same time a shield was applied to the gun, for the protection of the detachment. This advantage is solely the result of the non-recoiling carriage. The gunners had formerly to stand clear of the recoiling gun, and a shield was therefore of but slight value.

17. *Time Shrapnel.*—The power of modern artillery owes even more to the improvement of the projectile than to that of the gun (see AMMUNITION). The French, always in the forefront of artillery progress, were the first nation to realize the new significance of the time-fuze and the shrapnel shell. These had been in existence for many years; to the British army are due both the invention and the development of the shrapnel, which made its first appearance in European warfare at Vimeira in 1808. But, up to the introduction of rifled pieces, the Napoleonic case-shot attack was universally and justly considered the best method of fighting, and in the transition stage of the *matériel* many soldiers continued to put faith in the old method,—hence the Prussian artillery in 1866 had many smooth-bore batteries in the field,—and between 1860 and 1870 gunners, now convinced of the superiority of the new equipments, undoubtedly sought to turn to account the minute accuracy of the rifled weapons in unnecessarily fine shooting. Thus, in 1870 the French time-fuze was only graduated for two ranges, and the Germans used percussion fuzes only. But this phase has passed, and General Langlois has summarized the tactics of the newest field artillery in one phrase: "It results in transferring to 3000 yds. the point-blank and case-shot fire of the smooth-bore." The meaning of this will be discussed later; here it will be sufficient to say that it is claimed for the modern gun and the modern shell that the Napoleonic method[1] of annihilating by a rain of bullets has been revived, with the distinction that the shell, and not the gun, fires the bullets close up to the enemy. In the Boer War, Pieter's Hill furnished a notable example of this "covering," as distinct from "preparation," of an assault by artillery fire.

18. *Heavy Field, Siege and Garrison Artillery.*—Amongst other results of this war was a recrudescence of the idea of "dispersion." This will be noticed later; the more material result of the Boer War, and of the generally increasing specialization in the various functions of the artillery arm, has been the reintroduction of heavy ordnance into field armies. The field howitzer reappeared some time before the outbreak of that war, and the British howitzers had illustrated their shell-power in the Sudan campaign of 1898. During the latter part of the 19th century, siege and fortress artillery underwent a development hardly less remarkable than that of field artillery in the same time. Rifled guns, "long" and "short" for direct and curved fire, formed the siege artillery of the Germans in 1870–71, and

[1] Napoleon's maxim, quoted above, reappears in spirit in the British *F. A. Training* of 1906 (p. 225).

with the reduction of the old-fashioned fortresses of France began a new era in siegecraft (see FORTIFICATION AND SIEGECRAFT). At the present time howitzers[1] (B.L. rifled) are the principal siege weapons, while heavy direct-fire guns (see ORDNANCE *passim*) still retain a part of the work formerly assigned to the artillery of the attack. For an account of a siege with modern artillery see Macalik and Länger, *Kampf um eine Festung*, which describes an imaginary siege of Königgrätz. On the whole, it may be said that modern artillery has caused a revolution in methods of fortification and siegecraft, which is little less far-reaching than the original change from the trébuchet to the bombard.

ORGANIZATION

19. *Field Artillery Organization.*—A *battery* of field artillery comprises three elements, viz. *matériel*,—guns, carriages, ammunition and stores; *personnel*,—officers, non-commissioned officers, gunners, drivers and artificers; and *transport*,—almost invariably horses, though other animals, and also motor and mechanical transport, are used under special circumstances. As for the *matériel*, the guns used by field artillery in almost all countries are quick-firers, throwing shells of 13 to 18 pounds; details of these will be found in the article ORDNANCE. The number of guns in a battery varies in different countries between four and eight; by far the most usual number is six. With the introduction of the quick-firing gun, the tendency towards small batteries (of four guns) has become very pronounced, the ruling motives being (*a*) better control of fire in action, and (*b*) more horses available to draw the increased number of ammunition wagons required. "Mixed" batteries of guns and howitzers were formerly employed on occasion, and were supposed to be adapted to every kind of work. However, the difference between the gun and the howitzer was so great that at all times one part of the armament was idle, while the general increase in the artillery arm has permitted batteries and brigades of howitzers to be formed, separately, as required. Machine guns (*q.v.*) are not treated in Great Britain as being artillery weapons, though abroad they are often organized in batteries. During, and subsequent to the Boer War, heavier machine guns, called pompoms, came into use. The rocket (*q.v.*), formerly a common weapon of the artillery, is now used, if at all, only for mountain and forest warfare against savages.

20. *Ammunition.*—The vehicles of a battery include (besides guns and limbers) ammunition wagons, store and provision carts or wagons and forage wagons. On the amount of ammunition that should be carried with a field battery there was formerly a considerable diversity of opinion. The greater the amount a battery carries with it, the more independent it is; on the other hand, every additional wagon makes the battery more cumbrous and, by lengthening out the column, keeps back the combatant troops marching in rear. But since the introduction of the Q.F. gun it has been universally recognized that the gun must have a very liberal supply of ammunition present with it in action, and the old standard allowance of one wagon per gun has been increased to that of two and even three. Formerly batteries were further hampered by having to carry the reserve of small-arm ammunition for infantry and cavalry. But the greater distances of modern warfare accentuate the difficulties of such a system, and the reserve ammunition for all arms is now carried in special "ammunition columns" (see AMMUNITION), the *personnel* and transport of which is furnished by the artillery.

21. *Interior Economy.*—The organization and interior economy of a battery is much the same in all field artillery. In England the command is held by a major, the second in command is a captain. The battery is divided into three "sections" of two guns each, each under a subaltern officer, who is responsible for everything connected with his section—men, horses, guns, carriages, ammunition and stores. Each section again consists of two sub-sections, each comprising one gun and its wagons, men and horses, and at the head of each is the "No. 1" of the gun detachment—usually a sergeant—who is immediately responsible to the section commander for his sub-section.

The No. 1 rides with the gun, there is also another mounted non-commissioned officer who rides with the first wagon, and the gunners are seated on the gun-carriage, wagon and limbers. The increased number of wagons now accompanying the gun has, however, given more seating accommodation to the detachment, and this distribution has in some cases been altered. The three drivers ride the near horses of their respective pairs, each gun and each wagon being drawn by six horses. On the march, the gun is attached to the limber, a two-wheeled carriage drawn by the gun team; the wagon consists likewise of a "body" and a limber. A battery has also a number of non-combatant carriages, such as forge and baggage wagons. In addition to the gunners and drivers, there are men specially trained in range-taking, signalling, &c., in all batteries.

22. *Special Natures of Field Artillery.—Horse Artillery* differs from field in that the whole gun detachment is mounted, and the gun and wagon therefore are freed from the load of men and their equipment. The organization of a battery of horse artillery differs but slightly from that of a field battery; it is somewhat stronger in rank and file, as horse-holders have to be provided for the gunners in action. Horse artillery is often lightened, moreover, by sacrificing power (see ORDNANCE). The essential feature of *Mountain Artillery* in general is the carrying of the whole equipment on the backs of mules or other animals. The total weight is usually distributed in four or five mule-loads. For action the loads are lifted off the saddles and "assembled," and the time required to do this is, in well-trained batteries, only one minute. For the technical questions connected with the gun and its carriage, see ORDNANCE. The weight of a shell in a mountain gun rarely exceeds 12 lb., and is usually less. In most armies the *field howitzer* has, after an eclipse of many years, reasserted its place. The weapons used are B.L. or Q.F. howitzers on field carriages; the calibre varies from about 4 to 5 in. In Great Britain the field howitzer batteries are organized as, and form part of, the Royal Field Artillery, two batteries of six howitzers each forming a brigade.

23. *Heavy Ordnance.—Heavy Field Artillery*, officially defined as "all artillery equipped with mobile guns of 4-in. calibre and upwards," is usually composed, in Great Britain, of 5-in. or 4·7-in. Q.F. guns on field carriages. 6-in. Q.F. guns have also been used. A battery (4 guns) is attached to the divisional artillery of each division, a company of the Royal Garrison Artillery furnishing the *personnel*. The four guns are divided into two sections, each section under an officer and each sub-section under a non-commissioned officer, as in the horse and field batteries. *Siege* and *garrison artillery* have not usually the complete and permanent organization that distinguishes field artillery. For siege trains the *matériel* is usually kept in store, and the *personnel* and transport are supplied from other sources according to requirement. In garrison artillery, the guns mounted in fortresses and batteries, or stored in arsenals for the purpose, furnish the *matériel*, and the companies of garrison artillery the *personnel*. In Great Britain, the Royal Garrison Artillery finds the mountain batteries and the heavy field artillery in addition to its own units. The siege trains are, as has been said, organized *ad hoc* on each particular occasion (see FORTIFICATION AND SIEGECRAFT). In Great Britain, the guns and howitzers manned by the R.G.A. would be 6-in. and 8-in. howitzers, 4·7-in. and 6-in. guns, and still heavier howitzers, as well as the field and heavy batteries belonging to the divisions making the siege.

24. *Higher Organization of Artillery.*—The higher units, in almost every country except Great Britain, are the regiment, and, sometimes, the brigade of two or more regiments. These units are distributed to army corps, divisions and districts, in the same way as units of other arms (see ARMY). In Great Britain the Royal Regiment of Artillery still comprises the whole *personnel* of the arm, being divided into the Royal Horse, Royal Field and Royal Garrison Artillery; to each branch Special

[1] The old smooth-bore mortar for high-angle fire has of course disappeared, but the name "mortar" is still applied in some countries to short rifled howitzers.

Reserve and Territorial artillery are affiliated. Over and above the military command of these higher units, provision is usually made for technical control of the *matériel*, and a variety of training and experimental establishments, such as schools of gunnery, are maintained in all countries. The more special unit of organization in mobile artillery is the *brigade*, formerly called brigade-division (German, *Abteilung*; French *groupe*). The brigade is in Great Britain the administrative and tactical unit. Mountain artillery is not organized in brigades in the British empire. The unit consists, in the case of guns, of three batteries (18 guns, heavy artillery 12), in the case of field howitzers of two batteries (12 howitzers), and in the horse artillery of two batteries (12 guns), and is commanded by a lieutenant-colonel. To each brigade is allotted an ammunition column. The necessity for such a grouping of batteries will be apparent if the reader notes that 54 field guns, 12 howitzers and 4 heavy field guns form the artillery of a single British division of about 15,000 combatants.

25. *Grouping of the Artillery.*—The "corps artillery" (formerly the " reserve artillery ") now consists only of the howitzer and heavy brigades, with a brigade of horse artillery. The latter is held at the disposal of the corps commander for the swift reinforcement of a threatened point; the howitzers and the heavy guns have, of course, functions widely different from those of the mass of guns. As the field artillery is required to come into action at the earliest possible moment, it has now been distributed amongst the infantry divisions, and marches almost at the head of the various combatant columns, instead of being relegated perhaps to the tail of the centre column. The redistribution of the British army (1907) on a divisional basis is a remarkable example of this; even the special natures of artillery (except horse artillery) are distributed amongst the divisions. In Germany two " regiments " (each of 2 *Abteilungen* = 6 batteries) form a brigade, under an artillery general in each division who thus disposes of 72 field guns, and the howitzers, with such horse artillery batteries as remain over after the cavalry has been supplied, still form a corps or reserve artillery. In 1903 the French, after long hesitation, assigned the whole of the field artillery to the various divisions, but later (for reasons stated in the article TACTICS) arranged to reconstitute the old-fashioned corps artillery in war. (See also ARMY, § 49).

TACTICAL WORK

26. *General Characteristics of Field Artillery Action.*—The duty of field artillery in action is to fire with the greatest effect on the target which is for the moment of the greatest tactical importance. This definition of field artillery tactics brings the student at once to questions of combined tactics, for which consult the article TACTICS. The purpose of the present article is to indicate the methods employed by the gunners to give effect to their fire at the targets mentioned. For this purpose the artillery has at its disposal two types of projectile, common (or rather, high explosive) shell and shrapnel, and two fuzes, " time " and " percussion " (see AMMUNITION). The actual process of coming into action may be described in a few words. The gun is, at or near its position in action, " unlimbered " and the gun limber and team sent back under cover. Ammunition for the gun is first taken from the wagon that accompanies it, as it is very desirable to keep the limbers full as long as possible, in case of emergencies such as that of a temporary separation from the wagon. Limber supply is, however, allowed in certain circumstances. The wagon is now placed as a rule by the side of the gun, an arrangement which immensely simplifies the supply of ammunition, this being done under cover of the armour on the wagon and of the gun-shield and also without fatigue to the men. The older method of placing the wagon at some distance behind the gun is still occasionally used, especially in the case of unshielded equipments. No horses are allowed, in any case, to be actually with the line of guns. According to the British *Field Artillery Training* of 1906, a battery in action would be thus distributed: first, the " fighting battery " consisting of the six guns, each with its wagon alongside, and the limbers of the two flank guns; then, under cover in rear, the " first line of wagons " comprising the teams of the fighting battery, the four remaining gun limbers, and six more wagons. The non-combatant vehicles form the " second line of wagons."

27. *Occupation of a Position.*—This depends primarily upon considerations of tactics, for the accurate co-operation of the guns is the first essential to success in the general task. In details, however, the choice of position varies to some extent with the nature of the equipment: for instance, an elevated position is better adapted than a low one for high velocity guns firing over the heads of their own infantry, and again, the " spade " with which nearly all equipments are furnished (see ORDNANCE) should have soil in which it can find a hold. Cover for the gun and its detachment cannot well be obtained from the configuration of the ground, because, if the gun can shoot over the covering mass of earth, the hostile shells can of course do likewise. Sufficient protection is given by the shield, and thus " cover " for field-guns simply means concealment. Cover for the " first line of wagons " is, however, a very serious consideration. As to concealment, it is stated that " the broad white flash from a gun firing smokeless powder is visible " to an enemy " unless the muzzle is at least 10 ft. below the covering crest " (Bethell, *Modern Guns and Gunnery*, 1907, p. 147). Concealment therefore, means only the skilful use of ground in such a way as to make the enemy's ranging difficult. This frequently involves the use of retired positions, on reverse slopes, in low ground, &c., and in all modern artillery the greatest stress is laid on practice in firing by indirect means. Controversy has, however, arisen as to whether inability to see the foreground is not a drawback so serious that direct fire from a crest position, in spite of its exposure, must be taken as the normal method. The latter is of course immensely facilitated by the introduction of the shield. A great advantage of retired positions is that, provided unity of direction is kept, an overwhelming artillery surprise (see *F. A. Training*, 1906, p. 225) is carried out more easily than from a visible position. The extent of *front* of a battery in action is governed by the rule that no two gun detachments should be exposed to being hit by the bullets of one shell, and also by the necessity of having as many guns as possible at work. These two conditions are met by the adoption of a 20-yards interval between the muzzles of the guns. At the present time the gun and its wagon are placed as close together as possible, to obtain the full advantage of the armoured equipment. The *shield*, behind which the detachments remain at all times covered from rifle (except at very short range) and shrapnel bullets,[1] enables the artillery commander to handle his batteries far more boldly than formerly was the case. General Langlois says " the shield-protected carriage is the corollary to the quick-firing gun." Armour on the wagon, enabling ammunition supply as well as the service of the gun, to be carried on under cover, soon followed the introduction of the shield. The disadvantage of extra weight and consequently increased difficulty of " man-handling " the equipment is held to be of far less importance than the advantages obtained by the use of armour.

28. *Laying.*—" Elevation " may be defined as the vertical inclination of the gun, " direction " as the horizontal inclination to the right or left, necessary to direct the path of the projectile to the object aimed at. " Laying " the gun, in the case of most modern equipments, is divided, by means of the device called the independent line of sight (see ORDNANCE), into two processes, performed simultaneously by different men, the adjustment of the sights and that of the gun. The first is the act of finding the " line of sight," or line joining the sights and the point aimed at; for this the equipment has to be " traversed " right or left so as to point in the proper direction, and also adjusted in the vertical plane. The simplest form of laying for direction, or " line," is called the " direct " method. If the point aimed at is the target, and it can be seen by the layer, he has merely to look over the " open " sights. But the point aimed at is rarely the target itself. In war, the target, even if visible, is often indistinct,

[1] Though not of course against the direct impact of shrapnel or H.E. shells.

and in this case, as also when the guns are under cover or engaging a target under cover, an "aiming point" or "auxiliary mark," a conspicuous point quite apart and distinct from the target, has to be employed ("indirect" method). In the Russo-Japanese War the sun was sometimes used as an aiming point. When the guns are behind cover and the foreground cannot be seen, an artificial aiming point is often made by placing a line of "aiming posts" in the ground. If an aiming point can be found which is in line with the target, as would be the case when aiming posts are laid out, the laying is simple, but it is as often as not out of the line. Finding the "line" in this case involves the calculation, from a distant observing point, of the angle at which the guns must be laid in order that, when the sights are directed upon the aiming point, the shell will strike the target. It is further necessary to find the "angle of sight" or inclination of the line of sight to the horizontal plane. If aim be taken over the open sights at the target, the line of sight naturally passes through the target, but in any other case it may be above or below it. Then the point where the projectile will meet the line of sight, which should coincide with the target, is beyond it if the line of sight is below or angle of sight is too small, and short of it if the line of sight is too high—that is, range and fuze will be wrong. The process of indirect laying for elevation therefore is, first, the measurement of the angle of sight, and secondly, the setting of the sights to that angle by means of a clinometer; this is called clinometer laying. In all cases the actual elevation of the gun to enable the shell to strike the target is a purely mechanical adjustment, performed independently; the gun is moved relatively to the sights, which have been previously set as described. Frequently the battery commander directs the guns from a point at some distance, communication being maintained by signallers or by field telephone. This is the normal procedure when the guns are firing from cover. Instruments of precision and careful calculations are, of course, required to fight a battery in this manner, many allowances having to be made for the differences in height, distance and angle between the position of the battery commander and that of the guns.

29. *Ranging*[1] (except on the French system alluded to below) is, first, finding the range (*i.e.* elevation required), and secondly, correcting the standard length of fuze for that range in accordance with the circumstances of each case. To find the elevation required, it is necessary to observe the bursts of shells "on graze" with reference to the target. The battery commander orders two elevations differing by 300 yds., *e.g.* "2500, 2800," and tells off a "ranging section" of two guns. These proceed to fire percussion shrapnel at the two different elevations, in order to obtain bursts "over" (+) and "short" (−). When it is certain that this "long bracket" is obtained, the "100 yds. bracket" is found, the elevations in the given case being, perhaps, 2600 and 2700 yds. "Verifying" rounds are then fired, to make certain of the 100 yds. bracket. The old "short bracket" (50 yds.) is not now required except at standing targets. Circumstances may, of course, shorten the process; for instance, a hit upon the target itself could be "verified" at once. The determination of the fuze (by time shrapnel) follows. The fuze has a standard length for the ascertained range, but the proper correction of this standard length to suit the atmospheric conditions has to be made. The commander has therefore already given out a series of corrector[2] lengths, his object being to secure bursts both in air and on graze. When he is finally satisfied he opens fire "for effect."

30. An example of the ordinary method of ranging, adapted from *Field Artillery Training*, 1906, is given below.

Battery commander gives target, &c., and orders: "Right section ranging section; remainder corrector 150 increase 10, 4400–4700," for the long bracket.

No. 1 gun fires, elevation 4400 yds., P.S., round observed −
No. 2 " " " 4700 " " " " +
B.C. orders "4500–4600."
No. 1 gun fires, elevation 4500 yds., P.S., round observed −
No. 2 " " " 4600 " " " " +

The 100 yds. bracket appears to be 4500–4600. B.C. orders: "Remainder 4500 time shrapnel," and gives the ranging section 4500–4600 to "verify." Guns 3, 4, 5, 6 set fuzes for 4500 with correctors 150, 160, 170, 180.

No. 1 gun fires, elevation 4500 yds., P.S., round observed −
No. 2 " " " 4600 " " " " +

B.C. orders: "Remainder 4500, one round gun fire, 3 seconds."

No. 3 elevation 4500 yds. T. S. corrector 150 air
No. 4 " " " " " 160 air
No. 5 " " " " " 170 graze
No. 6 " " " " " 180 "

B.C. selects corrector 160 and goes to "section fire."
The battery now begins to fire "for effect."

No. 1 elevation 4500 yds. T.S. corrector 160 air
No. 3 " " " " " " "

followed by Nos. 5, 2, 4 and 6.

There is another method of ranging, viz. with time shrapnel only. In this the principle is that several shells, fired with the same corrector setting, but at different elevations, will burst in air at different points along one line. Bursts high in the air cannot be judged, and it is therefore necessary to bring down the line of bursts to the target, so that the bursts in air appear directly in front or directly in rear of it. Rounds are therefore fired (in pairs owing to possible imperfections in the fuzes) to ascertain the corrector which gives the best line of observation. This found, the target is bracketed by bursts low in the air observed + and −, as in the ordinary method with percussion shrapnel.

The operations of finding the "line of fire" and the proper elevation may be combined, as the shells in ranging can be made to "bracket" for direction as well as for elevation. The line can be changed towards a new target in any kind of direct and indirect laying, in the latter case by observing the angle made with it by the original line of fire and giving deflection to the guns accordingly. Further, the fire of several dispersed batteries may be concentrated, distributed, or "switched" from one target to another on a wide front, at the will of the commander.

31. *Observation of Fire*, on the accuracy of which depends the success of ranging, may be done either by the battery commander himself or by a special "observing" party. In either case the shooting is carefully observed throughout, and corrections ordered at any time, whether during the process of ranging or during fire for effect. The difficulties of observation vary considerably with the ground, &c., for instance, the light may be so bad that the target can hardly be seen, or again, if there be a hollow in front of the target, a shell may burst in it so far below that the smoke appears thin, the round being then judged "over" instead of "short." On the other hand, a hollow behind the target may cause a round to be lost altogether. Ranging with time shrapnel has the merit of avoiding most of these "traps." The "French system of fire discipline," referred to below, has this method as the usual procedure.

32. *Fire.*—Field Artillery ranges are classed in the British service as: "distant," 6000 to 4500 yds.; "long," 4500 to 3500; "effective," 3500 to 2000; and "decisive," 2000 and

[1] Finding the line is also an integral part of ranging. When an aiming point is used, the angle at which the guns must be laid with reference to it is calculated and given out by the battery commander. The modern goniometric sight permits of a wide angle (in England 180° right or left) being given. "Deflection" is a small angular correction applied to individual guns.

[2] The "corrector" is an adjustment on the sights of the gun used to determine the correct fuze. In the British Q.F. equipment, a graduated dial or drum shows the elevation of the gun above the line of sight. The fuze lengths are marked on a movable scale opposite the range graduations to which they apply, and the "corrector" moves this fuze scale so as to bring different fuze lengths opposite the range graduation. For example, a certain corrector setting gives 11½ on the fuze scale opposite 4000 yds. on the range scale, and if the shells set to 11½ burst too high, a new corrector setting is taken, the fuze length 12 is now opposite to the 4000 range graduation, and this length gives bursts closer up and lower. In the German service a corrector (*Aufsatzschieber*) alters the real elevation given to the gun, so that while throughout the battery all guns have the same (nominal or ordered) elevation shown on the sights, the real elevations of individual guns vary according to the different corrector settings. Thus bursts at different heights and distances from the target are obtained by shifting the trajectory of the shell. The fuze, being set for the nominal elevation common to all the guns, burns for the same time in each case, and thus the burst will be lower and closer to the target with a less (real) elevation, and higher and farther from it with a greater.

under. The actual methods of fire employed are matters of detail; it will be sufficient to say that "section fire," in which the two guns of a section are fired alternately at a named interval, usually 30 seconds, and "rapid fire," in which two, three or more rounds as ordered are fired by each gun as quickly as possible, are the normal methods. Each battery usually engages a portion of the objective equal in length to its own front, owing to the spread of the cone of shrapnel bullets (see below). The fire is, of course, almost always frontal, though enfilade and oblique fire, when opportunities occur for their employment, are more deadly than ever, because of the depth of the cone. As for the general conduct of an artillery action, accurate fire for effect, at a medium rate, is used in most armies, but in the French and, since 1906, in the British services a new method has arisen, in consequence of the introduction of the modern quick-firer and the perfection of the time shrapnel. The French battery (1900 Q.F. equipment) consists of four guns and twelve wagons. The gun is shielded, as also are the wagons; the high velocity and flat trajectory give a maximum depth to the cone of shrapnel bullets. In the hope of obtaining a rapid and overwhelming fire, the French artillery ranges only for a long bracket, and once this bracket is found, the ground within its limits is swept from end to end in a burst of rapid fire. This is termed a *rafale* (squall or gust), and technically signifies "a series of eight rounds per gun, each two rounds being laid with 100 metres more elevation than the last pair, the whole fired off as rapidly as possible." The cone of time shrapnel being assumed as 300 yds. (or metres), it is clear that four pairs of rounds, bursting, say, at 1000, 1100, 1200 and 1300 yds. (adding, for the last, 300 yds. for its forward effect), sweep the whole ground between 1000 and 1600 yds. from the guns. The maximum depth would, of course, be obtained with four elevations differing by the depth of the cone; in such a case the space from 1000 to 2200 yds. would be covered, though much less effectively, since the same number of bullets are distributed over a larger area. On the other hand, the *rafale*, at a minimum, covers 300 yds., all the guns in this case being laid at the same elevation throughout. Here the maximum number of bullets is obtained for every square yard attacked. Between these extremes, a skilful artillery officer can vary the *rafale* to the needs of each several case almost indefinitely. "Sweeping" fire is a series of three rounds per gun, one in the original line, one to the right and one to the left of it; this is significantly called "mowing" (*tir fauchant*). A further refinement in both services is the combined "search and sweep." Forty-eight rounds, constituting in the French army a series of this last kind, can, it is said, be fired in 1 minute and 15 seconds, without setting fuzes beforehand, to cover an area of 600 × 200 metres. The result of such a series, worked out mathematically, is that 19 % of all men and 75 % of all horses, in the area and not under cover, should be hit by separate bullets (Bethell, *Modern Guns and Gunnery*, 1907). Even allowing a liberal deduction for imperfect distribution of bullets, we may feel certain that nothing but shielded guns could live long in the fire-swept zone. This is, of course, a rate of fire which could not be kept up for any length of time by the same battery. A French battery, firing at the maximum rate, would expend every available round in 13 minutes.

33. *Projectiles Employed.*—"Time shrapnel," say the German Field Artillery regulations, "is the projectile *par excellence* . . . against all animate targets which are not under cover." It achieves its purpose, as has been said, by sending a shower of bullets over an area of ground in such quantity that this is swept from end to end. These bullets are propelled, in a cone, forward from the point of burst of the shell, and the effective depth of this cone at medium ranges with a fairly high velocity gun may be taken at 300 yds. Further, the corrector enables the artillery commander to burst his shells at any desired point; for example, a long fuze may be given, to burst them close up when firing upon a deep target (such as troops in several lines, one behind the other), and thereby to obtain the maximum searching effect, or to obtain direct hits on shielded guns, while a short corrector, bursting the shell well in front of the enemy, allows the maximum lateral spread of the bullets, and therefore sweeps the greatest front. The number of bullets in the shell is such that troops in the open under effective shrapnel fire must suffer very heavily, and may be almost annihilated. If the enemy is close behind good cover, the bullets, indeed, pass harmlessly overhead. This, however, leads to a very important fact, viz. that artillery can keep down the fire of hostile infantry, "blind" the enemy, in Langlois' phrase, by *pinning it down* to cover. Under cover the men are safe, but if they raise their heads to take careful aim, they will almost certainly be hit. Their fire under such conditions is therefore unaimed and wild at the best, and may be wholly ineffective. *Common* shell and *high-explosive* shell (see AMMUNITION) belong to another class of projectile. The former is now not often used, but a certain proportion of H.E. shell is carried by the field artillery in many armies (see table in ORDNANCE: *Field Equipments*). This has a very violent local effect within a radius of 20 to 25 yds. of the point of burst (see AMMUNITION, fig. 10). It therefore covers far less ground than shrapnel, and is naturally used either (*a*) against troops under substantial cover or (*b*) to wreck cover and buildings. In the former case the shell is supposed to send a rain of splinters vertically downwards. This it will do, provided the fuze is minutely accurate, and a burst is thus obtained exactly over the heads of the enemy, but this is now generally held to be unlikely, and in so far as effect against *personnel* is concerned the H.E. shell is not thought to be of much value. Indeed, in the British and several other services, no H.E. shells at all are carried by field batteries, reliance being placed upon percussion shrapnel in attacking localities, buildings, &c., and for ranging. Experiments have been made towards producing a "H.E. shrapnel," which combines the characteristics of both types (see, for a description, AMMUNITION). For the projectiles used in attacking shielded guns, see section on "field howitzers" below. *Case shot* is now rarely employed. In the war of 1870–71 Prince Kraft von Hohenlohe-Ingelfingen, who commanded the Prussian Guard artillery, reported the expenditure of only one round of case, and even that was merely "broken in transport." The close-quarters projectile of to-day is more usually shrapnel with the fuze set at zero. Langlois, however, calls case shot "the true projectile for critical moments, which nothing can replace."

34. *Tactics of Field Artillery.*—On the march, the position and movement of the guns are regulated by the necessity of coming quickly into action; the usual place for the arm is at or near the heads of the combatant columns, *i.e.* as far forward as is consistent with safety. Safety is further provided for by an "escort," or, if such be not detailed, by the nearest infantry or cavalry. In attack, the rôle of the field artillery is usually (1) to assist if necessary the advanced guard in the preliminary fighting—for this purpose a battery is usually assigned to that corps of troops, other batteries also being sent up to the front as required, (2) to prepare, and (3) to support or cover the infantry attack. "Preparation" consists chiefly in engaging and subduing the hostile artillery. This is often spoken of as the "artillery duel," and is not a meaningless bombardment, but an essential preliminary to the advance. Massed guns with modern shrapnel would, if allowed to play freely upon the attack, infallibly stop, and probably annihilate, the troops making it. The task of the guns, then, is to destroy the opposing guns and artillerymen, a task which will engage almost all the resources of the assailant's artillery in the struggle for artillery superiority. Shielded guns, enhanced rate of fire, perfection in indirect laying apparatus, and many other factors, have modified the lessons of 1870, and complicated the work of achieving victory in the artillery duel so far that the simple "hard pounding" of former days has given way to a variety of expedients for inflicting the desired loss and damage, as to which opinions differ in and within every army. One point is, however, clear and meets with universal acceptance. "The whole object of the duel is to enable the artillery subsequently to devote all available resources to its principal task, which is the material and moral support of the infantry during each succeeding stage of the fight" (French regulations). One side must be victorious in the end, and when, and not until, the hostile artillery is beaten out of action, the

victor has acquired the power of pressing home the attack. The British regulations (1906), indeed, deal with the steps to be taken when, though the artillery of the attack is beaten, the infantry advance is continued, but only so as to order the guns to "reopen at all costs," in other words, as a forlorn hope. The second part of the preparation, the gradual disintegration of the opposing line of infantry, has practically disappeared from the drill books. The next task of the guns, and that in which modern artillery asserts its power to the utmost, is the *support* of the infantry attack. The artillery and infantry co-operate, "the former by firing rapidly when they see their own infantry . . . press forward, and the latter by making full use of the periods of intense artillery fire to gain ground" (British *F.A. Training*, 1906). Thus aided, the infantry closes in to decisive ranges, and as it gains ground to the front, every gun "must be at once turned upon the points selected . . . the most effective support afforded to the attacking infantry by the concentrated fire of guns and field howitzers. The former tie the defenders to their entrenchments (for retreat is practically impossible over ground swept by shrapnel bullets), distract their attention and tend to make them keep their heads down, while the shell from the field howitzers searches out the interior of the trenches, the reverse slopes of the position, and checks the movement of reinforcements towards the threatened point." In these words the British Field Artillery drill-book of 1902 summarizes the act of "covering" the infantry advance. Unofficial publications are still more emphatic. The advance of the infantry to decisive range would often be covered by a mass of one hundred or more field guns, firing shrapnel at the rate of ten rounds per gun per minute at the critical moment. Against such a storm of fire the defending infantry, even supposing that its own guns had refitted and were again in action, would be powerless. It is in recognition of the appalling power of field artillery (which has increased in a ratio out of all proportion to the improvements of modern rifles) that the French system has been elaborated to the perfection which it has now attained.

With modern guns and modern tactics artillery almost invariably fires over the heads of its own infantry. The German regulations indeed say that it should be avoided as far as possible, but, as a matter of fact, if the numerous guns of a modern army (at Königgrätz there were 1550 guns on the field, at Gravelotte 1252, at Mukden 3000) were to be given a clear front, there would be no room for deploying the infantry. Consequently the French regulations, in which the power of the artillery is given the greatest possible scope, say that "it almost always fires over the heads of its own infantry." With field guns and on level ground it is considered dangerous that infantry in front of the guns should be less than 600 yds. distant—not for fear of the shells striking the infantry, but because the fragments resulting from a "premature" burst are dangerous up to that distance. The question of distance is more important in connexion with the "covering" of the assault. Up to a point, the artillery enables the attacking infantry to advance with a minimum of loss and exhaustion, and thus to close with the enemy at least on equal terms, if not with a serious advantage, for the fire of the guns may shake, perhaps almost destroy the enemy's power of resistance. But when the infantry approaches the enemy the guns can no longer fire upon the latter's front line without risk of injuring their friends. All that they can do, when the opposing infantries can see the whites of each other's eyes, is to lengthen the fuze, raise the trajectory and sweep the ground where the enemy's supports are posted. Under these circumstances it is practically agreed that the risk should be taken without hesitation at so critical a moment as that of a decisive infantry assault which must be pushed home at whatever cost. "It will be better for the infantry to chance a few friendly shells than to be received at short range with a fresh outburst of hostile rifle fire" (Rouquerol, *Tactical Employment of Quick-firing Field Artillery*). Thus, the distance at which direct support ceases, formerly 600 yds., has been diminished to 100, and even to 50 yds. Howitzers can, of course, maintain their fire almost up to the very last stage, and, in general, high-explosive shell, owing to its purely local effect, may be employed for some time after it has become unsafe to use shrapnel.

35. Field artillery in *defence*, which would presumably be inferior to that of the attack, must, of course, act according to circumstances. We are here concerned not with the absolute strength or weakness of the passive defensive, which is a matter of tactics (*q.v.*), but with the tactical procedure of artillery, which, relatively to other methods, is held to offer the best chance of success, so far as success is attainable. On the defensive in a prepared position, which in European warfare at any rate will be an unusually favourable case for the defender—the guns have two functions, that of engaging and holding the hostile artillery, and that of meeting the infantry assault. The dilemma is this, that on the one hand a position in rear of the line of battle, with modern improvements in communicating and indirect laying apparatus, is well suited for engaging the hostile guns, but not for meeting the assault; and on the other, guns on the forward slope of the defender's ridge or hill can fire direct, but are quickly located and overwhelmed, for they can hardly remain silent while their own infantry bears the fire of the assailant's shrapnel. Thus the defender's guns would, as a rule, have to be divided. One portion would seek to fight from rearward concealed positions, and use every device to delay the victory of the enemy's guns and the development of the battle until it is too late in the day for a serious infantry attack. Further, the enemy's mistakes and the "fortune of war" may give opportunities of inflicting severe losses; such opportunities have always occurred and will do so again. In the possible (though very far from probable) case of the defender not merely baffling, but crushing his opponent in the artillery duel, he may, if he so desires, himself assume the rôle of assailant, and at any rate he places a veto on the enemy's attack.

The portion told off to meet the infantry assault would be entrenched on the forward slope and would take no part in the artillery duel. Very exceptionally, this advanced artillery might fire upon favourable targets, but its paramount duty is to remain intact for the decisive moment. Here again the defender is confronted with grave difficulties. It is true that his advanced batteries may be of the greatest possible assistance at the crisis of the infantry assault, yet even so the covering fire of the hostile guns, as soon as the hostile infantry had found them their target, may be absolutely overwhelming; moreover, once the fight has begun, the guns cannot be withdrawn, nor can their positions easily be modified to meet unexpected developments. The proportion of the whole artillery force which should be committed to the forward position is disputed. Colonel Bethell (*Journal Royal Artillery*, vol. xxxiii. p. 67) holds that all the mountain guns, and two-thirds of the field guns, should be in the forward, all the howitzers and heavy guns and one-third of the field guns in the retired position. But in view of the facts that if once the advanced guns are submerged in the tide of the enemy's assault, they will be irrecoverable, and that a modern Q.F. gun, with plenty of ammunition at hand, may use "rapid fire" freely, artillery opinion, as a whole, is in favour of having fewer guns and an abnormal ammunition supply in the forward entrenchments, and the bulk of the artillery (with the ammunition columns at hand) in rear. But the purely passive defensive is usually but a preliminary to an active counter-stroke. This counter-attack would naturally be supported to the utmost by the offensive tactics of the artillery, which might thus at the end of a battle achieve far greater results than it could have done at the beginning of the day. In *pursuit*, it is universally agreed that the action of the artillery may be bold to the verge of rashness. The employment of field artillery in *advanced* and *rear guard actions* varies almost indefinitely according to circumstances; with *outposts*, guns would only be employed exceptionally.

36. *Marches.*—The importance of having the artillery well up at the front of a marching column is perhaps best expressed in the phrase of Prince Kraft von Hohenlohe-Ingelfingen, "save hours and not minutes." The Germans in 1870 so far acted up to the principle that Prince Hohenlohe, when asked, at the beginning

of the battle of Sedan, for a couple of guns, was able to reply, "You shall have ninety" (see, for details of the march of the Guard artillery, his *Letters on Artillery*, 6th letter). The German regulations for field service say, very plainly, "the horses have not done their work until they have got the guns into action, even at the cost of utter exhaustion." A notable march was made by the 62nd battery, R.F.A., in the South African War. On the day of the battle of Modder River, the battery marched 32 m. (mostly through deep sand) arriving in time to take part in the action. Such forced marches, if rare, are nowadays expected to be within the power of field artillery to accomplish. Horse artillery is capable of more than this, and as to pace, manœuvring at the cavalry rate. Heavy guns are the least mobile, and would rarely be able to keep pace with infantry in a forced march. Field artillery walks 4, trots 9, and gallops at the rate of 15 m. an hour. A fair marching pace (trot and walk) is 4 m. an hour for field, 5 for horse batteries. A march of 14 m. would, according to the German regulations, be performed by

a field battery in 5 hours,
a horse battery in 4 hours,

under favourable circumstances (Bronsart von Schellendorf).

37. *Power and Mobility.*—It will have been made clear that every gun represents a compromise between these two requirements, and that each type of artillery has been evolved in accordance with the relative requirements of these conditions in respect of the work to be performed. The classification which has been followed in this article represents the practically unanimous decision of every important military state. Still, there has always been controversy between the individual adherents of each side, and the Boer War experiences raised the question as to whether field artillery, as the term is usually understood, should not be abolished, with a view to having only heavy guns and horse artillery with a field army.

38. *Concentration and Dispersion.*—The use of their artillery made by the Boers in the South African War led to the revival of the idea of "dispersing" guns instead of "concentrating" them. It would be more accurate to say that military thinkers had, after the introduction of the quick-firing gun, challenged every received principle, and amongst others the employment of artillery in masses, which, as a result of the war of 1870, "had become almost an article of faith." The idea was to make use of the increased power of the guns to gain equally great results with the employment of less material than formerly. Thus the dispersion of guns is bound up with the passive defensive. The first editions of the British *Field Artillery Training* and *Combined Training*, strongly influenced as they were by South African experience, did not legislate, even in dealing with defence, for "dispersion" in the Boer manner, but only for adaptability (see *Field Artillery Training*, 1902, p. 15). In the Boer War, whilst the Boers nearly always scattered their guns, almost the only occasion upon which their artillery played a decisive part was at Spion Kop, where its fire was concentrated upon the point of assault. At Pieter's Hill, the fire of seventy guns covered the British infantry assault in the Napoleonic manner. On the whole it may be accepted as a general truth that guns are safe, and may be locally effective, when dispersed, but that they cannot produce decisive effect except when used in masses. It must, however, be clearly understood that a "mass" in this sense means a large number of guns, under one command, and susceptible of being handled as a unit, so far as the direction and effectiveness of their fire is concerned. *This being secured*, and on that condition only, it does not matter whether the actual gun positions are scattered over a few square miles, or are closed in one long line and using direct fire—they are still a mass, and capable of acting effectively as such. While there are undoubtedly grave dangers in using the indirect method too freely, technical improvements in laying, telephones, &c., have had much to do with the possibility, at any rate under favourable circumstances, of a concentration which may be described as one of shells rather than of guns, and the reader is reminded in this connexion that the work formerly done by the gun is now performed by the shell.

39. *Horse Artillery* is to be regarded as field artillery of great mobility and manœuvring power. Its value may be said, in general terms, to lie in augmenting the weak fire-power of the mounted troops, and in facilitating their work as much as possible. Thus, when cavalry meets serious opposition in reconnoitring, the guns may be able to break down the enemy's resistance without calling for assistance from the main body of the cavalry, and, in the action of cavalry *versus* cavalry, the "paramount duty of the horse artillery is to shatter the enemy's cavalry" (*Field Artillery Training*, 1906), *i.e.* to "prepare" the success of the cavalry charge by breaking up as far as possible the enemy's power of meeting it. In the cavalry battle, covering fire is practically impossible, owing both to the short distances separating the combatants and to the rapidity of their movements, but steps are taken "to enable all the guns to bear on the enemy's cavalry at the points of collision." The ideal position for the horse artillery is out to a flank, the cavalry manœuvring so as to draw the enemy's cavalry under enfilade fire, and at the same time to force them to mask the fire of their own horse artillery. Another and a most important function of the horse batteries is to reinforce, with the greatest possible speed, any point in the general line of battle which is in need of artillery support. For this reason the corps artillery generally includes horse batteries.

40. *Field Howitzers* are somewhat less mobile than field guns; they have, however, far greater shell power. The special features of the weapon are, of course, the product of the special requirements which have called it into existence. These are, briefly (*a*) the necessity of being able to "search" the interior of earthworks, a task which, as has been said, is beyond the power of high-velocity field guns, and (*b*) demolition work, which is equally beyond the power of even a H.E. shell of field-gun calibre. The first of these conditions implies a steep "angle of descent," which again implies a high angle of elevation. The second requires great shell power but does not call for high velocity. The howitzer, therefore, is a short gun, firing a heavy shell at high angles of elevation. Howitzers almost always are laid by the indirect method of fire from under cover, since it is clear that, with high angles of elevation, the gun may be brought close up to the covering mass, and still fire over it. Ranging must be done very accurately and yet economically, as but few of their heavy shells can be carried in the wagons and limbers, and the shells descending upon an enemy almost vertically lose the long sweeping effect of the field shrapnel which neutralizes minor errors of ranging. The projectiles employed are high explosive and shrapnel, the latter for use against *personnel* under cover, the former for demolition of field works, casemates or buildings. It is very generally held that howitzer time shrapnel is the best form of projectile for the attack of shielded guns. Here it may be said that no completely satisfactory method of dealing with these has yet been discovered. The best procedure with field guns is said to be lengthening the fuze to obtain a high percentage of bursts on graze. A shell striking the face of the shield will penetrate it, and should kill some at least of the gun detachment behind. The high-explosive shrapnel alluded to above is designed primarily for the attack of shielded guns.

41. *Heavy Field Artillery*, alternatively called *Artillery of Position*, as has been said, includes all guns of 4-in. calibre and upwards, mounted on travelling carriages. In South Africa, where firm soil was usually to be found, 6-in. guns were employed as heavy field guns, but in Europe even the 5-in. (British Service) is liable to sink into the ground. In Great Britain, guns only are used by this branch; abroad, the "heavy artillery of the field army," the "light siege train," &c., as it is variously called, is as a rule composed of howitzers of a heavier calibre than the field howitzer, the 15-cm. (6-in.) howitzer being most commonly met with. This artillery has, however, a different tactical rôle from the heavy field artillery of the British service; and it is always with a view to the attack of permanent or semi-permanent fortifications that the *matériel* is organized. In Great Britain, heavy batteries armed with the 5-in. gun are considered as "an auxiliary to the horse and field artillery" (*Heavy Artillery Training*). Ranging is conducted with greater

deliberation than ranging with the lighter guns, though upon the same general lines. Parts of the process may, however, be omitted in certain circumstances. Heavy guns use high-explosive (lyddite) shells and time shrapnel, the former for ranging and for demolishing cover, the latter against *personnel*. Laying is usually indirect. The tactical principles upon which heavy artillery does its work are based, in the main, on the long range (up to 10,000 yds.) and great shell-power of the guns. This power enables the artillery to reach with effect targets which are beyond the range of lighter ordnance, and it is, therefore, considered possible to disperse the guns in batteries, and even in sections of two guns, along the front of the army, without forfeiting the power of concentrating their fire on any point—a power which otherwise they would not possess owing to their want of mobility. At the same time it is not forbidden to bring them into line with the rest of the artillery, in order to achieve a decisive result. In the *attack*, beside the general task of supplementing the effect of other natures of ordnance, heavy artillery may demolish cover, buildings, &c., held by the enemy, and during the infantry assault they may do excellent service in sweeping a great depth of ground, their smaller angle of descent, and the greater remaining velocity and heavier driving charge of their shrapnel, as compared with field guns, enabling them to do this effectively. In the *defence*, long-range fire has great value, especially in sweeping approaches which the enemy must use. In *pursuit*, the heavy artillery may be able to shell the main body of the enemy during its retreat, even if it has left a rear-guard. In *retreat*, the want of mobility of these guns militates against their employment in exposed positions, such as rearguards usually have to take up.

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A complete bibliography and criticism of the artillery works of the 14th, 15th and 16th centuries will be found in Max Jähns, *Geschichte der Kriegswissenschaften*, pp. 221-236, 382-424, 621, 658 and 747-752. For the early 17th century, Diego Ufano, *Tratado de la Artilleria* (1613) is a standard treatise of the time, but the mystery preserved by artillerists in regard to their arm is responsible for an astonishing dearth of artillery literature even in the time of the Thirty Years' War. In 1650 appeared Casimir Simienowicz' *Ars magnae artilleriae*, an English translation of which was published in London in 1729, and in 1683 Michael Mieth published *Artilleriae Recentior Praxis*. The first edition of Surirey de S. Remy, *Mémoires d'Artillerie*, appeared in Paris in 1697. With the reorganization of the arm in the early 18th century came many manuals and other works (see Jähns, *op. cit.* pp. 1607-1621 and 1692-1698), amongst which may be mentioned the marquis de Quincy's *Art de la guerre* (1726). From 1740 onwards numerous manuals appeared, mostly official *règlements*—see French General Staff, *L'Artillerie française au XVIII^e siècle* (1908); and the tactical handling of the arm is treated in general works, such as Guibert's, on war. See also de Morla, *Tratado de la Artilleria* (1784), translated into German by Hoyer (*Lehrbuch der Art.-Wissenschaft*, Leipzig, 1821–1826); *Du Service de l'artillerie à la guerre* (Paris, 1780, German translation, Dresden, 1782, and English, by Capt. Thomson, R.A., London, 1789), Bardet de Villeneuve's *Traité de l'artillerie* (Hague, 1741), and Hennébert, *Gribeauval, Lieut.-Général des armées du Roy* (Paris, 1896). Important works of the period 1800–1850 are Scharnhorst, *Handbuch der Artillerie* (Hanover, 1804–1806, French translation by Fourcy, *Traité sur l'artillerie*, Paris, 1840–1841); Rouvroy, *Vorlesungen über die Artillerie* (Dresden, 1821–1825); Timmerhans, *Essai d'un traité d'artillerie* (Brussels, 1839–1846); C. v. Decker, *Die Artillerie für alle Waffen* (1826); Griffiths, *The Artillerist's Manual* (Woolwich, 1840); Piobert, *Traité d'artillerie* (Paris, 1845–1847); Taubert (translated by Maxwell), *Use of Field Artillery on Service* (London, 1856); Capt. Simmonds, R.A., *Application of Artillery in the Field* (London, 1819); Gassendi, *Aide-mémoire à l'usage des officiers d'artillerie* (Paris, 1819). See also Girod de l'Ain, *Grands artilleurs, Drouot, Sénarmont, Éblé* (Paris, 1894). Among the numerous works on modern field artillery may be mentioned Prince Hohenlohe-Ingelfingen, *Briefe über Artillerie* (Berlin, 1887, 2nd ed., English translation by Col. Walford, *Letters on Artillery*, Woolwich, 1887); Hoffbauer, *Taktik der Feldartillerie, 1866 und 1870–1871* (Berlin, 1876), and *Applikatorische Studie über Verwendung der Artillerie* (Berlin, 1884); Erb, *L'Artillerie dans les batailles de Metz* (Paris, 1906); Leurs, *L'Art. de campagne prussienne 1864–1870* (Brussels, 1874); v. Schell, *Studie über Taktik der Feldartillerie* (quoted above); Hennébert, *Artillerie moderne* (Paris, 1889); and for quick-firing artillery, Langlois, *Artillerie de campagne en liaison avec les autres armes* (Paris, 1892 and 1907); Wille, *Feldgeschütz der Zukunft* (Berlin, 1891); *Waffenlehre* (2nd ed., 1901); and *Zur Feldgeschützfrage* (Berlin, 1896); Rohne, *Die Taktik der Feldartillerie* (Berlin, 1900), *Studie über d. Schnellfeuergeschütze in Rohrrücklauflafette* (Berlin, 1901), *Die französische Feldartillerie* (Berlin, 1902); *Entwicklung des Massengebrauchs der Feldartillerie* (Berlin, 1900); and articles in *Jahrbücher f. d. Deutsche Armee und Marine* (October 1901 and January 1905); Hoffbauer, *Die Frage des Schnellfeuerfeldgeschützes* (Berlin, 1902), and *Verwendung der Feldhaubitzen* (Berlin, 1901); Wangemann, *Für die leichte Feldhaubitze* (Berlin, 1904); von Reichenau, *Studie über . . . Ausbildung der Feldart.* (Berlin, 1896), *Einfluss der Schilde auf die Entwicklung des F.-A. Materials*, and *Neue Studien über die Entwicklung der Feldart.* (Berlin, 1902 and 1903); Smekal, *Führung und Verwendung der Divisions-Artillerie* (Vienna, 1901); Korzen and Kühn, *Waffenlehre* (Vienna, 1906); G. Rouquerol, *Emploi de l'artillerie de campagne à tir rapide* (Paris, 1901), and *Organisation de l'artillerie de campagne* (Paris, 1903); Girardon-Lagabbe, *Organisation du matériel de l'artillerie de campagne* (Paris, 1903); and in English, Capt. P. de B. Radcliffe's translation of Rouquerol's work (*The Tactical Employment of Quick-firing Field Artillery*, London, 1903), and especially Lt.-Col. H. A. Bethell, *Modern Guns and Gunnery* (Woolwich, 1907). See also the current drill manuals of the British, French and German artillery. (C. F. A.)

[1] Most of the works named deal with technical questions of equipment, ammunition, ballistics, &c.

ARTIODACTYLA (from Gr. ἄρτιος, even, and δάκτυλος, a finger or toe, "even-toed"), the suborder of ungulate mammals in which the central (and in some cases the only) pair of toes in each foot are arranged symmetrically on each side of a vertical line running through the axes of the limbs. As contrasted with the Perissodactyla living, and in a great degree extinct, Artiodactyla are characterized by the following structural features. The upper premolar and molar teeth are not alike, the former being single and the latter two-lobed; and the last lower molar of both first and second dentition is almost invariably three-lobed. Nasal bones not expanded posteriorly. No alisphenoid canal. Dorsal and lumbar vertebrae together always nineteen, though the former may vary from twelve to fifteen. Femur without third trochanter. Third and fourth digits of both feet almost equally developed, and their terminal phalanges flattened on their inner or contiguous surfaces, so that each is not symmetrical in itself, but when the two are placed together they form a figure symmetrically disposed to a line drawn between them. Or, in other words, the axis or median line of the whole foot is a line drawn between the third and fourth digits (fig. 1). Lower articular surface of the astragalus divided into two nearly equal facets, one for the navicular and a second for the cuboid bone. The calcaneum with an articular facet for the lower end of the fibula. Stomach almost always more or less complex. Colon convoluted. Caecum small. Placenta diffused or cotyledonary. Teats either few and inguinal, or numerous and abdominal.

Artiodactyla date from the Eocene period, when they appear to have been less numerous than the Perissodactyla, although at the present day they are immeasurably ahead of that group, and form indeed the dominant ungulates. As regards the gradual specialization and development of the modern types, the following features are noteworthy.

1. As regards the teeth, we have the passage of a simply tubercular, or bunodont (βουνός, a hillock) type of molar into one in which the four main tubercles, or columns, have assumed a crescentic form, whence this type is termed selenodont (σελήνη, the new moon). Further, there is the modification of the latter from a short-crowned, or brachyodont type, to one in which the columns are tall, constituting the hypsodont, or hypsiselenodont, type. It is noteworthy, however, that in some instances there appears to have been a retrograde modification from the selenodont towards the bunodont type, the hippopotamus being a case in point. Other modifications are the loss of the upper incisors;