Projectile Weapons of War and Explosive Compounds

John Scoffern
PROJECTILE WEAPONS OF WAR.
PROJECTILE WEAPONS OF WAR
AND
EXPLOSIVE COMPOUNDS;
INCLUDING SOME
NEW RESOURCES OF WARFARE,
WITH ESPECIAL REFERENCE TO
RIFLED ORDNANCE,
IN THEIR CHIEF KNOWN VARIETIES.
WITH THE AUTHENTICATED WEIGHT, MEASUREMENT, AND MODE OF
CONSTRUCTION OF
ARMSTRONG'S WROUGHT IRON BREECH-LOADING GUNS;
TOGETHER WITH AN ACCOUNT OF THEIR SHELLS AND FUSES.

ILLUSTRATED BY DESCRIPTIVE DRAWINGS.

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TO THE OFFICERS

OF

The U. S. Frigate "Merrimac"

THIS BOOK

IS RESPECTFULLY DEDICATED,

IN MEMORY OF THEIR HOSPITALITY TO

AN INQUISITIVE STRANGER.
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PREFACE TO THE FOURTH EDITION.

Though little more than a year has elapsed since the third edition of this work appeared, the march of discovery in all that relates to projectiles has been so rapid in the interim, that the most complete record of what had been discovered in this line, up to the beginning of 1858, would leave much room for amplification now.

To make the truth of this statement apparent, I need only cite the then almost unknown, but now celebrated Armstrong rifled ordnance.

Circumstances have rendered it possible for me to communicate now, for the first time,* an authentic, and therefore accurate, description of that variety of ordnance, including weight, calibre, pitch of rifling; in short, all fundamental particulars bearing upon the construction of the gun.

* The published accounts of the Armstrong gun which have appeared hitherto deviate from the truth in several essential particulars.
I have justified this publication in the course of the descriptive statement which follows. Indeed, knowing as I do the whole secret of Armstrong's gun to have been communicated to the governments of France and the United States, the only argument which could have been adduced in favour of not issuing this treatise fails to be applicable.

Mingled with the large measure of satisfaction an author cannot fail to experience from the indulgent reception of his book, there is, in the present case, a feeling of regret, not the less sincerely felt than it is peculiar. I am precluded from testifying nominally, the obligations I am under to many who have supplied me with valuable information in the mere behalf of science, and with no view to advantage, present or future.
PREFACE TO THIRD EDITION.

When, now about twelve years since, the First Edition of this work was published, I little imagined it would be my fate to re-appear before the curtain twice, and make my acknowledgments.

Though deeply sensible of the flattering manner in which former Editions have been reviewed by the organs of the press, I hope I may be permitted to confess, without offence to the fourth estate, that a compliment has been paid to my little book, which I value even more. It has found its way into garrison libraries, and schools of musketry;—it is read not by officers alone, but also by the rank and file.

The remembrance of this pleasing fact has influenced my method of dealing with certain points not touched upon in previous Editions.

In trying to keep close to the logic of projectile force, I have adapted my language, not so much to the exigencies of the mess room, as of the barracks; not caring how homely an explanation may be, so that it be comprehensible.
PREFACE TO SECOND EDITION.

It may be proper to inform the reader that these pages are the Second Edition of a *brochure* published in 1845, and the fate of which was unusual. Immediately on being announced for publication, the whole stock, with the exception of about a dozen copies, was purchased by the agent of a foreign State, and exported—so that it never found its way into British literary commerce.

As the peculiar circumstances under which Great Britain is now placed have created a desire on the part of many to be made acquainted with the nature and qualities of arms of fire, I have been induced to publish this Second Edition.

Since 1845 the development of fire-arms has been very great. The improvements of Minié, Delvigne, and others, on rifle projectiles; the practice of oval rifle-boring by Lancaster; the celebrated needle gun of Prussia,—were all that period either unknown, or an acquaintance with their principles limited to a comparatively few. A similar remark may be made as
respects the revolving or repeating fire-arms of Colonel Colt, and the rifled rocket of Mr. Hale.* All these topics are brought up to the condition of the present era, and the chapter on rifle guns has been entirely re-written.

In saying that this little volume is altogether devoid of military technicalities, I take no credit to myself. Being totally ignorant of military evolutions—and even military terms—I could not well do less. My object has been, in these pages, to regard arms of fire as so many varieties of philosophical instruments, embodying and illustrating chemical and mechanical laws; to demonstrate their powers, and develop their principles. If I have succeeded to this extent, I shall be content; and in any case, I shall have the satisfaction of remembering that the task was not undertaken without the presumptive justification of having devoted the leisure hours of many years to the practical consideration of fire-arms, and their effects.

* To which may now be added the revolver system of Adams (unquestionably the best), the monster mortars of Mallet, the breech-loading carbines of Greene and Sharpe.
PROJECTILE WEAPONS OF WAR

AND

EXPLOSIVE COMPOUNDS.

The intellectual qualifications which raise man far above all other animals, have never been more industriously exercised than in perfecting the art of war; so that whilst the lion and the tiger are still obliged to meet their enemies at close quarters, and savages, by their rude missiles, scarcely gain a point in civilisation,—we, of more refinement, bring to the conflict every accessory of modern science, and kill our foes according to the most approved laws of mathematics and chemistry. The Utopian may shrink from the contemplation of a subject so painful; the moralist may raise his voice against the justice of war; but the practical philosopher can see very little chance of its cessation, and, actuated by the very best intentions, he will endeavour to render warfare as terrible as possible, well knowing that so soon as certain death awaits two rival armies, princes must fight their own battles, or wars must cease.
Amongst the many improvements in the art of war, those relating to missile weapons, by which men are slaughtered at a distance, afford the greatest scope for scientific investigation; and are of the greatest interest to general readers.

Such being the state of public feeling on this topic, I purpose giving an account of military projectiles in general, and especially those which are urged by the ignition of explosive compounds.

It would be impossible justly to appreciate the value of explosive compounds in their particular application to the launching of projectiles, without devoting some attention to the means and appliances generally employed anterior to the period of their introduction. I intend, therefore, to give a slight sketch of the nature and uses of missile weapons; commencing with remote periods, and continuing to the present time. As much as possible, the following remarks will be restrained within the limits which bound the immediate subject; but occasionally those limits will be found not very definite, and the reader will be obliged to follow me into the stream of general history; to speculate on the moral consequences of improved systems of war; to notice varieties of defensive as well as offensive arms; to describe occasionally the manufacture of warlike implements; more particularly those to which present interest is attached; such as the war rocket and varieties of rifles, mortars,
fuses and shells: all this, and much more of interest, lies so near our prescribed bounds, that I shall not hesitate to avail myself of it, merely because the title of this dissertation may be slightly violated thereby.

Man's first rude attempts at missile weapons were doubtless limited to the throwing of sticks and stones, by the mere aid of his hands; acts in which the monkey, the bear, the elephant, and even the seal, are very successful emulators. A desire of more successful aggression doubtless soon suggested to man the use of projectiles more efficient than these. By a very slight change of form, the simple stick would become a javelin, capable of being hurled with great force, and precision. An aid would suggest itself for casting a stone by means of a fillet, or band, subsequently denominated the sling. Lastly, as involving a little more of mechanical contrivance, would be invented the bow; which, in process of time, by subsequent additions, would become the arbalesst, or cross-bow.

By the time portable weapons would have been brought to the perfection just indicated, man's increasing science and civilisation, would have led him to build cities, and inclose them with walls. Then would arise a necessity for other projectiles of greater force, inasmuch as in the event of war, such walls would have to be demolished. The transition from portable projectiles to those of a heavier class was
obvious enough; enormous javelins, and darts, were hurled by cross-bows of corresponding size, termed catapultae; and engines having the sling for their function,* and hurling enormous stones, were termed balistae.

This appears to be the proper distinction between the two terms; although, by many persons, they are spoken of as synonymous. A great number of warlike missile engines were in use besides these, and called by the most fanciful names; however, the balista, and catapult, may be considered as the types of all the rest; except, indeed, those which were adapted to particular localities, or extraordinary occasions; when the number and variety of engines were only limited by the engineer’s constructive skill.

In prosecuting this subject, I shall first describe the various portable missive weapons which have been used in different nations; and then enter upon the consideration of those of a larger class; such as would now be denominated "artillery:"—a word, by the way, which originally signified "archery."

The first missive weapon to be noticed in detail is the JAVELIN, or dart, variously modified, and known under several names.

The ancients were well acquainted with this weapon. In the Scriptures we have frequent notice

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* Though the cross-bow for their model.
of it; and every one is aware how extensive was its employment by Homer's heroes. In order to perfect the practice of this weapon, the ancients instituted javelin matches, constituting a part of what the Romans called their "jaculations." According to Plato,* there were two sorts of jaculations; the first he called τοξικη, and the latter ακοντίσμα; the Romans translated the first word by "sagittatio," and the second by "jaculatio." The latter would appear to refer solely to the throwing of javelins; the former term having reference to the action of a bow. It would appear that the javelin used on horseback was about five feet and a half long, and the steel with which it was headed was usually three-sided; but sometimes round. In order to launch it with greater force, it was propelled by the unaided arm, but by the assistance of a thong fastened to its butt end.

Such was the javelin employed by the Greeks and Romans on horseback, and for the most part in their games; but the Roman infantry possessed a much more efficient weapon of the javelin kind, termed "pilum." Of these weapons every man of the legionary soldiers carried two, which he hurled against an enemy in the charge. Polybius mentions that the point of this weapon being very long and small, was usually so bent at the first discharge as to be rendered useless

* De Leg., 1. viii.
afterwards. This was not an imperfection, but a necessary quality, lest the enemy might use it in his turn. Accordingly, we find that Marius was considered to have greatly improved this instrument, when, during the Cimbrian war, he so fashioned it, that on striking the enemy's shield, it bent down at an angle in the part where the wood and iron were joined, thus becoming totally useless to the party who received it.

With every improvement of which the javelin was susceptible, it never could acquire a long range; consequently we find that as archery became developed, the use of this weapon declined. Even at the present time, however, the javelin termed "djereed" is used with considerable effect by certain oriental nations; who invariably employ it on horseback. It is totally unadapted, however, to the nature of regular combinations, and systematic attack.

Amongst savage nations, the use of the javelin is very common; but the aborigines of Australia have a manner of throwing it altogether peculiar to themselves;—not grasping it in the middle, and throwing it whilst poised at a balance, but projecting it by means of a stick applied to the butt end. This contrivance accomplishes a great increase of range, but does not contribute to the accuracy of direction. Compared with such projectiles as we are now in the habit of using, the javelin does not appear a very efficient weapon; yet, at short distances, its penetrat-
ing force is considerable, as is learned from the act of harpooning a whale: harpoons being merely javelins thrown by hand.

These few remarks will suffice for the javelin; let us now proceed to treat of another very celebrated missive weapon of antiquity—the Sling.

The force with which a stone can be thrown by the unaided hand is altogether insignificant in a military point of view; several mechanical contrivances suggest themselves, however, for increasing the effect. Amongst the most simple of these is a fillet of leather, or similar substance, broad in the middle, and tapering away towards either end. This is the common sling, which was used in the following manner:—A stone, or bullet, being placed on the broad middle part, the two ends were grasped in the right hand; then the stone being whirled violently around the head, and one end suddenly slipped, the stone flies towards an object with great velocity. The islands Majorca, Minorca, and Ivica were, it is well known, called the “Balearic Isles,” on account of the expertness to which their inhabitants had attained in the use of this weapon. This dexterity they acquired by constant practice; being trained to it from their infancy: their mothers placing their daily food on the top of a pole, and giving them no more than they beat down with stones from their slings. This art is in some measure preserved by the Minor-quin shepherds at the present day. The Romans had
slingers in their armies, for the most part inhabitants of those islands. Diodorus Siculus says that they always carried three slings, one of which they held in their hands, another being tied round their middle, and a third round their head. Such was the violence with which, in battle, they projected their missiles, that the latter seemed as though they were cast by some military engine; and no armour could resist their stroke. In besieging a town, they wounded and drove the garrison from the walls, throwing with such exactitude as rarely to miss their mark.

Slings never appear to have been much used by the English; although Froissart* mentions an instance of their having been used for them by the people of Brittany, in a battle fought in that province during the reign of Philip de Valois, between the troops of Walter de Mauni, an English knight, and Louis d'Espagne; who commanded six thousand men, in behalf of Charles de Blois, then competitor with the Earl of Montfort for the duchy of Brittany. Froissart says, that what made Louis lose the battle was, that during the engagement the country people came unexpectedly and assaulted his army with bullets and slings. According to the same author, they were also used in naval combats. Slings were used in 1572, at the siege of Sancerre, by the Huguenots, in order to

* Vol. i. chap. lxxxv. p. 304.
save their powder. D'Aubigné, who reports this fact, says they were thence called "Sancerre harquebuses." With respect to the range of this projectile, it is said that a good slinger would throw a stone 600 yards. This assertion, however, seems very doubtful.

The Bow.—This weapon, under some shape or other, was employed by most nations of antiquity, but not always as a warlike instrument. Scarcely any two nations have made their bows exactly alike. The Scythian bow, we are told, was very much curved, as are the Turkish, Persian, and Chinese bows, at the present day; whilst the celebrated weapon of our ancestors, when unstrung, was nearly straight. All these bows, however, belong to the same class, being bent, and discharged by the hand alone, without the aid of machinery. In process of time a modification of the bow was invented: in place of the original instrument, a much shorter and stiffer bow, usually of steel, was placed transversely in a stock, bent by a lever, and discharged by a trigger, after the manner of a gun. Bows of the former type were called "long-bows," whereas the latter were denominated "cross-bows."

It is neither my intention to give an elaborate history of the bow, nor attempt to describe the many varieties of it which antiquarian research has disclosed. I shall, therefore, do little more than advert to the bows and archery of ancient times, and distant nations;
devoting my chief attention to the development of this instrument in our own land. We frequently read of the bow in Scripture. The first passage in which the use of the bow is inferred is Genesis xxii. 20, where it is said of Ishmael, "And God was with the lad, and he grew, and dwelt in the wilderness, and became an archer." The overthrow of Saul was particularly owing to the Philistine archers. (1 Sam. xxxi. 3.) David, too, who succeeded him, bade them teach the children of Judah the use of the bow: "Behold it is written in the book of Jasher." (2 Sam. i. 18.)

The Greeks ascribed the invention of the bow to Apollo, by whom its use was communicated to the inhabitants of Crete; hence, in later ages, the Cretan archers were thought superior to all others. Some, however, ascribed the invention to Perses, son of Perseus; others to Scythes, the son of Jupiter, the progenitor of the Scythians. All these tales show the antiquity of the instrument.*

The Grecian bows were usually made of wood, but sometimes of horn, and frequently, in either case, beautifully ornamented with gold and silver; the string was generally made of horse-hair, but sometimes of twisted hide, as we read of in Homer; whence the appellation τοξαβυτια. That part of the bow to which

* See Potter's Arch. Graec.
the string was fastened, the upper part, was called κορώνη, being commonly made of gold; and was the last thing towards finishing the bow.

The bow was not drawn in the same way by every nation. The ancient Persians* drew the string towards their ear, as is the practice still with the English. The ancient Greeks, however, drew the bow-string towards the breast, and represented the fabled Amazons as doing the same. Every one is conversant with the tradition of these women cutting off the right breast in order to give facility to drawing the bow.

Until the second Punic war the Romans had no archers in their armies, except those which came with their auxiliary forces.† Subsequently bows and arrows were more employed by this people; although, so far as we can learn, not by native troops, but by orientals in Roman pay.

During the reign of Clovis, who died 514, the French in their armies made no use of the bow, but it was employed during the reign of Charlemagne, who flourished in the beginning of the eighth century. This is undoubted, as, in an article of the Capitularies of that king, a count is mentioned who was directed, on conducting soldiers to the army, to see they had their proper arms—that is, a lance, a buckler, a bow, two strings, and twelve arrows.‡

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* Procopius, De Bello Persico. † Potter, ut suprâ. ‡ P. Daniel.
I shall not trace the progress of foreign archery any further, but come to the consideration of our own. It is certain that both Anglo-Saxons and Danes were well acquainted with the use of the bow; an art which they derived, without doubt, from Scandinavia. In the account of the games of the heroes of that country, given by the Scalds, or Scandinavian poets, archery is frequently mentioned. It would appear, however, that both Anglo-Saxons and Danes used the bow rather as an instrument of amusement or the chase, than a warlike weapon; and for its latter application we are indebted to the conquests of the Normans. In an ancient manuscript* of the tenth century, there is represented a Saxon bow, from which it appears that its construction was not at all adapted to render it a military weapon, the string not being fastened to the extremities, but suffered to play at some distance from them. Moreover, its size was altogether that of a mere toy.† There is very little doubt that the bow, as a military weapon, was introduced by the Normans at the battle of Hastings; we know that Harold was shot by an arrow. No mention, however, is made of archers on the side of the Saxons.

Although we know that archers tended very materially to secure to the Normans this memorable battle,

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* MS. Cott. Claud., B. iv.
† Strutt's Sports and Pastimes, p. 39.
history has not yet determined whether they used the long-bow or the arbailest; otherwise called cross-bow. Grose, in his "Military Antiquities," states the former; general testimony, however, is in favour of the latter; and there seems collateral evidence to the same effect. We find that the English, at subsequent periods, greatly preferred the use of the long-bow, so that it was considered as a national weapon; while the cross-bow was much more employed in France. Now, we may easily fancy the English gradually perfecting the old Saxon instrument, and developing from it the long-bow, whilst they would be disinclined to use a weapon introduced by the Normans; against whom there long remained an unconquerable aversion.

The exact time when shooting with the long-bow commenced, is uncertain, but its use was much extended about 1139, owing to a curious circumstance. The second Lateran Council* forbade, under the penalty of an anathema, the use of the arbailest, or cross-bow, as hateful to God, and unfit to be employed among Christians. Pope Innocent III. confirmed this prohibition. The reason of this strange decree seems to be the dangerous and painful wounds caused by this weapon; but it would require the united genius of many popes to discover agreeable methods of putting soldiers hors

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* "Artem illam mortiferam et Deo odibilem balistrariorum et sagittariorum, adversas Christianos et Catholicos exerceri de caetero sub anathemate prohibemus."—Can. 29.
de combat. This prohibition was observed under the reign of Louis the Young, and in the beginning of that of Philippe Auguste; but afterwards no regard was paid to it, either in France or in England. Richard I., despite Innocent's injunctions, introduced the cross-bow into our armies, and being subsequently killed by an arrow-shot from one of them at the siege of the Castle of Chaluz, in Normandy, his death was considered as a judgment from heaven, inflicted on him for his impiety. Notwithstanding this example, the cross-bow still continued to be much used by English troops, and in the list of the forces raised by Edward II. against the Scots, cross-bowmen are enumerated.

Although we know the cross-bow to have been used in the reign of Edward II., yet it would appear that about this time the use of the long-bow became extended; at least, we now begin to find the word "sagittarius" (an archer), whereas he who shot with a cross-bow was termed "balistrarius." Not only were long-bows employed as well as cross-bows against the Scots, in 1323, but also in the next year, by the army sent to the relief of Aquitain. It would seem that the arbalest and the long-bow had only to be used together in order to prove the vast superiority of the latter, for its extension now rapidly increased, and in the reign of Edward III. the glory of this weapon was in its zenith. This monarch appears to have taken great
pains to increase its efficiency and extend its use. In 1342, the sheriffs of most counties in England were ordered to provide 500 white bows, and as many bundles of arrows, for the intended war against France. Subsequently to this, the king again sent to the sheriffs, complaining that the practice of archery was too much neglected by the people, who, instead of shooting on Sundays and holidays as heretofore, were in the habit of amusing themselves with various unlawful games. The terrible execution effected by the English archers at the battle of Crécy, in 1346, is well known; and in this instance the peculiar genius of the weapon, and its superiority over the arbalest, were well displayed. Previously to the battle, there fell a shower of rain, which so slackened the strings of the cross-bows used by a troop of Genoese in the French pay, that the weapons became almost unserviceable; whereas the English long-bows, which had been encased during the shower, were perfectly effective. It is obvious that the very shape of the cross-bow would prevent its being surrounded by a case; and here, as in many other instances, the long-bow had a decided advantage.

Ten years after this occurred the battle of Poictiers, which was also won by the skill of our archers. The decisive victory of Homeldon against the Scots, in 1402, was entirely achieved by them; and the Earl of Douglas found that the English arrows were so swift,
and so strong, and discharged so forcibly, that no armour could repel them; his was of the most perfect temper, and yet he was wounded in five places. The English men-at-arms, knights, and squires, never drew sword or couched the lance, the whole affair being decided by the archers. The archers again did terrible execution at the battle of Shrewsbury, in 1403, where Hotspur was slain; and the battle of Agincourt, in 1417, was their undivided conquest. So many victories accomplished by the employment of our favourite weapon, would, it might be supposed, have induced the enemy to imitate us; nevertheless, this does not seem to have been the case; the French pertinaciously adhering to the employment of the arbalest; for which reason, Henry V., as Duke of Normandy, confirmed the charters and privileges of the "Balistrarii," who had been long established as a society at Rouen. When we come to consider the long training, strength, and address necessary to constitute a successful archer, we need not wonder that the practice of the long-bow was not more copied by our neighbours. How severe this training was, may be gathered from certain statutes made long subsequently to the periods we have just spoken of, in the reign of Henry VIII., when portable fire-arms had been some time introduced, and when the practice of archery had in consequence somewhat declined. Henry VII., it should be premised, altogether pro-
hibited the use of the cross-bow,* although he did not hesitate to use it himself for the purpose of shooting for wagers; this prohibition might have been effectual at the time, but it was not permanently so, as we may learn from the fact that Henry VIII., less than twenty years afterwards, renewed the prohibition. He forbade the use of cross-bows and hand-guns, and passed a statute which inflicted a fine of £10 for keeping a cross-bow in the house.† Now followed a complaint from the bowyers, the fletchers (or arrow makers), the stringers, and the arrow-head makers, stating that many unlawful games were practised in the open fields, to the detriment of public morals and the great decay of archery. Those games were therefore strictly forbidden by parliament; and then followed a third act, which obliged every man, being the king’s subject, to exercise himself in shooting with the long-bow, and also to keep a bow with arrows continually in his house. Fathers, and guardians, were also commanded to teach their male children the use of the long-bow, and to have at all times bows provided for them, as soon as they arrived at the age of seven years. In connection with this compulsory shooting at marks, we must notice the following remarkable proviso:— “In case any person should be wounded or slain in these sports with an arrow shot by one or other of the

* Stat. 29 Hen. VII., A.D. 1508.
archers, he that shot the arrow was not to be sued or molested, if he had, immediately before the discharge of the weapon, cried out 'Fast.'"* These statutes will show how necessary to the formation of an expert archer constant exercise in the use of these weapons was regarded.

Hereafter, when I shall treat of fire-arms, it will be found that in the reign of Henry VIII. they had arrived at no considerable perfection; yet the long-bow was still the favourite weapon. Indeed, much later, in the reign of Elizabeth, the musket was so unwieldy, and slow to charge, and discharge, that the bow was considered superior by many.† By this time, the prohibition of Henry VIII. against the use of the cross-bow had been forgotten, or was disregarded, for we find that in the year 1572, Queen Elizabeth, in a treaty with Charles IX. of France, engaged to furnish him with 6,000 men, part of them armed with long-bows, and part with cross-bows; and in the attack made by the English on the Isle of Ré, in 1627, it is said some cross-bowmen were in the army, since which period they have been entirely laid aside, except for amusement.‡ The last time the legislature interfered

† Toxophilus; or, the Schole of Shooting.
‡ The long-bow, however, continued in use until a later period: in 1643, a company of archers was raised for the service of Charles I., and the Marquis of Montrose employed archers against the Scots.—Grose, Mil. Antiq.
for the protection of archery, was in 1633, when Charles I. issued a commission for preventing the fields near London being so inclosed "as to interrupt the necessary and profitable exercise of shooting." There have not been wanting, however, in later times, advocates for the occasional use of the long-bow, in preference to the musket, and although the reasons adduced have some weight, they are greatly influenced by the prejudices of the writers. It is true that arrows can be shot from a long-bow with far greater rapidity than balls from a musket, even with all the newest improvements: the flight of an arrow, too, is visible, whereas that of a ball is not; these two circumstances are in favour of archery. It has been maintained, also, that arrow wounds are more dangerous than those produced by ball, which to me appears, I confess, a very doubtful proposition. It has been argued that, out of an equal number of arrows and balls, more of the former will hit the mark; a statement which was indeed probable, owing to the very unskilful manner in which the firing of musketry was usually conducted. An archer would be exposed to ridicule if he shot very wide of the mark; not so formerly the musketeer, whilst plain brown Bess was the fire-arm. To this extent the advantages are on the side of archery; but let us now consider the disadvantages. In damp weather, the bow and bowstring were so much relaxed, that the efficiency of the instrument became very much impaired.
A side wind deflected the arrow exceedingly in its flight, and against even a moderate wind it was difficult to shoot at all. In these respects the musket is as superior to the cross-bow as the latter is to the long-bow. We need not, however, endeavour to settle this point on theoretical grounds, there being on record the particulars of a battle, in which muskets were opposed to bows, and the result was decidedly in favour of the former. I allude to the battle of Lepanto, fought between the Venetians and the Turks, in 1571, a detailed account of which is given by Paruta, the Venetian historian, who states that one chief reason why so few Christians were killed in comparison with the Turks, was because the latter used for the most part bows and arrows, whereas the former were supplied with muskets. True, the archers in this case were not English but Turks; these people, however, used the bow exceedingly well, perhaps just as well as our own ancestors.

Having thus far traced the history of the bow, I purpose giving a short account of its range and powers. Unquestionably, the longest arrow-shot concerning which we have any testimony, is that mentioned in Sir J. Malcolm’s "Sketches of Persia." * The story was originally told by Firdousi, the Homer of Persia, and has been repeated by many historians of good

repute. In ancient times (so goes the tale), when Mensocheher, the grandson of Feridoon, made peace with Afrasial, the Scythian invader, one of the articles of the treaty was, that Persia should have all the country to the north-east, over which an arrow could be shot from Demavend. A hero, named Arish, ascended to the top of the mountain, and shot an arrow to the banks of the Oxus, a distance of between five and six hundred miles. One Persian author, in relating this fact, states that the arrow, which was discharged at sunrise, did not fall until noon! and another author of high reputation informs us that the festival of the arrow, on the 13th of October, which is still kept by the followers of Zoroaster, is in consequence of this event. Neither historian states from what kind of bow this was shot; the general tenor of the story would seem to indicate the "long-bow." The English archers, justly celebrated as they were for the long range and precision of their shots, could not accomplish more than 600 yards—at least, except on a few extraordinary occasions. The greatest range which our modern English archers can accomplish is from 300 to 500 yards. The Turkish ambassador, when in England in 1795, sent an arrow upwards of 480 yards, in the presence of several members of the Toxopholite Society.* His bow was made of horn,

* The Turkish ambassador's secretary said that the (then)
and is still in their possession. This was considered a very long shot; yet there are two or three on record, as occurring since archery has been merely a pastime, which have exceeded it by twenty or thirty yards.*

With regard to extraordinary feats of correct aim, history affords us several instances. The story of Astor of Amphipolis and Philip is well known, but savours a good deal of the improbable. The reputed feats of Domitian in archery are more worthy our credence. He would frequently, it is said, cause one of his slaves to stand at a great distance, with his hand spread as a mark, and would shoot his arrows so correctly, as to drive them between his fingers. Commodus, too, was a very expert archer, and with an arrow headed with a semicircular cutting edge, he could sever the neck of a bird. The story of William Tell is known to every one, and generally regarded in the sense of an historical fact: this, however, does not seem likely to be the case, there being many reasons

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present Grand Sultan shoots 500 yards, which is the greatest performance of the modern Turks; but that pillars stand on a plain near Constantinople commemorating ancient distances, about 600 yards. (Mem. Mr. Jones at Mr. Waring's, an. 1796.) —Banks. *MS. Mus. Brit.*

* There is a tradition, that an attorney of Wigan, in Lancashire, shot a mile in three flights. By 33 Hen. VIII., no one aged twenty-four is to shoot at any mark under eleven score yards.
to suppose that his historian borrowed the tale from a Danish story related by Saxo-Grammaticus, who wrote in the twelfth century. This very feat he states to have been performed by *Toko*, a Dane.* The bow of Tell must have been a cross-bow.

In illustration of this subject, I shall be pardoned for making a pretty long extract from Garrick's collection of old plays, where there are found two legends relative to the skill of English archers. The first is related in a ballad of eight fyttes or parts, entitled "A Merry Geste of Robin Hode." According to the story, the king (Edward IV.) disguised himself as an abbot, and paid Robin a visit. The outlaw, by way of entertainment, proposed a shooting match. He set up two wands, but so far removed from each other, that the king made some objections; but I will quote parts of the ballad:—

"By fifty space our kynge sayde
The markes were too longe.
On every syde a rose garlande
The shot under the lyne.
Whoso faileth of the rose garlande, said Robyn,
His takyll he shall tyne, †
And yelde it to his maister
Be it never so fine.
Twyse Robyn shot about,
And ever he cleved the wande."

* Tales and Popular Fictions, &c., by Thomas Keightley, 1834.
† *i.e.*, shall lose it.
Little John, Scathelocke, and Gilbert did the same; but

"At the last shot that Robyn shot
For all his frendes fore,
Yet he sayled of the garland
Three fyngers and more."

Of course he forfeited his "takyll," which he consequently presented to the disguised king.

The second ballad refers to Adam Bell, Clym of the Cloughe, and William Cloudesdale; archers as celebrated in the northern, as Robin Hood was in the midland counties. The king is represented in company with these worthies, and the royal archers having set up the marks, Cloudesdale censured them, saying,

"I hold him never as good archer
That shoteth at buttes so wide;"

and having procured two "hasell roddes," he set them up, at the distance of four hundred yards from each other; his first attempt at shooting at them, contrary to the king's expectations, was successful, for it is said,

"Cloudesdale with a bearyng arrowe
Clave the wand in two."

The king was naturally much surprised at this exercise of skill, and told him he was the best archer he had ever seen. The brigand on this said he would show him a still more extraordinary proof of his talent, and tying his eldest son, a child of seven years old, to a stake, and placing an apple on his head, he retired
one hundred and twenty paces from the child's back, and having cautioned the spectators to be silent, and his son to stand still,

"He then drewe out a faye brode arrowe,
His bowe was greate and longe;
He sette that arrowe in his bowe,
That was both styffe and stronge.

"Then Cloudesdale cleft the apple in two,
As many a man might se,
Over Gods forbode!* sayde the king,
That thou shode shote at me!"

These quotations are not made with the view of their being received as undoubted historical records; but popular traditions are nevertheless valuable in giving breadth, and tone, to undisputed facts of a similar nature. Had these tales been egregiously beyond the limits of probability, they could scarcely have succeeded as popular ballads intended for the age in which they were made. Indeed, history would seem rather to strengthen the probability of the skilful archery just mentioned. Carew, speaking of the skill of the Cornish archers† two centuries back, says, "For long shooting, their shaft was a cloth yard in length, and their prickes twenty-four score paces (equal to 480 yards), and for strength they would pierce any ordinary armour; and one Robert Arundell, whom I well knew, could shoot twelve score paces with his right hand, with his left, and from behind his head."

* God forbid!  † Survey of Cornwall, 1602.
Another anecdote of the skill of the Cornish archers is related in the Life of Henry VIII. by Hall. "There came to his grace (the king) a certayn man with a bowe and arrowe, and he desired his grace to take the muster of hym and to see him shoote; for that tyme his grace was contented; the man put hys one fote in his bosome and so dyd shoote, and shote a very good shote, and well towards hys marke; whereof not onely his grace, but all others greatly merveyled; so the kynge gave him a rewarde: and for this curious feate he afterwards obtained the bye-name of Fote in Bosome."

The bow having become at this time a mere toy, it would be highly interesting to know the amount of force with which our renowned archers could formerly hit an object at a given distance. A journal of King Edward VI. partly supplies us with this information. His Majesty relates that 100 archers of his guard shot before him two arrows, and afterwards altogether. The object aimed at was a well-seasoned deal board, an inch in thickness: many arrows pierced it quite through, and some stuck in another board on the other side. Unfortunately, the distance is not mentioned; but we know that Henry VIII. prohibited any one above the age of twenty-four years to shoot at a mark at a less distance than 220 yards,* and we

* 33 Henry VIII.
may presume that professed archers, on such an occa-
sion as a trial of skill in presence of their king, would
shoot at a much longer distance than the legal mini-
mum.

It might be imagined that the cross-bow, bent as
it was by the aid of machinery, would be capable of
projecting an arrow further than the long-bow; such,
however, does not seem to have been the case. Ac-
cording to Sir John Smith,* a cross-bow would kill
point blank between forty and sixty yards, and, if
elevated, six, seven, or eight score yards, and even
farther. Mons. William de Bellay† gives the cross-
bow a still greater range, and says, that if archers and
cross-bowmen could carry about their provisions for
their bows and cross-bows as easily as harquebusiers
do for their harquebus, he would prefer the former
weapon over the latter. He states, moreover, that
cross-bowmen and archers would kill at 100 or 200
paces, as surely as the best harquebusier. On the
whole, it appears that the cross-bow was more certain
of hitting a mark than the long-bow, but could not be
shot with such rapidity, nor would it throw so far.
Cross-bows not only shot arrows, but also darts, called
"quarrels" or "carreaux," from their heads, which were
square pyramids of iron. They also shot stones and

* Instructions and Observations, &c., p. 204.
† Instructions for the Wars, 1569.
bullets. There were two sorts of cross-bows used in the English service, one called latches, and the other prods. The Genoese were most expert in the use of this weapon.

Both archers and cross-bowmen were liable to be greatly annoyed by the attack of cavalry. For the purpose of defending themselves under these circumstances, they were supplied with sharp stakes, which they planted in the ground, and presented to the advancing troops, after the plan of the modern bayonet. Very late, indeed, in the annals of archery, in the reign of Charles I., an individual called Neade developed an exercise—a weapon combining bow and pike. The evolutions were witnessed by the king, in St. James's Park; were approved by him, and ordered to be taught throughout England; but political storms would appear to have prevented the execution of this mandate.* For the amusement of the curious, the words of command for this exercise are appended:—†

<table>
<thead>
<tr>
<th>Order your pike.</th>
<th>Nock your arrow.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slope your pike.</td>
<td>Shoot wholly together.</td>
</tr>
<tr>
<td>Unfasten your bow.</td>
<td>Port your pike and march.</td>
</tr>
<tr>
<td>Draw out your arrow.</td>
<td>Port your pike and retire.</td>
</tr>
<tr>
<td>Fasten your bow.</td>
<td>Charge your pike.</td>
</tr>
<tr>
<td>Recover your pike.</td>
<td>Recover your pike.</td>
</tr>
<tr>
<td>Advance your pike.</td>
<td>Shoulder your pike and march.</td>
</tr>
<tr>
<td>Come up to your close order.</td>
<td>Comport your pike and march.</td>
</tr>
</tbody>
</table>

* The description of this exercise was printed in 1633, under the title of "The Double-armed Man."

† This combination shows how stiff an archer's bow must have been.
AND EXPLOSIVE COMPOUNDS.

Other testimony, indirect but authentic, may be adduced to show the great power of the long-bow. I have before me a treatise on military surgery, by William Clowes, Surgeon to Queen Elizabeth.* In this book is related a case of injury from an arrow, which demonstrates the force with which the weapon was imbedded in the thigh bone, and the great difficulty experienced in extracting it. I shall make no apology for quoting this narrative, which is doubly interesting, showing as it does how a rude and empirical practice of surgery must have added to the danger of wounds in those days.

"The cure of a servingman, which was shot into the leg with a sheafe arrow, and the head sticking in the bone.

"A few yeares past, at a great mustering and training up of souldiers, at Pile End Greene, neere London: amongst those bands of trained men there was appointed a certain number of archers: who after they had marched a long time, in the end the bow-men were divided from the pike-men, and shot onely

* "A profitable and necessarie booke of observations for all those that are burned with the flame of gunpowder, &c., and also for curing of wounds made with musket, and caliver shot, and other weapons of warre commonly used at this day both by sea and land, as hereafter shall be declared. With an addition of most approved remedies, gathered for the good and comfort of many out of divers learned men, both old and new writers."—4to, 1637. Black letter.
to trie and exercise their bowes: it chanced in their shooting at a marke, about sixe or seven score off, by misfortune one of their arrowes did hit a gentleman's servant called Master Withipole into the outside of his left legge, so that the shaft was firmly fixed in the bone, yet being a good way off beyond the marke when he received this hurt." The italics are mine, not the author's. Here, then, is an instance of an arrow being imbedded in the leg bone (with what firmness we shall hereafter see), at a distance a good way beyond a hundred and forty yards. Let us now resume the quotation. "There was at that time one in the field which professed surgerie, and proffered to dress the wounde, presently in the place where the patient was hurt: hee being in great paines, was glad of any helpe, and so permitted the fellow to dresse him, who forthwith did attempt to take out the arrowe, nothing regarding the renting or tearing of the muscles, but ouer-hastily, and unadvisedly did pull out the shaft, and left the arrowe-head fast fastened in the bone, being a barbed head, 'as are commonly all our English sheafe arrows.' After, willingly he would have excuses the matter, and seemed to say, that the head was ill glued or fastened to the arrowe, and so he dressed the patient, to his friends' great disliking, for that the patient was immediately troubled, and molested with a hot distempera-
ture, much pains, and innumerable swellings, which
induced a feuer, and his stomacke clean taken from the meate. Then it was the will and pleasure of one Master Spinola, in Fenchurch Street, where I did dwell, to send for me, and there I found the surgeon, but his patient being in extreme paines: wherefore in my presence, for that they would be rid of this fellow, they said they were greatly aggrieved with him, and told him that he had stained his practice in preserving and dressing the patient so ill, and that his abuse was great, and deserved punishment. Then he went about to blear their eyes with a little beggarly eloquence, the which he had learned amongst a sort of treacherous runagates, counterfeit land-lopers, sophisticated mounty-banks, cosing quacksaluers, and such like false ings-ling deceiuers, with their paradoxical innovations, whose native soile is to them a wilde cat, and who abuse all good artes wheresoeuer they come or abide. But to auert circumstances, I say, he vanished awaye in darkness, as may appeare in my former bookes, where I have more at large spoken of him and other the like abusers, whose bloudy hands, without knowledge, doe hazard the lives of many.” Mr. Clowes, having thus abused his rival pretty copiously, yields to the torrent of his emotions, and rejoicing in his superiority over the other practitioner, favours us with no less than four stanzas of poetry, in glorification of himself and depreciation of his rival. I shall take the liberty of omitting this effusion, and see what our
surgeon does to extract the weapon. "I did put downe a probe," says he, "into the bottome of the wound, where manifestly I did seele the head fixed in the bone, and by reason the orifice of the wound was so straight and swolne, that I could not dilate any instrument sufficiently to apprehend and take hold of the arrowe-head, therefore I was driuen to make reasonable large incision down to the bottome, and then did put into the place of my incision a dilatorium, to open the wound, and so presently took hold of the arrowe-head with a 'rostrum gruinum,' and then moved it by little and little, so very gently with safety I tooke out the arrowe-head." He then details the progress of the case to its result, which was favourable, and proves that, for those days, he was a very accomplished surgeon.

I have given the foregoing description thus in detail, as throwing much light upon an interesting subject: amongst other things, it mentions a peculiarity of the English sheaf arrow. Antiquarians have made inquiries relative to the difference between, "flight arrows" and "sheaf arrows." The latter are known to have been the shorter and heavier of the two, adapted for the purposes of war; whereas the former were longer and lighter, employed for shooting at a mark. Clowes gives us a further amount of information: he tells us that the English sheaf arrow was usually forked.
AND EXPLOSIVE COMPOUNDS.

The old writer Giraldus Cambrensis relates instances of the force with which an arrow may be shot, much more extraordinary than anything I have yet mentioned on the same subject. He says that some archers belonging to the Venta, a warlike tribe of Wales, shot at the oak doors of a portal, behind which certain soldiers had concealed themselves.* These doors were no less than four fingers in thickness, yet the arrows penetrated quite through. It is related also by William de Breusa, according to the same author, that, in a battle at which he was present, a Welshman having directed an arrow at a horse soldier, who was clad in armour, and had his leather coat underneath, the arrow pierced the man through the hip, penetrated the saddle, and mortally wounded the horse. Another Welsh soldier pinned a man through the hip to the saddle in a similar way, and with this addition, the man feeling the wound, pulled the bridle and turned about, when immediately he received a second shaft in the other hip, which fastened him to the saddle on that side also, in such a manner that he could not stir.†

* Temp. Hen. II.

Those who wish for further information on the power of the bow, may refer to Froissart's Chronicles, Ascham's Toxophilus, the various treatises on war of Sir J. Smyth, Knt., Philip de Commie on archery (temp. Hen. VI.), Markham's Art of Archery, and The Banksian MS. on the same subject.
ANCIENT ARTILLERY.

The term "artillery," as formerly applied, had a very different signification from that which we now assign to it; the word being pretty nearly synonymous with "archery." In the present instance, however, I do not intend employing it in that sense; I mean it to comprehend a list of those larger machines of projectile warfare which were used in place of the modern cannon.

No sooner did the spread of civilisation cause men to assemble in communities, and prosecute the arts which are inseparable from such a condition, than increasing wealth began to incite the cupidity of the civilised races. Towns were now built, and surrounded with lofty walls; to attack which engines of great size and power were necessary. Great as is the increase of power conferred, by gunpowder, to the modern artilleryman, and wonderful as is the precision to which artillery practice is now brought, it must be confessed that a higher order of genius was necessary to the ancient engineer. To him the whole region of mechanical science was an open field on which he might exercise his constructive skill; levers, pulleys,
and springs might be employed in thousands of varying arrangements; forming collectively engines of terrific force; whereas the modern engineer, so far as regards the formation and use of weapons, is restrained within very narrow limits; to employ, in short, the explosive force of gunpowder, either in a tube for the purpose of projecting a ball, in a tube which may be itself repelled, in a shell, or in a mine. So great is the force of gunpowder, and so constantly are our ideas associated with the fact of its being now solely employed to project large bodies, for the purpose of battering down walls, that on rising from the contemplation, we begin to wonder that any other agent could have been capable of similar effects. One circumstance usually escapes our notice,—that the momentum of a projectile, or the force with which it impinges upon an object, is equal to its weight multiplied by its velocity. True, the ancient engines of war could not project a mass with the same velocity as a cannon projects a ball; but then those masses were so much larger and heavier than any cannon-ball, that the comparatively small initial velocity was compensated for.

The structure of fortifications, and that of offensive engines, must mutually influence each other. In ancient times, before the invention of fire-arms, the strength of cities depended on the height of their walls: now, this would constitute a weakness; whilst, on the
other hand, our modern, low, fortified walls, would have been no defence against the ancient mode of attack.

As I have already remarked, the forms of ancient engines of war were very many, differing according to the taste or constructive skill of the architect: they may, however, be included in the following classes:—

1. Catapultæ, or engines for projecting stones.
2. Balistaæ, or instruments for projecting beams and darts.
3. The battering ram.
4. Towers of war, from which projectile weapons were thrown.*

The Catapult.—So easily is the common bow

* The chief engines of war of the ancient Greeks and Romans were the aries, catapult, balista, and onager, slightly altered in shape, occasionally—without doubt, in order to accommodate them to particular services. These machines remained in vogue until considerably after the discovery of gunpowder, but designated by a great variety of names. When it is considered that the historians of those periods were monks, totally unacquainted with the details of the art of war, and possessing but a crude knowledge of mechanics—we shall not wonder at this multiplication and confusion of names. The principal military engines of the eleventh and twelfth centuries were, exclusive of the balista, catapulta, onager, aries, and scorpion;—the mangonel, trebuchet, petrary, robinet, mategriffon, bricolle, beugle or bible, espringale, matafunda, ribandequin, engine à verge, and war wolf.

The beugle, or bible, was an engine for throwing large stones, as we learn from an ancient poem:—
made a cross-bow, and so wide are the limits of size within which the cross-bow can be made, that the formation of gigantic engines of this kind was not a very elaborate suggestion to the mind of its first inventor. Thus originated the catapult and the balista, both engines of the cross-bow kind, but employed for different uses—one throwing stones, and the other darts.*

Without diagrams to illustrate the subject, it would be of no great service to describe minutely such accounts of those instruments as have been handed down to us; suffice it to say that, in making those

"Et pierres grans et les pierrières
Et les bibles qui sont trop fières;
Gétent trop manuement."

(From the romance of Claris, in the French king's library, No. 7,584.)

For a detailed account of these engines, see Grose's Military Antiquities, vol. i. p. 382.

* The terms "catapult" and "balista" have been generally confused, by most who have written on the subject. M. Folard, in his Traité de l'Attaque et de la Défence des Places des Anciens, considers that the catapult was the same as the "onager," an instrument of the sling kind. In favour of this opinion he can show no evidence; while, on the other hand, there is authority directly opposed to his statement. The Heronis Ctesibii telefactiva represents it as a cross-bow with two straight arms, the opposed ends of which are respectively imbedded in the cords of a vertical rope: moreover, ancient writers constantly confounded the term "balista" with "catapult," which is another argument in favour of their similarity. In our ancient law Latin, the term catapulta signified a sling.—Grose's Military Antiquities.
enormous cross-bows, a very curious expedient was resorted to in order that an increase of elasticity might be gained. Instead of making the bow out of one piece of substance, it was formed in two parts, each of which was merely a straight arm. To form the machine, each piece, at its mesial extremity, was closely matted in amongst the fibres of a rope; placed vertically, and firmly secured at either end. From this arrangement it is evident that the bow could not be bent without producing great tension of the ropes; thus adding another force to that of the resilient steel. A windlass or capstan was employed to bend these enormous bows; and when bent, the string was secured by a catch, and iron pin. In order to discharge this machine, the pin was suddenly knocked out by the blow of a mallet.

Catapultæ have occasionally been employed in modern warfare. There was one erected at Gibraltar, at the desire of Lord Heathfield, by General Melville. It was for the purpose of throwing stones a little way over the edge of the rock, in a particular place where the Spaniards used to frequent, and where they could not be annoyed by shot or shells.

Of all the machines which were formed on the principle of mere torsion, that called "onager" is the best known, and may be regarded as typical of many others. Its force entirely depended upon the torsion of a short thick rope acting upon a lever,
which described an arc of a vertical circle. Its construction may be very well illustrated by the common toy of a *jumping frog* or *mouse*. Most people have seen these little articles of amusement, and to such, a description is unnecessary; for others, however, who have not seen them, the following statement will be intelligible. The tail of the animal is a flat piece of wood inbedded in a short twisted rope, in such a manner that the end of the tail projects naturally in a horizontal position, from the body of the animal. Under the body is a lump of wax, to which the tail, bent forcibly down, is attached, and the instrument placed flat upon the ground. Gradually the tail separates from the wax with a sudden spring, and the animal is projected upwards, and forwards. The "onager" was a machine formed, then, on exactly similar principles; the lever had attached to its free extremity a sling; or sometimes it merely terminated in a spoon-shaped cavity; when bent back, it was secured by a catch, or trigger, and charged with a stone. On starting the catch, or trigger, by a sudden blow with a mallet, the lever described its arc of a circle, with great velocity, and projected the stone to a considerable distance.

The Battering Ram.—Of all the ancient projectile weapons, none were so efficacious, none have retained their celebrity so long, as the battering ram. Strictly speaking, it was not a projectile weapon, in the
modern and usual acceptation of the term; literally, however, it comes within the limits of that denomination, and under no circumstances can its description be omitted in a treatise having the objects of the present in view. The enormous size of these celebrated machines, the number of men used in working them, and the magnitude of the effects which they were capable of producing, might well awaken our incredulity, were the facts not attested by abundant evidence, and confirmed by modern experiment. The battering ram consisted of a long pole, or spar, headed with a huge mass of iron or brass, usually shaped like that portion of the animal which confers upon it the distinctive name "ram." The spar was sometimes mounted on wheels, but more frequently suspended by cords from a triangle of stout beams. In either case the intention was to impel it violently forward against an opposing wall; not with a view of its penetrating the mass, or even of dislodging a portion by its immediate shock, but to set up a vibration that, continually repeated, would shake the strongest walls to their foundation, and eventually make them fall.

Originally, the battering ram was probably nothing more than a long beam, which the soldiers carried in their arms, and urged by mere manual force against any obstacle that might oppose itself; the suspension of the beam from a triangle, or the mounting it
AND EXPLOSIVE COMPOUNDS.

upon wheels, were both self-evident suggestions, that required no great amount of constructive ingenuity to appropriate. Vitruvius affirms that the "aries," or ram, in its simplest form, was first used by the Carthaginians when they laid siege to Cadiz; that Pephasmenos, a Tyrian, afterwards contrived to suspend it with ropes, and that finally, Polydas, the Thessalian, mounted it on wheels, at the siege of Byzantium under Philip of Macedon. Pliny, however, states that the ram was used at the siege of Troy; and thus the fable of the wooden horse was allegorical. Some have ascribed the invention to Artemorus, a Greek architect, who flourished 441 years before Christ. Others have imagined that the rams' horns mentioned by Joshua as causing the fall of the walls of Jericho, were merely figurative of this instrument.

The ram was usually of enormous dimensions. According to Plutarch, Marc Antony, in the Parthian war, used a ram of 80 feet long; and Vitruvius states that they were sometimes made 106 and sometimes 120 feet long. We may easily suppose that a great number of men must have been absolutely required to wield so enormous a machine; in fact, a whole century of soldiers was employed for this purpose, and when tired, they were relieved by others, so that the vibrations produced were continuous. Modern writers on artillery have made some interesting calculations relative to the comparative force between the battering
ram and cannon-balls. Dr. Desaguliers* has shown that the momentum of a battering ram 28 inches in diameter, 180 feet long, with a head of cast iron of one and a half tons, the whole ram weighing with its iron hoops 41,112 pounds, and moved by the united strength of 1,000 men, would only be equal to that of a ball of 36 pounds weight shot point blank from a cannon. In this calculation, however, a very important element has been omitted; namely, the size of the impinging extremity of the battering ram, which, if its penetrating effect is to be compared with the penetrating effect of a 36 pound ball, should not be of greater size than the latter. Doubtless, however, it was of greater size, and therefore the momentum of the impinging extremity was diffused over a larger surface: thus the penetrating effect of the instrument would be considerably diminished, whilst its concussing, or vibratory and disintegrating effects would be increased. Now, against the tall walls of ancient fortifications, these latter qualities were far more destructive than mere penetration. If a slate stone be fixed erect on an edge, and struck with a bullet urged by gunpowder, the chances are that the stone will be perforated, but not thrown down; if, however, the bullet be impelled against it by the hand, the stone will certainly not be perforated, but, on the other hand,

* Lectures, vol. i. p. 65.
will most likely fall. The two cases afford a very good illustration of the difference in effect between the modern cannon and the ancient "aries:" the former impels a projectile with great velocity against an object, and penetrates and shatters, without much disturbing the repose of masses, situated near its point of impact; the latter possessed comparatively little penetrating force, but shook the strongest walls to their foundations. Many curious instances might be mentioned of the great effects produced by periodic vibrations; one of the most familiar, perhaps, is the well-known result of marching a regiment of soldiers over a suspension bridge, when the bridge, responsive to the measured step, begins to rise and fall with excessive violence; and if the marching be still continued, most probably separates in two parts. More than one accident has occurred in this way, and has led to the order that soldiers in passing these bridges,* must not march, but simply walk out of time.

Another curious effect of vibration in destroying the cohesion of bodies is the rupture of drinking glasses by certain musical sounds. It is well known that most glass vessels of capacity, when struck, resound with a beautifully clear musical note, of invariable and definite pitch, which may be called the peculiar note of the vessel. Now, if a violin or other musical instrument

* Or bridges of pontoons.
be made to sound the same note, the vessel soon begins to respond, is thrown into vibrations, its note grows louder and louder, and the vessel eventually may break. In order to insure the success of this experiment, the glass should not be perfectly annealed; the tendency to break, however, is invariably the same.

As the peculiar genius of modern artillery lies in perforation, one great quality of the battering ram has, since the introduction of fire-arms, been in great measure lost; engineers now, however, are beginning to see the advantages arising from the use of hollow shot, fired with diminished charges, by which means, large masses are projected with diminished velocity; thus increasing their shattering, but diminishing their penetrating, effects.*

The battering ram, although sometimes used as above described, was more generally employed in connection with a vast tower called "testudo," the nature of which shall now be explained.† It must be premised that the walls of ancient cities were of an amazing altitude, and, therefore, warriors placed on them encountered their opponents at a great advantage. Against such defences as these, soldiers armed

* Probably, as suggested by Mr. Mallet, enormous balls fired at low velocities will be amongst the best means of coping with iron-cased floating batteries.

† The terms Vinea, Pluteus, and Helepolis, were also applied to these towers.
with manual weapons availed but little; except by some means they could gain an elevation which commanded the city walls. This object was accomplished by employing towers of enormous magnitude.* Hero distinguishes three kinds of them; the smallest were, he says, sixty cubits, and five storeys high; the base, which was square, measured on each side sixteen cubits. The larger towers were ninety cubits high, and consisted of fifteen storeys; the greatest, called "double," were of twenty stages, were largest at bottom, and decreased every storey. These towers were supported on wheels of enormous size and strength; six was the number for the smaller towers, and eight for the larger ones. The lower storey was devoted to the battering ram; all the others were filled with archers, and light-armed soldiers generally. These large towers being brought up close to the fortifications, and overlooking them, became very dangerous machines, and consequently many expedients were devised for their destruction. Large excavations were made under the track along which the machine must pass, in such manner that its vast weight, not being supported by the superficial crust, made it sink into the snare. Arrows furnished with com-

* Sometimes, too, by expedients of greater ingenuity. Belisarius conquered Palermo by sailing into the harbours, elevating his boats to the mast head, and from thence assailing the garrison.
bustible materials were shot against it from bows and military engines; to guard against which, the machine was usually covered with raw hides or metal scales; hence the name of "testudo," which eventually the whole engine acquired. If, despite these precautions, it nevertheless succeeded in arriving close up to the city walls, vast stones were thrown upon it;—boiling water, molten lead, hot sand, and in short, every material of annoyance which circumstances or ingenuity enabled to be used, was thrown upon the hapless warriors. Nooses of rope or chain were let down from the walls; and in these the head of the battering ram was entangled. Bags of wool, hurdles of wicker-work, and other soft and yielding materials, were lowered, for the purpose of encountering the blows of the ram, and diminishing their violence. Not unfrequently these measures succeeded; for, unquestionably, in this primitive development of the art of siege, the assailed were more favourably circumstanced than the assailants. If, however, the "testudo" still maintained its ground unscathed, its occupants next threw out a drawbridge* across the chasm, and rushed into the fortification.

Such is a description of the towers used by the ancient Greeks and Romans, as related by Vitruvius, Ammianus Marcellinus, and other writers on these

* Called Exostra.—Vegetius, De Re Militari.
AND EXPLOSIVE COMPOUNDS.

subjects. The towers or belfries of more modern times were never so large; rarely exceeding two or three stages in height. These machines underwent very little, if any, alteration in form down to the period of the discovery of gunpowder. In the dark ages, however, we find them mystified by a great variety of fanciful names, amongst which we may enumerate the "sow," a term frequently applied, in later periods, to those movable towers. This name is said by some to have been derived from the circumstance of the contained soldiers lying closely together, like pigs under a sow; and hence the witty, but not very delicate remark, of a certain countess who defended the castle of Dunbar against King Edward III., in threatening, that unless the Englishmen kept their sow better she would "make her cast her pigs." This circumstance is mentioned by Camden, who also says, "the sow is still used in Ireland." During the siege of Corfe Castle, by the Parliamentarians, they used two machines of the above kind, one named the boar, and the other the sow.

With regard to the power of ancient artillery, it is probable that we cannot have in the present day any very correct notions. Judging, however, from the materials used, and the mode of their application, it must have been very great; although not comparable with that of missiles urged by gunpowder. Athenæus speaks of a catapulta which was only one foot long,
and threw an arrow to the distance of half a mile. Other engines, it is said, could throw javelins from one side of the Danube to the other. Balistae threw great beams of wood, lances of twelve cubits long, and stones that weighed 360lbs. Polybius mentions that balistae were used to throw stones against vessels entering into port. Josephus, too, has related several instances of the power of ancient artillery: he tells us they beat down battlements and corners of towers, and overthrew whole files of soldiers, even to the rear rank. He says that one of Vespasian's rams, which was only ninety feet long, and which was smaller than many Grecian rams, had a head as thick as ten men, and twenty-five horns, each of which was as thick as one man. Its weight was 1,500 talents (171,000lbs. troy). When removed entire, 150 yoke of oxen, or 300 pairs of horses and mules, were required to draw it, and the united strength of 1,500 men was employed in forcing it against the walls. Such are the accounts of effects produced by missile engines employed by the Greeks and Romans; and scarcely less terrible are those related of the same engines or their derivatives, when used in more modern times; although the mechanical skill of the ancients was then in great measure lost. It would seem, however, that our ancestors, in describing the military engines of the dark ages, must have greatly exaggerated the effective range and powers of them; otherwise, many of our ancient castles would
not have been built in situations where they could be commanded by hills at a distance of not more than four, or five, hundred yards; instances of which may be seen in the castle of Dover, once deemed the key of this kingdom; also of Corfe and Guildford. Monsieur Joly de Mezeray says, that the greatest range of a mangonel was five stadia, or 1,042 yards. These machines not only threw large darts and stones, but also the bodies of men and horses, as is mentioned more than once by Froissart.

This account of ancient weapons being merely preliminary to an investigation of the properties and effects of gunpowder, as well as other explosive substances, I shall not go into further details concerning them; but will presently enter upon the other branches of the subject. Interesting as it may be to raise up before our imagination engines of bygone times;—the ponderous ram, battering against the lofty walls of an ancient city; the catapult and balista, hurling their darts and massy fragments; barbed arrows glancing from coats of mail, and encounters of gallant knights and squires bold; we cannot forget that fiction ever and anon weaves her misty web around the records of former deeds where truth should reign supreme. Let us hasten, then, from such dim and dusky periods, to those of later date, when other sciences besides mechanics lent their aid to the perfection of the warlike art. The reader will already
have anticipated that the allusion refers to gunpowder; the most potent aid which chemistry or any other science ever proffered to the grim deity of war.

Between the balista and catapult, and other mechanical agents of war on one part, and gunpowder on the other, there is, however, a connecting link, namely,

**THE GREEK FIRE,**

Concerning which such marvellous accounts have been promulgated. Indefinite and variable as were the terms applied to chemical substances, until comparatively recent periods, it is not wonderful that we have received no credible testimony as to the composition of this celebrated Greek fire: nor, indeed, as to the period of its original discovery. It is pretended by some, that the composition of this substance was known to the Greeks of antiquity; but that we had no precise accounts concerning its use until the period of the Eastern empire. This assertion is, however, very improbable, invented, as would seem, by one of those zealous enthusiasts who assert that, not only were the ancients pre-eminently felicitous in their sculpture, poetry, and other fine arts, but also that they excelled in all branches of scientific acquirements; that the blaze of intellect in those days irradiated the whole domain of human learning; beyond the limits of which reason could not penetrate: in short, that the apparently brilliant results of the inductive process are
a fallacy; that they are merely so many gems known to the ancients—buried amidst the intellectual ruins of the middle ages, and now restored. It is certain enough, that we have no precise mention of the Greek fire in any ancient Greek or Latin author. * Gibbon appears to entertain no doubt of its invention by the Greeks of Constantinople, and of its having been subsequently stolen from them by the Saracens. According to Beckmann, † it was invented in the year 678 of the Christian era, by Callinicus, an architect of Heliopolis (the city afterwards called Baalbec), in the reign of the Emperor Constantine Pogonatus, and its use was not discontinued in the east until the latter end of the thirteenth century. Procopius, in his history of the Goths, calls it Medea’s oil, considering it as an infernal composition prepared by that sorceress. The writer of the "Esprit des Croissades" asserts that it was known in China in A.D. 917, three hundred years after Constantine Pogonatus, that it was called "the oil of cruel fire," and that it was carried there by the Kitan Tartars, who, in their turn, had it from the King of Ou. It is far from improbable that many Eastern nations used a liquid composition of this kind in their wars; and that it was discovered by several parties having no communication with each other.

* Something like it is alluded to by Quintus Curtius.
† Beiträge zur Geschichte der Erfindungen.
We know that in Persia, also in the Island of Zante, and many other parts of the world, there are naphtha springs, which continually pour out this inflammable liquid; we also know that the Parsees, or fire-worshippers, employed naphtha in supporting their religious flames. All they found necessary to do for this purpose was to insert one end of a cane, a little way under the earth thus impregnated with naphtha, which ascended by capillary attraction, and was easily ignited. It is well known that large districts are furnished with these naphtha springs, and a substance of properties so obvious could hardly escape being applied to the uses of war. Probably, then, naphtha was the basis of the Greek fire. We can hardly expect, at this time, to discover any trustworthy account of the operation of the compound; although many statements, such as they are, have been handed down to us respecting it.

Nothing conduces so much to the origination of historic inaccuracy as fear; under the influence of which have been perpetuated the most inaccurate exaggerations. Terrible were the reputed effects of ancient cannon, and yet they were altogether incomparable to those of modern days; and the citizen of Leyden, who first received an insignificant shock from an electric jar, protested that he would not be subjected to such another for all the kingdoms of the earth!—yet the employment of fire-arms was coeval with the re-illumination of the moral horizon; and the discovery
of the electric jar took place when the genius of inductive philosophy was rapidly pursuing her victorious career: we need not wonder, then, that accounts of of the Greek fire, handed down to us as they have been by ignorant and credulous scribes, and from periods of much greater mental darkness than those here adverted to, should be unworthy of implicit credence. It is more than probable that different pyrotechnic contrivances have been unwittingly confounded with the celebrated Greek fire. Joinville presents us with a description which would seem to refer not so much to a burning liquid as to a *rocket*, which has been used as an instrument of war in India and China from time immemorial.* That author says, "It was thrown from the bottom of a machine called a petrary, and that it came forward as large as a barrel of verjuice; with a tail of fire issuing from it as big as a great sword, making a noise in its passage like

* It is a common idea that Sir William Congreve was the first to introduce rockets as warlike instruments. Such, however, is not the case; he himself claims no such priority of invention, but candidly states, in his treatise on the military use of rockets, that he was aware of their having been employed from time immemorial in India and China. There formerly were several Chinese war rockets to be seen at the Adelaide Gallery of Practical Science. They were taken at Amoy. In point of size, they are much smaller than any used in our service; their case is made of paper, and they carry a barbed dart. Their stick, as might be expected, is lateral, not central, as in the modern Congreve rocket.
thunder, and seeming like a dragon flying through the air; and from the great quantity of fire it threw out, giving such a light that one might see in the camp as if it had been day.” Such was the terror it occasioned among the commanders of king Louis's army, that Gautier de Cariel, an experienced and valiant knight, gave it as his advice, that as often as it was thrown, they should all prostrate themselves on their elbows and knees, and beseech the Lord to deliver them from that danger against which he alone could protect them. This counsel was adopted and practised; besides which, the king, being in bed in his tent, as often as he was informed that the Greek fire was thrown, raised himself in his bed, and, with uplifted hands, thus besought the Lord: “Good Lord God, preserve my people!” Geoffry de Vinesauf, who accompanied King Richard I. to Palestine, says, that “with pernicious stench and livid flame it consumes even flint and iron, nor could it be extinguished with water.” The following Latin rhymes, composed by a Florentine monk, show the opinion which was in his time held of its properties:—

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"Pereat ő utinam ignis hujus vena
Non enim extinguitur aqua sed arenā
Vixque vinum acidum arctat ejus poenā
Et urinā stringitur ejus vix habēna:
Ignis hic conficitur tantum per pāganōs
Ignis hic exterminat tantum Christianōs
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* L'Esprit des Croissades.*
AND EXPLOSIVE COMPOUNDS.

Incantatus namque est per illos propheanos
Ab hoc perpetuo Christe, libera nos!"

The Greek fire was more extensively employed in European warfare than some have imagined. Père Daniel relates that Philip Augustus, King of France, having found a quantity of it ready prepared at Acre, brought it with him to France, and used it at the siege of Dieppe, for burning the English vessels in that harbour. It was also, according to this author, employed in many other sieges in France. He also states, that a Frenchman named Gaubert, a native of Mante, discovered the plan of making it. Another Frenchman, named Dupré, is also said to have discovered its composition. And on the authority of Grose,* an Englishman was fortunate enough to unravel the secret, and that the king being unwilling to have it made known, conferred on him a pension to suppress it. According to the testimony of an Icelandic MS., entitled "Speculum Regale," and supposed to have been written in the thirteenth century, the Greek fire, or something resembling it, was then commonly employed in Europe. The writer says, "Omnium autem quo enumeravimus armorum et machinarum præstantissimus est in curvus clypeorum gigas flammas venenatas eructans."

The Greek fire was employed in Europe long subsequently to the discovery of cannon, particularly

in sieges. In 1383, when the Bishop of Norwich besieged Ypres, the garrison is said to have defended itself so well, and particularly with Greek fire, and certain engines called guns, that the English were obliged to raise the siege with such precipitation that they left behind them all their great guns, which were of inestimable value. Afterwards the remainder of that army was besieged in the town of Barburgh by the French, who threw such quantities of Greek fire into it, that a third part was burnt, and the English were obliged to capitulate.*

So terrible are the reputed effects of this celebrated compound, that a knowledge of its true composition would be of exceeding interest. Several recipes have, indeed, been preserved to our own days, but they differ remarkably, and are all of them more or less inconsistent with the reputed effects of the substances. We must remember, however, that those effects were on the one hand doubtless exaggerated, and that the names of chemical substances employed were naturally ambiguous, and perhaps studiously made so.† The

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* J. Walsingham, pp. 308-4.

† As an instance of the ambiguity of ancient chemical terms, and of certain modern ones, I may remark, that Pliny frequently mentions alum; but there is very little doubt that our alum was not then known, and that he refers to rock salt. Again: the modern popular term copperas does not refer to a preparation of copper, as might be imagined, but to a compound of iron. Such are the fallacies of terms.
oldest prescription relative to the composition of the Greek fire, and the one seemingly most worthy of credence, is that mentioned by the Princess Anna Comnena, in which the component parts are said to be resin, sulphur, and oil. It has not, however, been found possible to produce a substance out of these ingredients at all like the reputed Greek fire: theory, indeed, would indicate that saltpetre ought to be one ingredient; this, however, is not mentioned. Nevertheless, there is abundant testimony, as I have endeavoured to prove, that it was a fluid, and that its knowledge was not confined to the Greeks. Moreover, during the Crusades, the Saracens frequently employed it with success against the Christians, as already mentioned,* and the armies of Genghis Khan† seem to have been furnished with it. One chief purpose for which this extraordinary fire was employed, was to annoy the enemy in naval engagements; it was then thrown from large engines; or sometimes, as would seem, blown through tubes. Fire-ships also were filled with it, and sent loose amongst a hostile fleet; also vessels containing it were shot from balistæ. Genghis Khan is said to have had in his army, elephants furnished with these fire-tubes. It is a common opinion that in losing the

* L’Esprit des Croissades, &c., Amsterdam, 1780.
† Patro de la Croix, Histoire de Genghis Khan.
composition of the Greek fire, we have lost an aid to war of far greater potency than gunpowder itself. This, however, is a mistake; the very fact of the Greek fire being a liquid would render it inapplicable to general purposes of modern warfare. If a liquid possessing the reputed qualities of Greek fire were desired, chemists would soon elaborate it in greater perfection than the Greeks of the Eastern empire, or Genghis Khan, or any other semi-civilised people. It is not consonant with the genius of modern warfare, and, therefore, has fallen into disuse. Bonaparte is reputed to have known the composition of the Greek fire, or at least a fluid closely resembling it, but considered it inapplicable. His opinion must be decisive of the question: all know how ardently he promoted the advancement of science; how he cherished the now obsolete sentiment that a sovereign's personal encouragement of science might be conducive to the public weal; how he attached to his court and loaded with honours the celebrated chemist Berthollet. Doubtless, under circumstances so favourable, had Napoleon wished to possess an inflammable liquid similar to that of the Greeks, his chemists could have supplied him. I repeat, then, that under these circumstances, if this compound had been adapted to the general purposes of war as the art now exists, it would have been reintroduced.

I am very far, however, from asserting that all com-
bustive liquids are unadapted for every exceptional condition of warfare; on the contrary, several are known which would prove most destructive, if properly applied. Whether any of these combustive liquids can be employed as the charge of an artillery shell I do not know; if so, the shell must be an elongated rifle shell. I do know these combustive charges can be shot in the form of small rifle shells,* and, if necessary, attached to the heads of rockets; but they could never form part of ordinary military stores, or be used by other than men of finished chemical education, and cool nerve.

During the progress of the Russian war public attention was drawn to the experiment of throwing a sort of glass grenade filled with combustive liquid against a bulk of timber, when the glass grenade breaking, liberated its contents, which, after a time, spontaneously ignited, and set the timber on fire. Subsequently, experiments were conducted at Woolwich on the same sort of fluid inclosed in a shell,† the latter being projected from a gun. The result was perfectly successful, so far as the ignition of the object struck was concerned; but I conceive the difficulties in the way of using such shells generally, would be insurmountable.

* They are now common. Captain Norton was, I believe, the first to employ them.
† An invention of Captain Disney.
Fully admitting these difficulties, I am not insensible to the terrible efficiency of a fluid like this, dropped, as a chemist would know how to drop it, amidst the rigging of a ship, or amongst the timbers of a dock-yard.

As regards the composition of these spontaneously combustive liquids it may vary. A solution of phosphorus in sulphide of carbon was that employed, I believe, in the experiments already adverted to. It commences burning in about a few seconds after it has been deposited. The solution may be made when required; phosphorus dissolving in sulphide of carbon with the rapidity almost of ice in hot water.

Instead of sulphide of carbon, chloride of sulphur may be substituted, as a solvent for the phosphorus; and, perhaps, advantageously. This liquid does not ignite so soon after deposition as the other, which, perhaps, in most cases would be advantageous; inasmuch as time would be given for the liquid to penetrate well into woodwork and canvas; moreover, the odour diffused whilst this liquid burns, is so poisonous and abominable, that it would be a hard matter indeed, to approach the scene of its desolation.

But, perhaps, the very best of all spontaneously combustible liquids for the purposes we are now investigating, is the arsénical alcohol, discovered by Professor Bunsen, and known by the designation of "kakodyl," owing to its abominable smell.
The difference between the composition of ordinary alcohol, and kakodyl, or arsenical alcohol, will be perceived by the subjoined statement:—

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<th>Carbon</th>
<th>Hydrogen</th>
<th>Oxygen</th>
<th>Arsenic</th>
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<tr>
<td>Common Alcohol</td>
<td>4</td>
<td>5</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Arsenical Alcohol, or Kakodyl</td>
<td>4</td>
<td>5</td>
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<td>1</td>
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According to which we see that in kakodyl the one-part of chemical equivalent of oxygen is replaced by one-part chemical equivalent of arsenic. I cannot do better than quote here the original proposition for using kakodyl in warfare, as suggested in the "Mechanic's Magazine," August 18, 1844.

"Now, this body possesses the most extreme and rapid spontaneous inflammability the moment it is exposed to the air, which oxidises it, and forms the oxide of 'kakodyl,' of which principally Cadet's liquor consists. If, therefore, a fragile vessel of this fluid, say a glass globe, be thrown into the port-hole of a ship, the moment it breaks against the deck, or any hard object, the spilled fluid is in a blaze, and capable of setting on fire anything combustible in contact with it. But this is not all. The result of this combustion is the evolution of clouds of white arsenic, so that the atmosphere around becomes instantly a deadly poison! Thus, if inflamed between decks, the atmosphere would at once be rendered fatal; for it is well known
to toxicologists that a most minute dose of arsenic, taken in this form into the lungs, is almost certain to produce death, more or less speedily. Further, the substance is insoluble in water, and heavier than it; and water will not extinguish it when on fire. The oxide produced by its combustion, moreover, is a violent poison. It would be difficult to conceive a collection of more formidable properties in one body, or of any more fitting it for an agent of destruction in warfare." The writer suggests that it might have been the Greek fire, in which supposition I differ from him; although I see no other objections to its employment in warfare, except the difficulty and danger of preparing and stowing the material, added to a certain chivalrous feeling which cavils at particular modes of death, although permitting others. For my part, I would hail with satisfaction any discovery that could make warfare more terrible; conscientiously believing that the application of such wholesale methods of slaughter would be the surest means of establishing universal peace. I have not the affectation of admiring war: I wish it would cease:—but if war must be cultivated as a science, I presume it, like other sciences, has its theoretical point of absolute perfection. This would seem to consist in accomplishing the total slaughter of two belligerent hosts. Once render warfare perfect to this extent, and men would not fight. Slaughter, I take
it, is the main object of all battles. This granted, it can matter very little whether men are cut in two by round-shot, perforated by musket-balls, blown to atoms by bomb-shells, or poisoned by arsenical fumes.

**The Ethics of Warlike Destruction.**—At all times certain limitations have been imposed to the means of military destruction—certain codes of action tacitly felt, if not specified, beyond which belligerents, without detriment to their honour, might not go. At one time the arbalest was scouted as an unchristian weapon; at other times gunpowder was inveighed against; and later in military annals, the employment of red-hot cannon shot. I remember reading in the life of Admiral Saumarez an epistolary correspondence which passed between him and a Spanish governor, originating in this way. The British admiral, during his attack on a Spanish town, Cadiz I think, was assumed to have employed red-hot shot; therefore he, moved by a chivalrous feeling as to what was due to the usages of Christian warfare, took some trouble to convince the Spaniard how unfounded was the report;—that he could not have brought himself to wage war in such improper fashion, &c. &c. I confess my inability to understand the ethics of this. I cannot understand why red-hot shot might not have been employed by the Englishman, had he seen proper. There seems to be a lurking fallacy here; the fallacy of assimilating a military, or naval, contest, to a
duel between two individuals; in the prosecution of which, known and equal means of offence, and defence, are mutually agreed upon. There is no parallelism. The recognised object of a belligerent nation is to overcome its enemy by putting forth an excess of force; and whatever prejudice there may linger against the exercise of one method of destruction or another, I conceive that adherence to conventional means of killing is based on prejudice alone, not upon morality. Supposing the inhabitants of a beleagured town to have the option of surrendering, yet refusing to do so, it seems to me unreasonable that the enemy should be accorded the privilege of choosing the precise destructive agencies, by which he is to be killed.

The practice of warfare is not a Christian practice; one cannot too frequently remember that fact. No sane human being could advocate it as a thing to be desired. But if it cannot be avoided—if once entered upon, I conceive the plain duty of a belligerent is to gain the end proposed as effectually as may be. To throw away any sort of power or aid within his reach, would seem to savour of hypocrisy; and therefore to partake of sin. As time progresses, belligerents are coming to view the practice of war in this light. One has heard of “boulets asphyxiants,” or poison balls, intended to take effect in close places; such as case-mated batteries, and 'tween decks. One may rest quite assured that in future wars, as powers now used
become equalised, others will get into vogue;—to what extent I know not; but the tendency is inevitable.

If ever a city underlaid with gas pipes should be the object of prolonged siege, some fearful notions might come into the brain of the beleaguering engineer. He would only have to possess himself of an outlying gas pipe, belonging to the general system, and inject atmospheric air into it by obvious means, when the whole city, wherever a gas pipe might ramify, would be at the mercy of a subterranean mine, more terrible than any which ever entered into the conception of a Vauban; more fraught with evil than even gunpowder in its wickedest moods could compass. Throughout every house supplied with gas,—ramifying under every street, there would be a terrible store of fire-damp! Need one demand what the result must be? Whoever does not know may consult the annals of coal mines. But the beleaguered city might have taken fright—might have anticipated the possibility of fire-damp explosion, and preferred to exist in darkness. Well, that would only be to subject itself to a still more dreadful fate at the will of the engineer. An invisible gas laden with arsenic—(arseniuretted hydrogen)—a gas concerning which the annals of chemistry testify, that all who have breathed even so much as a mouthful of it have died—might be transmitted through the tubular system, with even more facility than fire-damp. I speak of
what *may* be. It is well to be aware of the existence of means, out of which come possibilities!

Many agents in warfare as well as in other arts, are stamped with unmerited ridicule; not so much because they are worthless, as because their use has been suggested under ineligible conditions. Warner's scheme of dropping shells from the car of a balloon has been justly ridiculed, because mortars and howitzers would deal with shells far more efficiently; yet balloons employed as portable observatories did good service in some of the early wars of the French revolution; a period when balloons and all belonging to them were far less manageable than now. Probably they might be employed advantageously during the progress of seiges; and if instead of carrying heavy shells they were to carry a few Winchester quarts, of one of these self-inflammable liquids, of which mention has been made, they would prove uncomfortable things to hover over a dock-yard, or arsenal.
ON PROJECTILE FORCES.

It may be well here, before taking up the introduction of gunpowder in relation to modern projectiles, to consider the nature of projectile forces. Reviewing what has already been said, the position will be made apparent that, so far as we have examined the subject of ancient projectiles, the forces employed in launching them have been limited to two—namely, muscular contraction, and elasticity. The simple act of throwing a stone illustrates the former, and in the sling we have seen it carried to the highest degree of perfection of which it seems susceptible. The bow, in all its varieties, illustrates the latter.

The force employed in launching modern projectiles, is that of elasticity too;—no longer the elasticity of wood, and steel as of yore, but of gaseous matter. Thus, a distinction no less broad, and marked, than philosophical, is seen to subsist between the genius of ancient, and of modern projectiles. The former, when they aimed at embodying a force more powerful than direct muscular impulse could give, turned the elasticity of solids to account; the latter,
the elasticity of gases. It may be well here, also, to remark that under the general denomination "gas," steam is also comprehended; inasmuch as between vapour, and steam, there is no functional difference whatever.

A great deal turns upon the proper comprehension of the sort of force which is adapted to the urging of projectiles. If people comprehended it better, there would be fewer mistakes committed in the way of expecting long increase of projectile range from the adoption of certain highly explosive bodies with which chemists are familiar. Elasticity may be popularly defined as the gradual putting forth of motive force within limits; and it is only the elasticity which exists between certain limits which can ever be useful as a projectile force. It is easy to conceive the existence of an explosive body which, during the act of explosion, shall evolve the whole of its gases at once. Fulminating silver, and the iodides and chlorides of nitrogen, very nearly approach this mark; wherefore, though no gun-barrel can be made strong enough to restrain them, they are contemptible as projectile agents. In point of fact, in proportion as an explosive body evolves its gases suddenly, so does the force of it approach the nature of the force displayed by liquid pressure, which is the very greatest that the power of man has ever brought to bear. If about five grains of gunpowder, made up in a little cartridge, be fired in a
common wine bottle corked, as can easily be done by an electrical device, the bottle would infallibly be shattered, and the fragments driven about with dangerous velocity; yet the force exerted on the sides of the bottle is much less than that produced by filling the bottle with water, inserting a tapering cork, and striking the latter with a sharp blow of a mallet. The latter experiment may, however, be performed with complete impunity, the operator holding the bottle in his hand. A still stronger exemplification of the harmlessness of non-elastic force, considered as to its shattering or projectile agency, has been afforded within a few days of the period at which I write, by the bursting of the cylinders of various hydrostatic presses employed in the launch of the great iron ship. The cylinders, unable to bear the enormous pressure exerted against them, gave way, as the reader will doubtless have been informed through other channels. At the time of the rupture of one of these a force of no less than 14,000 pounds per square inch was exerted upon its sides, whereas the first pressure exerted by the gases of ignited gunpowder is not more than 14,750 pounds per square inch, even under the most favourable circumstances. Yet, though the iron cylinder of the hydrostatic press was rent, as though it had been made of wax, its fragments were not driven about—they were not projected: simply because the whole amount of force capable of being
exerted by water pressure was exerted at once; water not being elastic, or so trivially elastic that one need not take cognisance of it. Now the fact cannot be too strongly inculcated that certain highly explosive bodies liberate their gases so suddenly that the sort of energy of which they are capable, approaches to that of compressed water. These considerations lead us to appreciate a fact indicated for the first time by Mr. Mallet, I believe: viz., That the ultimate cohesion or limit of rupture possessed by an artillery material, does not involve a consideration of so great a moment, as the elasticity of such material within profitable limits.

In this discussion concerning the nature of gaseous elastic force, it will have been observed that the position has been tacitly occupied, of regarding explosive combustion as the only means at our command for using the projectile force of gases. Practically this is so. Steam guns, and air guns, as the reader will perceive, both take advantage of gaseous elasticity, though the gas in neither case is developed from the combustion of an explosive material: but neither steam guns nor air guns can be regarded otherwise than mere toys. Combustion is the only source of gaseous elasticity, which we can turn to account for practical uses.

Combustion, Tranquil, and Explosive.—Even the most casual investigator of these matters cannot fail to have noticed that combustion has various types.
Ordinary domestic fires, whether for heating or illumination, suggest our most common ideas of combustion. In these cases the march of destruction, as ordinarily the result is thought to be, goes tranquilly on, till all the combustible matter has burned away.

Restricting our ideas to the combustion of charcoal (pure charcoal), contemplating thoroughly the changes which take place, we shall acquire some notions that will help us in understanding hereafter, the routine of explosive combustion. If the charcoal be absolutely pure, not a fragment of ash will remain; all the charcoal will disappear, converted into an invisible gas. Notwithstanding the ease with which pure charcoal burns under ordinary circumstances, it will not burn when placed underneath the receiver of an air pump, and the air removed; therefore, to adopt a common phrase—not absolutely correct, but correct enough so far as it goes—charcoal must be ranged amongst the combustibles, and air (or something which the air contains), amongst supporters of combustion.

Now, charcoal, as almost everybody knows, is one of the three ingredients which enter into the composition of gunpowder; this fact borne in mind, the next experiment performed, or supposed to be performed, on saltpetre (nitre), a second constituent of gunpowder, will help us to a clearer understanding of the nature of explosive, or projectile combustion. If a little saltpetre be placed in an iron tube, such as
gas pipe, plugged at one end—an old gun barrel will serve perfectly well, provided its touch-hole be stopped—if a flexible tube, such as lead, gutta percha, or India-rubber, be adapted to the iron pipe, as represented below, so that anything which may distil over from the apparatus when heated shall pass into the inverted bottle filled with water, and standing in some convenient vessel, as represented; if all these arrangements be made, and the closed end of the gun barrel be heated to redness in a common fire, a certain colourless gas will come over:—it is oxygen.

Now, this is not the best method of producing oxygen; on the contrary, it is about the very worst, and only mentioned here to prove that the gas in question lies locked up in nitre.

A far simpler way of producing oxygen is the following: Take a small glass tube about three-quarters of an inch in diameter, and five inches long; place into
it a mixture of chlorate of potash and black manganese, equal parts; join on a tube (one of lead will be most manageable) by means of a perforated cork, as represented below, and collect the gas as before; using either a spirit lamp flame, or a few embers of lighted charcoal to distil with. The glass tube may be supported by the fingers, if the precaution be taken of holding it by a slip of cloth or strong paper, as thus—

![Image of a glass tube with a hand holding it](image)

The gas thus liberated exists to the extent of some twenty-one per cent. by measure in the air, and it is entirely to the presence of this gas that the power which air has, of being able to support combustion, is due. The power which this gas, oxygen, has of supporting combustion, fills with wonder the mind of one who sees it for the first time. A piece of steel wire, if tipped with a little brimstone or chip of wood, and dipped into the gas after the brimstone or chip has been ignited, burns vividly. The experiment may be
performed by means of a small physic bottle, as represented below.

By winding the wire into the spiral form, more of it can be immersed, which is the only advantage of doing so. The bottle will certainly be broken; probably, too, drops of molten iron darting against its sides will burn holes quite through it. In this case it will be observed that the result of combustion is a solid. Little drops of this solid mass may be collected after the burning has ceased. A great deal might be said about this result, if now were the proper time for it. The ordinary combustions we meet with, produces either no solid remnants (as combustion of our lamps, and candles, and gas flames, for instance), or a trivial amount of ashes, as yielded by our coals and our wood. If iron had been designed for the fuel of man, and if man’s atmosphere had been pure oxygen, instead of holding only about twenty-one per cent. of it, our world long before this would have been covered with ashes.

If, instead of steel wire, a bit of charcoal be set fire to, and immersed in another bottle full of gas, the charcoal will burn furiously until quite gone. It is not destroyed, however; the charcoal is converted into gas, and rendered invisible.
AND EXPLOSIVE COMPOUNDS.

If instead of burning the piece of charcoal, by bringing oxygen in contact with the outside of it, we could place the gas everywhere within it, then the combustion of the charcoal would proceed with enormous activity; it would be converted into gas almost at once, and the result would be an explosion.

Well, this can be done—*it is* done. Have we not seen that nitre contains this very oxygen in a solid form? Therefore, if nitre and charcoal be intimately mixed in due proportions, we have a compound which holds within itself both combustibles and a supporter of combustion. A little brimstone improves the result, and we have gunpowder. Hence the reason of the fact will be evident, that gunpowder can burn whether air be in contact with it or no: it contains its own oxygen; and therefore wants none from the atmosphere.

Reflecting on these facts, we shall not fail to perceive that the only sort of combustible which can be used for projectile purposes must be—

*Firstly.*—One that is not beholden to the air for its supporter of combustion.

*Secondly.*—One, the combustive results of which, occupy more space than the body burned.

*Thirdly.*—One, the combustion of which does not take place on the outside alone, after the manner of a coal; but outside and inside at the same time, as gunpowder, for example.
These three points are three necessities. Without them, projectile force, by combustion, cannot be obtained. Many other points are desirable, though unattainable. It is desirable to obtain, if we could, a good explosive projectile substance which yields nothing but gas on combustion; unlike gunpowder, which, however pure, needs must leave some cinders.* Gun-cotton fulfils this requisition, but it seems in-applicable, for reasons to be mentioned hereafter.†

It would be a great thing if an explosive gaseous combustible could be devised, the gases of which were incapable of acting upon metal, and at the same time yielded no smoke. Gun-cotton burns with a smokeless flame, and burns without leaving any cinders; but amongst the invisible gases which come from it, there is one which turns to aquafortis on the instant, and does more damage to iron and bronze than the deposited foulness of the very worst gunpowder.

* The expression, though unusual, is quite correct.
† Nevertheless the Austrians are said to use gun-cotton in their military service.
GUNPOWDER.

We now come to the subject of gunpowder,—an invention which not only materially affected the art of war, but exercised most important influences on the fate of empires and the progress of civilisation. As might readily be imagined, the honour of a discovery so important, has been claimed for more than one individual. Polydore Virgil and Thevet attribute the invention to a monk named Constantine Anelzen, who was a chemist of some celebrity in his time. Others maintain that it was discovered by Bartholdus Schwartz, about the year 1320. It is not difficult however, to refer the invention to a period long anterior to the time of Schwartz, our own illustrious countryman, Roger Bacon, having distinctly mentioned it in the year 1267.* He describes its composition, enumerates some of its properties, and recommends its explosive powers as a means of destroying armies. He describes it as making a sound like thunder, and a flash similar to lightning, but exceeding the sound and brightness of natural thunder and lightning. He

* His works were published in 1845, at Oxford.
says it might be applied to the destruction of armies, and speculates on the probability of its employment by Gideon, when he defeated the Midianites with three hundred men.* Bacon is usually said, by Englishmen, to have been the inventor of gunpowder; but a slight examination of the treatise alluded to will convince any unprejudiced person that he, far from laying claim to the invention, mentions gunpowder as a substance well known in his time, and employed for the purpose of pyrotechnical display. The passage alluded to is as follows: "Ex hoc ludicro puerili quod fit in multis mundi partibus scilicet ut instrumento facto ad quantitatem pollicis humani ex hoc violentia salis qui salpetra vocatur tam horribilis sonus nascitur (this is the description of a parchment cracker) in ruptura tam modice pergamenæ quod fortis tonitru rugitum et coruscationem maximam sui luminis jubar excedit."

We can easily, then, shift the claim from Bacon to an anterior date, and Dutens† imagines he must have derived his knowledge from Marcus Græcus,‡ who

* Judges vii.
† See preface to Jebb's edition of Bacon's Opus Majus.
‡ Inquiry into the Origin of Discoveries attributed to the Moderns, by the Rev. Mr. Dutens.
§ The MS. of Marcus Græcus, which has given rise to this supposition, is still in the Royal Library at Paris. Both Dr. Mead and Dr. Hutton had a copy of it: Dr. Jebb also mentions it in his preface to Bacon's Opus Majus. The MS. is entitled Liber Ignium. Marcus Græcus lived about the end of the eighth century.
not only mentioned the ingredients of gunpowder, but gave better proportions of them than many authors of later date. In the Latin quotation just made from one of Bacon's treatises, saltpetre alone is mentioned as being the horribly explosive substance; but saltpetre alone will not even burn, much less explode; a fact which, the presumption is, Bacon must have known. The question, however, does not rest on presumptions; Bacon himself, in his treatise *De secretis operibus Artis et Naturæ et de nullitate magiae*, says that from "saltpetre and other ingredients we are able to make a fire that shall burn at any distance we please." In another part of the treatise he gives us a little more information; the words are these: "*Sed tamen salis petrae, luræ nope cum ubre et sulphuris, et sic facies tonitrum et coruscationem, si scias artificium.*" Here two ingredients, saltpetre and sulphur, are plainly enough indicated; but what can be the ingredient called *lura nope cum ubre*? This obscure fragment of Latinity might puzzle the ghost of a Scaliger; nevertheless, some admirer of the great friar has succeeded in proving that the barbarous words are merely a transposition of the letters *carbonum pulvere*! They who are accustomed to admire the liberality of sentiment possessed by cultivators of modern science, and are unacquainted with the more circumscribed views and illiberal sentiments of those who cultivated science in the ages of alchemy, will
marvel at the pains which Bacon took to preserve the secret; especially when it need not have been alluded to at all. Bacon, however, in following this course, merely subscribed to the doctrines of his age. Volume upon volume, for instance, has been written on the art of making gold and silver; every operator represents himself successful, but, unfortunately, the steps of his process are totally unintelligible. However, let us do the alchemists justice. They must needs write books, or their characters would have suffered: these books were intended to pass for oracles of wisdom; but the writers, unfortunately, had nothing to teach; they, therefore, employed a jargon of impenetrable mystery—perhaps the best substitute for wisdom in their age or ours.

If Bacon, then, did not discover gunpowder, to whom shall we refer it? Numerous documents can be adduced to prove that gunpowder was known in the East at periods of very great antiquity; and it might have been introduced into Europe, either through the medium of the Greeks of Constantinople, or the Saracens of Spain. Citizen Langles, in a memoir read before the French National Institute, contends that gunpowder was conveyed to us by the Arabs, on the return of the crusaders, and that the former people employed it at the siege of Mecca, in 690. He says they derived it from the Indians. At the period when Roger Bacon lived, Spain was the
favourite seat of literature and art. Unlike their rude and turbulent predecessors, whose sole object was the extension of Mohammedanism by the sword, the Spanish Saracens of those days were a polite and contemplative race; their seminaries, and universities, were the most celebrated in the world. Christian Europe was glad to profit by the unbeliever’s tolerance, and glean in Spain those fruits of learning which in other European countries found but a barren soil.* Bacon is known to have travelled through Spain, and to have been well conversant with Arabian literature: the account of the composition of gunpowder he might have seen in an Arabian manuscript; this is at least as probable a supposition as that he saw the treatise of Marcus Graecus; indeed, there is in the Escorial Collection a treatise on gunpowder, written in 1249.

The earliest account which we have of gunpowder exists in a code of Gentoo laws, where it is mentioned as applied to fire-arms, and consequently, if the document be authentic, the most recondite of its properties, that of projecting heavy bodies, must have been well understood.

That particular code in which gunpowder and fire-arms are mentioned, is thought by many to have been coeval with the time of Moses! The notice occurs in

* Vide Thomson's History of Chemistry.
the Sanscrit preface, translated at page 53, by Halhed. It is as follows: "The magistrate shall not make war with any deceitful machine, or with poisoned weapons, or with cannon and guns, or any kind of fire-arms; nor shall he slay in war a person born an eunuch, nor any person who putting his arms together supplicates for quarter, nor any person who has no means of escape."

Referring to this document, Halhed observes, "It will no doubt strike the reader with wonder to find a prohibition of fire-arms in records of such unfathomable antiquity, and he will probably renew the suspicion, which has long been deemed absurd, that Alexander the Great did absolutely meet with some weapons of this kind in India, as a passage in Quintus Curtius seems to ascertain. Gunpowder has been known in China as well as in Hindostan far beyond all periods of investigation. The word fire-arms is literally Sanscrit, Agnee-aster (agnyastra), a weapon of fire; they describe the first species of it to have been a kind of dart or arrow tipped with fire, and discharged upon the enemy from a bamboo. Among several extraordinary properties of this weapon, one was, that after it had taken its flight, it divided into several separate streams of flame, each of which took effect, and which, when once kindled, could not be extinguished;* but this kind of Agnee-aster is now lost. Cannon in the Sanscrit

* This description corresponds better with the nature of Greek fire than with that of gunpowder.
idiom is called Shēt-aghnee (sataghni), or the weapon that kills a hundred men at once, from shētē (sata), a hundred, and ghēnēh (hana), to kill; and the Pooran Shasters, or histories, ascribe the invention of these destructive engines to Bēēshōēkērmā (Viswakerma) the artist, who is related to have forged all the weapons for the war which was maintained in the Suttee Jogue between Dewta and Ossoor (Devata and Asura), or the good and evil spirits, for the space of one hundred years.”*

Dutens, in the work referred to, in page 344, has selected many passages from Greek and Latin authors, favourable to the opinion that gunpowder was known to the ancients. He mentions the attempt of Sal-moneus to imitate thunder,† of the Brahmins to do the same;‡ but his most remarkable quotation is from the life of Apollonius Tyaneus, written by Philostratus; showing that Alexander was prevented extending his conquests in India, because of the use of gunpowder by a people called Oxydrace.

The passage here adverted to is so curious, that I make no apology for giving it. "These truly wise

† Virg., Æneid, vi. 585; Themistius' Orat. xxvii. p. 3 37. Dutens also quotes, in support of this argument, Hyginus, Fabul. 61, 650; Eustathius, Ad Odys., A. 234, p. 1682, l. 1.
‡ Valerius Flaccus, lib. i. 662; Dion. Cassius, Hist. Rom in Caligul., p. 662; and Johannes Antiochinus, Chronica apud Peirasciana Valesii, Paris, 1604, p. 804.

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men (the Oxydracæ) dwell between the rivers Hyphasis and Ganges; their country Alexander never entered, deterred not by fear of the inhabitants, but, as I suppose, by religious motives, for had he passed the Hyphasis, he might, doubtless, have made himself master of all the country round them; but their cities he never could have taken, though he had led a thousand as brave as Achilles, or three thousand such as Ajax, to the assault; for they come not out to the field to fight those who attack them, but these holy men, beloved by the gods, overthrew their enemies with tempests and thunderbolts shot from their walls. It is said that the Egyptian Hercules and Bacchus, when they overran India, invaded this people also, and having prepared warlike engines, attempted to conquer them; they in the meantime made no show of resistance, appearing perfectly quiet and secure, but upon the enemy’s near approach they were repulsed with storms of lightning and thunderbolts hurled upon them from above.”

It is true Philostratus is not considered remarkable for veracity,† and this assertion is not of a kind to be received without great suspicion; but taking into consideration the records of oriental history, and the fact of pyrotechny having been cultivated from time immemorial in India and China, his assertion does not seem

* Lib. ii. c. 14.
† Vide Lemprière’s Class. Dict., art. Philostratus.
at all improbable. In India and many other parts of Asia, nitre occurs in great quantity, spread over the surface of the earth. Now, suppose a fire lighted in such a spot, the most careless observer must have noticed the effect of the saltpetre in augmenting the flame; if, then, attention having been directed to this phenomenon, charcoal and saltpetre had been mixed together purposely, gunpowder would have been formed. The third ingredient, sulphur, is not absolutely necessary; indeed, very good gunpowder, chemically speaking, can be made without it. Sulphur, however, increases the plasticity of the mass, and better enables it to be made into, and to retain the form of, grains.

Some persons refer us to Plutarch's Life of Marcellus, also to Vitruvius, as authorities in favour of the supposition that gunpowder was known to the famous Archimedes. All are acquainted with the talented aid which he lent to Hiero of Syracuse in repelling the attacks of Marcellus—how by volleys of enormous stone he destroyed, at a considerable distance from the walls, a stupendous machine of war, floating on eight galleys, and termed the Sambuca; how he burned his opponents' ships by mirrors; hooked up their prows by cranes; and sank them stern foremost under the waves: in short, how he so terrified the enemy, that on seeing a rope or spar project from the wall, they cried out that Archimedes was levelling some machine
at them. Amongst the engines which his fertile genius enabled him to construct, were some which are said to have gone off with a great noise—a description which it has been assumed does not apply to any then commonly in use, and that gunpowder seems indicated. This assumption does not appear to have much validity; I feel no difficulty in imagining the enormous engines used by Archimedes to have made a great deal of noise, even though their agency merely depended on bent springs and levers.

Those persons who are in favour of the opinion that gunpowder is a modern discovery, say that the historical records in which gunpowder is mentioned without ambiguity, such as the Gentoo codes, are of doubtful authenticity; that the narrative of Philostratus, besides its ambiguity of allusion, is vitiated by the character of the writer; that the traditions of other historians are open to one or both of the same remarks; that poetic allusions are not to be literally translated, and used as testimony in historic and scientific matters:—lastly, they urge that if gunpowder and fire-arms had been known so early in the East, some of the conquering hordes who roamed from thence and devastated Europe, should have used such powerful auxiliaries to war: Mahomet, at least, should have been aware of this element of destruction, they say,* and still more so Genghis Khan; yet such was not the case.

* Some believe Mahomet was aware of it. See page 80.
AND EXPLOSIVE COMPOUNDS.

These arguments have great weight, but are not insuperable. It may be answered, that the discovery of gunpowder, and the discovery of fire-arms, are separate questions; that gunpowder might easily have been made by a savage people; that, indeed, in countries where saltpetre occurs naturally, it must have in a manner been formed by chance; whereas the manufacture of fire-arms involves a great amount of mechanical skill; hence missives urged by mechanical aid would long be thought superior to the first rude fire-arms, as in the present day the bow is preferred by the Chinese to the musket,—as it was in England in the reign of Henry VIII., and amongst the Turks not 200 years ago.

Thus, then, the dispute stands. We do not know who discovered this compound; certainly not the German Schwartz, nor the English Bacon, nor Marcus Græcus; I incline to the opinion that it has been known in Asia from time immemorial, and that its discovery might have originated in accident. Certain it is, however, that its first application to artillery in Europe was about the beginning of the fourteenth century.

Having given a short sketch of the history of gunpowder, I might at once proceed to its application to fire-arms, and other warlike purposes. It seems more natural, however, to describe briefly the chemical nature of this substance, and the history and properties
of the ingredients from which it is formed. It may here be as well to remind the reader that gunpowder is not a chemical, but a mechanical compound, and that it is composed of saltpetre or nitre, sulphur, and charcoal, intimately commingled, and subsequently formed into grains.

It is not my intention to enter minutely into the chemical properties of these substances; but I may remark that their union forms an explosive compound which when inflamed eliminates a large quantity of various gases. Nitre, or saltpetre,* is a chemical compound of nitric acid and potash.† It may be

* The term neter, translated nitre, is found in the Old Testament, Prov. xxi. 20; Jeremiah ii. 22. Herodotus and Theophrastus used the word ορυκτον, and Pliny the word nitrum—but these authors seem to mean natron, quite a different substance from our nitre. Geber (Invention of Verity, xxiii.) is the first who distinctly mentions our nitre, or saltpetre. The term saltpetre is evidently derived from sal-petra, literally signifying rock salt.

† Until very recent times the composition and theory of the efficacy of nitre in gunpowder was not understood. Machiavelli (in 1588) seems to veil his ignorance of the matter under a great many quaint suppositions. "Salpetre," says his translator, Peter Whithorne, "is a mixture of many substances, gotten out with fire and water of dry and dustie ground, or of the flower that groweth out of new wallies in shellars, or of that ground which is found lose within toombes or desolate caues, where raine can not come in; in the which ground (according to my judgment) the same is ingendered of an ayrie moistnesse drunke up, and gotten of the earthie drines; whose nature (by the effect thereof) considering, I cannot tell how to bee resolved to say what thing properly it is. The well learned, and most wise
made by directly uniting these two substances, but I need scarcely remark that such is never done, except as a matter of synthetical demonstration. In some parts of the world—in India, for example—it is found as a natural efflorescence on the earth's surface;*

Physitions (besides medicinal experience), by the taste (finding it salte, and with exceeding sottill sharpnesse, and considering the great byting thereof), suppose verily that it is of a nature hotte and drie: on the other part, seeing it to be a thing engendered of ayre, and touched of fire to fall in a flame and vapore, and rise with a terrible violence, seemeth to be of an ayrie nature, hotte and moist: and againe, seeing it with shining and glistening whitenesse, as a thing to the nature of water conformable, it seemeth that it may be said, that it is of a watery nature.”—P. 23.

* It also occurs pretty frequently as a natural efflorescence on the earth in many parts of Spain, especially in the south of Andalusia, where the peasants are in the habit of collecting it, separating foreign bodies by solution and evaporation, and finally manufacturing it by a domestic process into gunpowder. In Spain, the public gunpowder manufacture is a government monopoly, and the article is both dear and bad. Hence the peasants have long been stimulated to the preparation of their own. The operation is carried on with great secrecy, just as illicit distillation in the wilds of Ireland and Scotland, and subject to frequent interruption; yet the result is by no means despicable, as I have often proved. The chief defect of this powder is softness of grain, but it ignites with great facility, and fires with sufficient rapidity in a percussion gun to answer all common purposes. Having secured the confidence of a gentleman of uncertain profession, who spent a great deal of his time amongst the mountain passes leading from Salobrefia and Almuñecar to Granada, armed with a blunderbuss (for defence, it is polite to assume), the writer of these pages was favoured with a private inspection of the domestic powder manufacture.
and this, indeed, is the only source from which we English derive it. Other nations, however, not having the commercial facilities of England, make it artificially, by a process which was first perfected by the celebrated chemist Berthollet. The origin of the extensive manufacture of nitre is curious, and forcibly illustrates the advantage which may accrue to a state from its cultivation of science. At one period of the French revolutionary wars, operations had nearly ceased, owing to a want of saltpetre; which, on account of the vigilance of the English, could no longer be imported into France. At this crisis Bonaparte applied for aid to his friend Berthollet, who, after giving the subject a short consideration, is said to have made this confident reply, "Sire, within three days we will make our own nitre,"—and he kept his word.

It would be out of place here to give a detailed account of those chemical affinities on which the artificial manufacture of nitre is dependent. Suffice it to say, that both nitrogen and oxygen, the gaseous materials of saltpetre, exist to an unlimited extent in the atmosphere, and that under some circumstances they unite with lime spontaneously; thus in old walls

A mortar was employed for braying the three components together, moistened with water, and the half dry paste was grained by pressure through a sieve; no preliminary compression having been employed; hence the softness of grain.
we have frequently a nitrate of lime, and by the addition of potash, or substances containing it, such as wood-ashes, to this, we obtain nitrate of potash; nitre, or saltpetre.

Napoleon, at the juncture alluded to, issued a commission for the appropriation of old walls, and other suitable materials, to the manufacture of saltpetre; and eventually lime, rubbish, wood-ashes, &c., were mingled together, in what were called "nitre beds," for the sole purpose of forming this compound. Thus France was rendered independent of foreign supply.

It has been erroneously stated by some that Berthollet discovered the plan of thus preparing nitre, which was not the case. The process was known to and described by the chemist Glauber. In Prussia and in Sweden the making of nitre has been cultivated as a piece of state policy. The King of Prussia* obliged his farmers to build their fences of nitre-forming materials, which after a few years were taken down and appropriated. In Sweden,† so careful is the Government on this point, that each farmer is obliged annually to furnish a certain quantity which must be paid in kind—Government will not compound for it—thinking that by following such a course it guards

* Considerations on the Importance of the Production of Saltpetre in England, by William Denries. Also Dumas, Traité de Chimie.
† Berzelius, Traité de Chimie, t. iii. p. 391.
against the injurious consequences which might arise during a war if the supply of nitre were drawn exclusively from abroad.

In the manufacture of gunpowder, it is of the greatest possible importance that all the materials should be of the utmost purity. Saltpetre, on its first arrival in this country, is dark, foul, and in other respects totally unadapted to the purpose. Being dissolved in water, the earthy impurities with which it is contaminated sink to the bottom of the solution; particles of dust and other light substances rise to the surface, and are skimmed off; whilst nitrate of lime, chlorides of sodium and calcium, and some other salts, are eliminated by taking advantage of the difference between their solubility in water, and the solubility of nitrate of potash. Nitre is more soluble in boiling water than in cold; chloride of sodium (common salt) is not; therefore by drawing off the nitre at a high temperature, the common salt is left behind. Again, chlorides of calcium and magnesium, and the nitrates of lime and soda, are more soluble in water, hot or cold, than is nitre; therefore the latter crystalises, leaving the former in solution. By taking advantage of these beautiful natural laws nitre is purified; one operation, however, not being always sufficient; inasmuch as the least particle of foreign salt, particularly if nitrate of lime, or chloride of sodium, materially injures the resulting gunpowder; owing to the powerful attraction of these bodies for water.
After the purification of the nitre, the next operation to which it is subjected, previously to its being manufactured into gunpowder, is fusion. This is for the purpose of driving off any water that may be entangled amongst its particles (nitre does not contain any chemically united), and thereby enabling it to be weighed with accuracy—nothing more; and it would be well if the operation could be altogether dispensed with, inasmuch as the application of too high a temperature drives off oxygen and binoxide of nitrogen, thus materially injuring the substance—indeed, partially changing it into free potash and nitrate of potash.* The fusion should never be effected by a heat greater than 500 or 600 deg. Fahr., otherwise the injurious changes take place.

We will now leave the consideration of nitre for a time, and turn our attention to sulphur, another of the ingredients employed in the manufacture of gunpowder. This substance is one of the few simple non-metallic bodies which frequently exist in nature uncombined. In all volcanic countries it is very abundant; our chief supply is from Sicily, where it is found imbedded in thick masses very nearly pure, although not sufficiently pure for the purposes of the powder manufacturer. To effect this purification one of two methods is employed. In the Government powder-mills the sulphur employed

* A Treatise on Naval Gunnery, by Sir Howard Douglas.
is simply fused, when the grosser impurities sinking to the bottom of the vessel, and the lighter ones rising to the surface, leave the intermediate sulphur more or less pure, when it can be withdrawn by a proper contrivance. Some of our private manufacturers have recourse to the same operation, but others purify their sulphur by sublimation, taking advantage of a property which this substance possesses of vaporising at a temperature of about 170 deg. Fahr.

We now come to the manufacture of pure charcoal, which lately has been carried to a great perfection; to which cause, more than any other, the great superiority of gunpowder now manufactured over that of previous times, is mainly attributable. Charcoal, as all are aware, is essentially carbon,—that chemical principle which, in a state of absolute purity, constitutes the diamond. Charcoal is formed by exposing animal or vegetable substances to elevated temperatures under circumstances which do not favour combustion; that is to say, air being totally or partially excluded. The operation of charcoal making depends upon the fact that carbon is indestructible at any temperature, provided air be excluded. As charcoal made from vegetable substances is the kind invariably employed for the purpose of making gunpowder, we may confine our attention exclusively to that variety.

I need scarcely advert to the common plan of making charcoal; namely, by putting billets of wood
AND EXPLOSIVE COMPOUNDS.

into a pit, setting fire to them, then covering them with turf, &c., in such a manner that just air enough may be admitted to effect slow combustion. Until lately charcoal made by this process was employed by the gunpowder manufacturer. Very early in the history of gunpowder it was discovered that light woods, such as willow and alder, were greatly superior to hard woods in yielding good charcoal, but facts of a chemical nature having reference to the further improvement of charcoal were not then known. When we consider how various are the secretions and juices of vegetables—how different in regard to their volatility and destructibility—how variable are the amounts of lime, potash, soda, and other bodies, some of which exist in most vegetables, and which, being devoid of volatility, must remain behind and contaminate the charcoal—it is evident that no inconsiderable amount of chemical knowledge is required in the manufacture of this substance for gunpowder.

The common plan, then, of manufacturing charcoal is found never to yield a result of the greatest possible purity: in other words, it is not possible to apply the due amount of heat, so that all volatile substances may be driven off, without at the same time partially destroying the charcoal. The process now followed is that of distillation; the wood, cut into billets of proper length and size, being inserted into cast-iron cylinders or retorts, heated to the requisite degree. By this
operation not only is the wood effectually charred, but acetic acid, called from its source "pyroligneous," and tar, and pyroxylic spirit, ordinarily called wood naptha, valuable results which formerly were dissipated, are now saved; moreover, charcoal thus prepared is said to be more free than any other from potash—a fact which seems attributable to the action of acetic acid in dissolving it out.

In France, since the last few years, a process of charcoal manufacture has been adopted, founded on the discovery of M. Violette, that high pressure steam transmitted amongst and through billets of wood, actually produces a similar result to the application of fire; but much better. Engineers have long been aware of the fact, that steam jets playing against vegetable matter, after a time charred them. The process of M. Violette is a practical application of that fact.

For the best kind of sporting powder soft dry wood is that employed; willow and alder are used for Government powder; any kind of wood is indiscriminately used for the common powder. In India the gram-bush plant (cylisus cajan), Parkinsonia, and milk-edge (euphorbia tiraculli), are found to answer well.* Whatever the wood, it should be carefully decorticated; wherfore it is usually felled in May, when the sap is up. The reason of removing the

* Braddock's Memoir on Gunpowder.
bark is to prevent scintillation, which, in gunpowder, would be an exceedingly dangerous quality. All who are accustomed to charcoal fires, must have noticed how the bark of charcoal shoots into coruscations; indeed, the experimental chemist carefully selects, for the purpose of showing the combustion of charcoal in oxygen gas, such portions of charcoal as are supplied with bark; and which, in consequence, beautifully scintillate.

Having sketched the mode of purifying the ingredients of gunpowder, let us now proceed to the manufacture of this substance.

The saltpetre, melted as already mentioned, and allowed to cool into flat cakes, is taken to the mill, placed on the bed of the trough, and broken to pieces by a hammer. The mill-stones being then set in motion, it is reduced to the state of coarse powder; in which condition it is removed to another mill, very much like that used for grinding corn, and reduced to impalpable powder. The charcoal and sulphur being pulverised in a similar manner, all these ingredients are taken to the mixing house, and weighed out into the proper quantities. Then the charcoal is spread in a trough, and the sulphur and nitre being sifted upon it, all these ingredients are incorporated by the hands. The components being thus imperfectly mixed, are taken to the powder-mill, which is a brick building with a light boarded roof. In the midst of this apartment is a circular trough,
provided with a cast-iron, or stone bed, on which revolve two mill-stones, attached to a horizontal axis, and each weighing from three to four tons. Manufacturers are forbidden by law to employ in these operations more than forty-two pounds of composition at a time, on account of the frequent accidents which take place.

The danger varies according to the degree of trituration to which the materials have been exposed; usually, however, it is not great: partly on account of the materials not being perfectly mixed, or if mixed, not grained, and in all cases damp; a little water being purposely added during the operation, though not enough to form a paste. The time during which the operation must be continued differs according to the goodness of the powder required, the nature of the atmosphere, and some other circumstances. At the Government mills, the time is usually three hours, and in general terms, we may say, from one to six hours. Time, however, is never made a criterion; but great attention is given to a certain plasticity which the mass ultimately acquires; when, in the workman's language, it is said to be "alive." It then glides from beneath the stones without attaching itself to them; and, under the name of mill cake, it is broken up and conveyed to the press-room.*

* Formerly a pestle and mortar were employed for the purpose of incorporating the materials. See Hanzelet, Recueil de
AND EXPLOSIVE COMPOUNDS.

The next operation consists in spreading this millcake on alternate copper plates, in layers of three inches thick, until the press is full; when a compressing force is applied either by the screw and capstan, or by Bramah's hydrostatic engine. The latter was first employed for this purpose by Sir W. Congreve, and of course is much more powerful than any other; but it is found that the extreme compressing force capable of being exerted by this machine must not be applied; for in that case the mass is rendered so compact as materially to interfere with the rapidity of combustion:—in other words, the resulting powder is deteriorated.

The next operation is that of corning, or graining; —a very ingenious contrivance, without which gunpowder would burn so slowly as to be inapplicable to most purposes. The graining is accomplished in the following manner:—In the graining house are sieves, the bottom of which are made of thick parchment, prepared expressly for this purpose from bullocks' hides, and perforated with small holes. These sieves are so arranged that they can be put in rapid circular motion by the aid of machinery, and each sieve

*plusieurs Machines Militaires, &c., 1620, p. 15, plate. On a larger scale a kind of fulling mill was used. See *Modelles Artifices de Feu, &c.*, by Boilet Langrois, 1620, p. 98. A modification of this latter apparatus seems to be used now by preference in France, under the name of *Pilon Mill.*—*Memoir on Gunpowder, by John Braddock, Esq.*, 1832, p. 47.*
contains two discs of lignum vitæ. Into the sieves is placed the mill cake just described, which, by the circular motion to which it is subjected, and the friction of the discs of lignum vitæ, is forced, in the state of grains, through the minute holes of the parchment. These, however, are not all of the same size, but require to be separated into various lots by the agency of different sieves.

The next operations are drying* and glazing, without the latter of which gunpowder would look dull. Glazing is accomplished by placing the grains in a barrel fixed on a horizontal axis, and made to revolve with great velocity. It will be seen from this that the glazing is due to friction; consequently some powder dust must result. This is separated from the grains by means of a gauze cylinder, into which the whole material is put, and subjected to violent rotation, during which the dust flies off, and the polished grains remain in the cylinder. The operation is now finished.

* Drying is now usually conducted by steam, at a temperature of just sufficient to drive off the water, but far from melting the nitre and sulphur. Hence gunpowder is always more or less attractive of moisture. Lieutenant Bishop (vide Braddock, sup. cit.) proposed the daring scheme of exposing gunpowder, at its last stage of manufacture, to a temperature of 500 deg. Fahr., by which the nitre and sulphur entering into its composition might be actually melted, and thus envelop the charcoal in a dense coat! Gunpowder thus prepared would certainly be less hygrometric than usual, but I would rather not be engaged in manufacturing it.
Most persons are aware that cannon and mining gunpowder is not so finely grained as powder for muskets, and this not so finely as gunpowder intended for fowling-pieces: though sporting powder is grained more coarsely than formerly, and the change found advantageous. Fineness of grain increases the rapidity of ignition, a quality necessary for the projection of small weights, whereas a certain tardiness of ignition is requisite for the projection of large balls and shells, mining, &c. It would perhaps be more correct to say, that the fineness of the grain should always be in proportion to the quantity employed. If several pounds of powder be used for the purpose of projecting a ball, the large grained variety will be found to accomplish the greatest distance: if only, on the contrary, a few ounces, the small grained has the preference.*

Certain varieties of gunpowder, especially some kinds manufactured for the African musket, are made to shine, as the cheeks of fire-places are made to shine, with black-lead; the negroes seemingly thinking that gunpowder which approaches their own complexion most is surely best. Of course, gunpowder is deteriorated thereby for general purposes: it is the very best, however, that can be employed in African muskets, formed as the barrels of many of them are out of veneered gas-pipe. Fired with really good powder they would, probably, kill at both ends.

* Wilkinson on Engines of War, p. 176.
Seeing the great amount of mechanical skill requisite to form gunpowder, and the chemistry which is involved in purifying its ingredients; it will perhaps be interesting to ascertain how our ancestors managed to form this compound. The earliest descriptions I have been enabled to find relative to this subject are of the years 1540,* 1588,† and 1620.‡

With regard to the proportion of ingredients in ancient gunpowder, I shall treat more fully hereafter. At present let us direct our attention to the mechanical details of preparing it. All those who are aware of the great extent to which gunpowder may be modified, solely by more or less perfect mixture and graining, the composition remaining the same—and who can appreciate the numerous ingenious mechanical resources which modern ingenuity has enabled the manufacturer of gunpowder to avail himself of—will be prepared to expect that the ancient powder must have been very deficient in many of the qualities necessary to constitute perfection. Our forefathers, however, proceeded very ingeniously to work, as we shall see. In the first place, they prepared charcoal of exquisite

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* Biringuccio (Vanucchio), De la Pirotechnia, 4to, Venetia, 1540.
† Machiavelli Nic. The Arte of Warre, transl. by Peter Whithorne, 1588, p. 27.
‡ Hanzelet's Recueil de plusieurs Machines Militaires, &c., 1620, p. 15; and Modelles Artifices de Feu, &c., par Boilet Langrois, 1620, p. 86.
fineness by burning the softest woods,—nay, sometimes linen rags and straw; the latter substance, however, is decidedly improper, owing to the large amount of silicic acid, or flint, which it contains. The sulphur was purified by sublimation, like a good deal of ours; and then they obtained it in a state of impalpable powder. The treatment of the saltpetre was, however, quite different from that followed by ourselves. Every one conversant with chemistry is aware that this salt may be obtained in a state of impalpable powder by dissolving the crystals in the smallest possible quantity of water, then applying heat to vaporise this water, stirring the solution all the time incessantly. Now, the ancient gunpowder manufacturers very ingeniously took advantage of this circumstance, to secure perfect mixture of the three ingredients. The saltpetre was first dissolved; then, the sulphur and charcoal being added, the mixture was stirred assiduously; by which means all three ingredients were mixed very effectually. As for the graining, our forefathers must have succeeded but indifferently; the mixture was moistened with vinegar, wine, brandy,—more frequently than water; indeed this process was thought to add strength to the powder; and it was imagined that vinegar, wine, brandy, &c., being what are popularly called "strong" fluids, were necessarily more efficacious than mere water. Various other nostrums were also occasionally added in this stage; all detrimental, however, to the
resulting powder.* The next stage consisted in granulation; no previous condensation by pressure having been thought necessary; or perhaps the process had not been thought of.† The granulation was conducted exactly as at present.

Now, it follows from a consideration of the foregoing circumstances, that, however pure might have been the ingredients, however intimately mixed, the grains of powder must have been deficient of hardness and tenacity; and hence the result must have been very imperfect. That such was the case is evident enough, from the reiterated directions which are given in all ancient books treating of gun practice, not to bruise the grains by ramming too hard.‡

It would be interesting to ascertain where and

* Machiavelli, transl. by Whithorne, lib. ii. chap. xiii. For an account of the ancient gunpowder manufacture, the reader may also consult Birincucio, De la Pirotechnia, Hanzelet's Recueil de plusieurs Machines Militaires, and Boillet Langrois' Modelles Artifices de Feu, &c. In the two latter works the process is illustrated with cuts. The first of the series in Boillet Langrois represents a monk weighing out the ingredients, assisted by a somewhat unworthy colleague for a divine, i.e., the Devil.

† Although pressure is now invariably employed previously to graining, the projectile force of the gunpowder is thereby diminished; however, it is rendered more compact and less hygrometric and light than before—advantages more than compensatory for a deficiency of range. See Braddock's Memoir, p. 58.

when gunpowder first began to be grained; for unquestionably this circumstance must have greatly enlarged the sphere of its application. This, however, I have been unable to determine. The earliest descriptions of gunpowder manufacture which I have succeeded in finding, are those already quoted; and were written at periods when its manufacture must have been subjected to great improvement.

It should be mentioned, that so long as matchlocks were used, the powder used for priming was literally powder—in other words, it was not grained. This was called "serpentine powder," deriving its name from that part of the lock which retained the match, and termed the "serpentine;" it corresponds to what we call the cock.

We have hitherto paid no regard to the relative quantity of ingredients in ancient gunpowders,—the proportions varied exceedingly at different times, as will be seen by the subjoined examples.

Tartaglia* gives twenty-five different compositions for gunpowder. I subjoin the first and the last—which at the same time are the strongest and the weakest.

**POLVER DI BOMBARDA AL MODO PIU ANTIQUO.**

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salnitro</td>
<td>1</td>
</tr>
<tr>
<td>Solfere</td>
<td>1</td>
</tr>
<tr>
<td>Carbone</td>
<td>1</td>
</tr>
</tbody>
</table>

* Quesiti e inventioni diversi, lib. iii. Ques. 5, Venetia, 1546.
Both these compositions must have yielded a very imperfect powder; it is difficult to imagine that the first could have had any formidable projectile effect.

Some of the other proportions, moreover, would yield powders scarcely more powerful than the composition of a squib; and altogether inapplicable to the purposes of modern warfare. We must not conclude, nevertheless, that this circumstance arose from ignorance of better proportions: a far more plausible explanation of the fact is, that guns were then so weak, that stronger powders would have destroyed them. No doubt the proper ratio of ingredients to form good gunpowder can be determined \textit{à priori}, from a consideration of chemical laws; yet it is a remarkable fact, that some time before chemistry was thus far advanced, manufacturers had, by dint of mere experience, discovered the best proportions; wherefore the chemist in this respect cannot now lend them any aid. The last great improvement in gunpowder consisted in the use of the cylinder charcoal already mentioned; when the material, thus formed, acquired such ad-

\begin{tabular}{lll}
Salnitro raffinato & . & parti 18 \\
Solfere & . & . & 2 \\
Carbon de legno de nizzolar & . & . & 3 *
\end{tabular}

\footnote{Machiavelli has copied these tables in full. See Whithorne's Translation, p. 31, lib. ii.}
ditional strength that the proportion of ordnance charges was in consequence reduced one-third.*

If gunpowder, as now prepared, have any fault, it consists in being rather too strong. If desirable, the strength of powder might, by mere peculiarities of manipulation, be still further increased, without any alteration of the ingredients or their proportions;—indeed, Sir William Congreve did make some of this gunpowder, but it was found to explode on percussion, besides being in other respects highly dangerous, and therefore inapplicable. Persons who anticipate the accomplishment of a long range by the use of dangerous fulminating compounds, hereafter to be described, should well consider this fact.

Subjoined is a table of the composition of gunpowder for different purposes, and the chemical results of its inflammation:—

<table>
<thead>
<tr>
<th></th>
<th>Atoms.</th>
<th>Theory (per cent.)</th>
<th>Practice (per cent.)</th>
<th>Results of Combustion</th>
<th>Atoms.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Nitre</td>
<td>102</td>
<td>63·35</td>
<td>65</td>
<td>{1 Bisulphuret of}</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>{Potassium}</td>
<td></td>
</tr>
<tr>
<td>2 Sulphur</td>
<td>32</td>
<td>19·87</td>
<td>20</td>
<td>1 Nitrogen .</td>
<td>14</td>
</tr>
<tr>
<td>4½ Carbon</td>
<td>27</td>
<td>16·77</td>
<td>15</td>
<td>{1½ Carbonic Acid}</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>{3 Carbonic Oxide}</td>
<td>42</td>
</tr>
<tr>
<td>Total</td>
<td>161</td>
<td>100·00</td>
<td>100</td>
<td>Total . .</td>
<td>101</td>
</tr>
</tbody>
</table>

### FINE SHOOTING POWDER.

<table>
<thead>
<tr>
<th></th>
<th>Atoms</th>
<th>Theory (per cent.)</th>
<th>Practice (per cent.)</th>
<th>Results of Combustion</th>
<th>Atoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Nitre</td>
<td>408</td>
<td>77·71</td>
<td>78</td>
<td>{3 Sulphuret of }</td>
<td>168</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>{Potassium }</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>{1 Carbonate of }</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>{Potash }</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>{4 Nitrogen }</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>{10½ Carbonic Acid }</td>
<td>231</td>
</tr>
<tr>
<td>3 Sulphur</td>
<td>48</td>
<td>9·14</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11½ Carbon</td>
<td>69</td>
<td>18·14</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>525</td>
<td>99·99</td>
<td>100</td>
<td>Total</td>
<td>527</td>
</tr>
</tbody>
</table>

### COMMON SHOOTING POWDER.

<table>
<thead>
<tr>
<th></th>
<th>Atoms</th>
<th>Theory (per cent.)</th>
<th>Practice (per cent.)</th>
<th>Results of Combustion</th>
<th>Atoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Nitre</td>
<td>102</td>
<td>75</td>
<td>75</td>
<td>{1 Sulphuret of }</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>{Potassium }</td>
<td></td>
</tr>
<tr>
<td>1 Sulphur</td>
<td>16</td>
<td>11·76</td>
<td>12·5</td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>3 Carbon</td>
<td>18</td>
<td>13·23</td>
<td>12·5</td>
<td>3 Nitrogen</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3 Carbonic Acid</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>136</td>
<td>99·99</td>
<td>100·0</td>
<td>Total</td>
<td>136</td>
</tr>
</tbody>
</table>

The enormous force of inflamed gunpowder is known to depend on the evolution of various gases, the volume of which, when cooled, it is easy enough to determine; but at the moment of their formation they are vastly dilated by heat, so that their actual effective volume and pressure cannot be justly ascertained. It has been pretty correctly determined that a cubic inch of gunpowder is converted by ignition into 250 cubic inches of permanent gases, which,
according to Dr. Hutton, are increased in volume eight times at the time of their formation by the expansive influence of heat. Assuming these data to be true, gunpowder confined and ignited in a cavity only large enough to hold it will exert, at least, a force of 14,750 lbs. on every square inch.*

The above conditions, however, do not obtain in respect of gunpowder employed as a gun charge; the ball or other projectile being displaced before complete ignition of the powder. The experiments of M. Piobert have rendered probable the assumption that the ordinary maximum pressure of gunpowder on a projectile lies between 2,000 and 3,000 lbs. per square inch.

Before concluding our notice of gunpowder, it may not be amiss to point out certain indications of its good and bad qualities. Its colour should be rather brown than black; the grains should be firm; not crushing by the pressure of the finger; not clotted together, and totally devoid of smell. Such are the physical qualities of good gunpowder; its chemical characteristics shall be mentioned presently. The disagreeable smell which sometimes arises from bad gunpowder is referable to the application of an undue amount of heat in the fusion of the nitre. This effects

* A force almost as great was exerted, as before stated, on the cylinder of one of the hydrostatic presses used in launching the "Leviathan" before rupture.
the decomposition of the salt, causing it to yield up
the elements of its acid, either totally or partially; thus
leaving nitrate of potash and free potash as residues.
In this way not only is the powder weakened by
the absence of the requisite quantity of nitre, but
potash is itself deliquescent, and moreover, by re-
acting on the sulphur, forms sulphuret, or sulphide, of
potassium; this, in its turn, reacting on aqueous
moisture, yields hydro-sulphuric acid gas, to which the
disagreeable odour adverted to is attributable. The
simplest plan of analysing gunpowder (as to the
relative proportions of its true ingredients) is by first
dissolving out the nitre by means of pure water; then
the sulphur by aid of a solution of potash; thus isolat-
ing the charcoal. Each of these substances, when
dry, may be weighed.

The solution of nitre should neither precipitate
nitrate of silver (indicative of the presence of common
salt and carbonate of soda), nor blacken a solution of
acetate of lead (indicative of the presence of hydro-
sulphuric acid), nor change turmeric paper brown, nor
litmus paper red; the former would be indicative of
an alkali, the latter of an acid.

We have seen that mechanical aid contributes no
less than chemistry to the perfection of gunpowder;
therefore other means of forming a judgment, in addi-
tion to chemical tests, become necessary. Manufac-
turers are in the habit of paying great attention to the
manner of its burning; whether it ignite rapidly or slowly, whether it scintillate or not:—whether it leave much residue, and on the contrary, &c. &c. There are also instruments called "eprouvettes" for ascertaining the comparative force of powder; but in our Government service the force of gunpowder is ascertained by trying the power of a given quantity in projecting a known weight. A charge of four drachms of fine-grained or small-arm powder is expected to project a steel ball with the requisite force to perforate a certain number of half-inch wet elm planks, placed three-quarters of an inch asunder; the first being thirty feet from the muzzle of the barrel.* A charge of four ounces of cannon powder must be capable of projecting, from an eight-inch Gomer mortar, a sixty-eight pound iron shot not less than 380 feet.

Few persons can be aware of the enormous quantities of gunpowder used for military purposes. At the siege of Ciudad Rodrigo, in January, 1812, 74,978 pounds of gunpowder were consumed in thirty hours and a half; at the storming of Badajos, 228,830 lbs. in 104 hours; and this from the great guns only!† At the first and second sieges of San Sebastian,

* The Government powder labelled T.P.F., when new, propels the ball through fifteen or sixteen boards; and when restored, through nine to twelve.—Wilkinson's Engines of War, &c., p. 177.

502,110 lbs.* were used; and at the siege of Zaragossa, the French exploded 45,000 lbs. in the mines, and threw 16,000 shells during the bombardment †

During the siege of Sebastopol, extending over a period of eleven months, the enormous quantity of 2,775,360 lbs., or 1,239 tons of gunpowder were expended by ourselves alone; 9,076 tons of shot and shell having been launched by us on that memorable occasion, from 476 pieces of heavy ordnance; of which only 11 actually burst, though 269 were rendered unserviceable.

* From the returns made to the Royal Arsenal, Woolwich.
ON THE
APPLICATION OF GUNPOWDER TO
MILITARY PURPOSES.

This subject is, as I have already remarked, distinct from the discovery of gunpowder; it may be considered under the following heads:—

The application of gunpowder to the purpose of projecting weights from tubes.

The application of gunpowder to the purposes of mining.

The application of gunpowder to effect the bursting of hollow spheres—called shells, grenades, &c.

The application of gunpowder in elaborating the rocket.*

When treating of the history of gunpowder, we carried its invention, by reference to documents, to a period anterior—how much we knew not—to the period of Marcus Græcus, or Gracchus, who lived in the eighth century. I mentioned, however, the pro-

* Chemically speaking, the material for filling rockets is gunpowder—i.e., a mixture of nitre, sulphur, and charcoal; although the proportions of these ingredients are different from those of common gunpowder.
bability that it had been known in Asia from time immemorial, and quoted several treatises having reference to this subject. Without adverting to the latter again in detail, it may be sufficient to remark, that not only do they refer to gunpowder, but also in most instances to guns: this remark applies most particularly to the Gentoo laws, which were printed by the East India Company in 1776. Whatever truth, however, may be accorded to those oriental documents (and collateral testimony would seem to be in favour of their credibility), it is certain that the period when fire-arms were introduced from Asia into Europe is either forgotten (no record of it having been made), or that the European employment of these weapons was altogether due to a fresh discovery. Marcus Græcus, although he mentions gunpowder and its application to many pyrotechnical devices, says nothing about its application to guns, which can scarcely be accounted for on any other supposition than that he was unaware of their existence.

This circumstance is in favour of the opinion that the employment of fire-arms in Europe was the result of an European discovery. Another circumstance may be mentioned to the same effect, although it does not rest on very good testimony.

The reader has already been made aware that the Germans claim the invention of gunpowder for their countryman Bartholdus Schwartz. We have already
discussed that claim, and proved that he has no pretensions of the kind whatever;—this is indisputable; yet it does not seem so clear that he might not have originated the idea of applying the force of gunpowder to missile weapons. It is said that this individual was operating in a mortar on a mixture of nitre, charcoal, and sulphur (gunpowder, in fact)—that the mixture exploded, urging the pestle to a considerable distance,—that hence originated cannon, and also the military term "mortar" as applied to a particular variety of cannon.

All this seems plausible enough, and may be true; but seeing that the use of fire-arms first became prevalent in Europe in those countries the people of which mixed with the Saracens, and that cannon are described by Arabian authors as early as 1312; considering, moreover, the scientific character of this people, and duly weighing the testimony of oriental nations, I am constrained to lean to the opinion that fire-arms were not re-invented in Europe.

Guns may be divided into artillery (in its modern acceptation) and small arms; not that the division is very correct, inasmuch as ancient small arms were all cannon, yet the division will answer our purpose.

The term cannon is most probably derived from καννα, or in Latin canna, a reed, although some persons refer it to the Greek κανών, signifying the beam of a steel-yard, a reed, cane, rod, &c. Older
military writers make use of the term cannon just as we do barrel, including that part of all fire-arms, whether large or small. We restrict it to artillery.

The first cannon were called bombardae, from βομβος, or a bombo et ardore, on account of the great noise which the firing of them occasioned.

A very few words will suffice to express all we know relative to the first employment of cannon in European warfare. It is generally believed that they have been commonly employed since the year 1338; at least Father Daniel, in his Life of Philip of Valois, seems to have proved this from the records of the Chamber of Accounts at Paris. Du Cange, indeed, finds them mentioned in Froissart and other French historians some time earlier. Although the French employed cannon in 1338, for the purpose of demolishing some castles, they did not use them in the field so soon as the English, who, in 1340, under Edward III., placed five of them on a small hill near the village of Crécy;* and this, it is said, contributed not a little to the success of that celebrated battle. This circumstance has been quoted by some French authors as a proof of our greater barbarity, in setting the example

* This fact is doubted by some. Froissart does not mention it, which is not easy to account for, if it were true. We have, however, the testimony of Petrarch to show that cannon were common before the year 1344, nuper rara nunc communis. According to Babour, Edward III. was supplied with cannon as early as 1327.
of killing our fellow-creatures by such murderous engines.

"On ne faisait" (says one of them) "point encore usage en France, en 1547, de cette arme terrible contre les hommes; les Français s'en étoient bien servis en 1338, pour l'attaque de quelques châteaux, mais ils rougissoient de l'employer contre leurs semblables. Les Anglois, moins humains, sans doute, nous devancèrent et s'en servirent à la célèbre bataille de Creçi, qui eut lieu entre les troupes du roi d'Angleterre, Edouard III., qui fut si méchant, si perfide, qui donna tant de fil à retordre à Philippe de Valois, et aux troupes de ce dernier; et ce fut en majeure partie à la frayeur et à la confusion qu'occasionnèrent les canons, dont les Anglois se servoient pour la première fois, qu'ils avoient postés sur une colline proche le village de Creçi, que les Français dirent leur déroute."

In the time of Henry III. of France, the use and practice of artillery was still in its infancy; D'Etrees, the master-general of the ordnance in 1558, was the first who made any progress in the construction of batteries. Before his time, continual accidents occurred from the bursting of cannon, and it was usual to cool them with vinegar, in order to prevent these misfortunes: scarcely a worse plan could have been followed. Armies were at this period but slenderly provided with cannon, which were thought chiefly necessary for
sieges; at least such was the opinion in France.* In England, however, the science of artillery was further advanced; and Lord Herbert observes, that in 1544 Henry VIII. had invented small pieces of artillery to defend his wagons.† When cannon were drawn by horses instead of oxen, and could keep pace with a moving army, it was thought to be a great achievement.

Before the fifteenth century, cannon were designated by various fanciful names; then, however, they began to be indicated by the weight of their balls, as at present. Much celebrity was formerly acquired by several cannon in various countries, but the most famous of all seems to be that enormous gun used by Mahomet II. against the Greeks, at the siege of Constantinople, in 1453. It was cast at Adrianople, by a Dane or Hungarian named Urban, who had deserted from the Emperor Constantine Palæologus. It is thus described by Gibbon: "At the end of three months, a piece of brass ordnance was produced of stupendous and almost incredible magnitude; a measure of twelve palms is assigned to the bore, and the stone bullet weighed above 600 lbs. A vacant place before the palace was chosen for the first experiment, but to prevent the sudden and mischievous

† Figures of these gun-wagons may be seen in Grose's Treatise on Military Armour.
effects of astonishment and fear, a proclamation was issued that the cannon would be discharged on the ensuing day. The explosion was felt or heard in a circuit of 100 furlongs; the ball, by the force of gunpowder, was driven above a mile, and on the spot where it fell it buried itself a fathom deep in the ground. For the conveyance of this destructive engine a frame or carriage of thirty wagons was linked together, and drawn along by a team of sixty oxen; 200 men on both sides were stationed to poise and support the rolling weight; 250 workmen marched before to smooth the way and repair the bridges, and near two months were employed in a laborious journey of 150 miles."

Any person who has the slightest mechanical knowledge must be aware that the formation of a cannon, or, indeed, of any other fire-arm, is necessarily a somewhat difficult task, requiring various mechanical contrivances only to be met with in comparatively civilised countries. It is not to be wondered at, therefore, that the resources of our ancestors were but slightly adequate to this end. The first cannon employed were nothing more than bars of iron arranged in such a manner that their internal aspects should form a tube; the bars were not welded, but merely confined by hoops. On some occasions, expedients much less efficient than this have been had recourse to; cannon having been made of coils of rope arranged
in a tubular form, and even of leather, or of wood. Of course nothing like perfection of form, or bore, was then attempted, indeed was not desirable; inasmuch as no amount of science, either mathematical or chemical, was then applied to artillery practice.

Cannon seem long after their first invention to have been regarded with a sort of awe and mystery—the flight of their projectiles was considered to be totally different from all other projectiles, and the wounds occasioned by fire-arms generally, were thought to be all but necessarily mortal.*

Tartaglia, an author already quoted in reference to the composition of gunpowder, was the first to apply mathematical reasoning to the practice of artillery; he took considerable trouble to prove the now well-known fact, that, no portion of the flight of a cannon-ball was a straight line; but that a curve was described from the very beginning of its course: he, moreover,

* This might easily be accounted for by the unskilful surgery of those days. The army surgeons were assuredly the most effectual of all destructive engines. I remember meeting with a recipe for a gunshot wound, which I cannot now recollect in its details, neither the authority. The prescription was, however, somewhat to this effect:—Take of oil and of wine equal parts, boil them, and then project into them a dog yet living; the animal was to be well boiled; and his flesh, together with the oil, wine, and other ingredients, formed the application!

† See his Nova Scientia, published at Venice, in 1587, and his Quesiti ed inventioni diversi, Venice, 1546.
proved, that a cannon shoots furthest at an elevation of 45 deg. Tartaglia, moreover, is reputed to have discovered the gunner's quadrant.

It remained for the great Galileo, and his pupil Torricelli, to investigate more narrowly the law of falling bodies. Tartaglia proved that a cannon-ball, when shot from the gun, moved in a curve; Galileo determined that this curve was the parabola, provided the ball fell on the same plane as the battery from which it was shot, and that the gun was elevated above the horizon; he proved, moreover, it was half a parabola, provided, under the same circumstances, the gun were pointed horizontally.

Torricelli extended these discoveries; he showed that whether the ball fell above, or below, the plane of its projection, it described a parabola of smaller or larger amplitude, according to the angle at which the gun was elevated, and the strength of the power.

Before the time of Galileo, artillery practice was imperfect, chiefly because no mathematical knowledge whatever had been applied: after the time of this philosopher, artillery practice was imperfect, chiefly because his views were too exclusively adopted; without attaching due importance to collateral and interfering causes.

Moving as we do slowly through the atmosphere, which cleaves and mingle again so that it has become the very type of non-resistance; we are scarcely com-
petent to judge of the immense force which it exercises against a projectile moving with great velocity. Galileo's experiments were performed with slowly moving bodies, on which atmospheric resistance could have had but little effect; so that the parabolic curve would have been but slightly departed from: hence he did not fully appreciate the influence attributable to this cause. Galileo, however, was not unaware that the air really did exercise some resistance; but he believed it to be more insignificant than it is.

The views of Galileo were adopted almost universally. Our countryman Anderson* laboured hard to prove their correctness, and M. Blondel, in France,† maintained a similar opinion. Dr. Halley, in 1686, expressly asserts, that "in large shot of metal, whose weight many times surpasses that of the air, and whose force is very great in proportion to the surface wherewith they press thereon, this opposition is scarce discernible," and he infers from the result of observation, that "although in small and light shot, the opposition of the air ought, and must be accounted for, yet in shooting of great and weighty bombs, there need be very little or no allowance made."‡ Artillerists might have been led to doubt the truth of this determination of Dr. Hutton, by the authority of a still

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* Genuine Use and Effects of the Gunne, 1674.
† Art de jeter les Bombes, Par. 1683.
‡ Phil. Trans., No. 179, p. 19.
AND EXPLOSIVE COMPOUNDS. 123

greater name—Sir Isaac Newton, who, in 1687,* demonstrated that the curve described by a projectile, in a strongly resisting medium, differed from a parabola; and that the resistance of the air was great enough to make the difference between the curve of projection of heavy bodies, and a parabola, far from being insensible; and therefore too considerable to be neglected. Huygens in 1690 made a similar statement.

Notwithstanding the testimony of two such names, and better testimony still—that of practice, the error of Galileo continued to be propagated. Blondel had calculated tables according to this theory, and they were pronounced incontrovertible.

In 1716, however, M. Ressons, a French artillery officer, did not hesitate to assert, in a memoir presented to the Royal Academy,† that the theory was of very little service in the use of mortars, and that practice had convinced him there was no theory in the effects of gunpowder.

It may be asked, why it was that the errors of the parabolic theory were perpetuated, when there was so easy a test as actual practice to determine their value? The answer is, that many were paralysed by the great name of Galileo, and did not venture to think for themselves; others there were who attributed the

* Principia, lib. ii. § 7.
† Discours de la Cause de la Pesanteur, Leide. 1690.
want of accordance existing between theory and practice, to some interfering cause;—anything, however, but the true one.

Our countryman Anderson, whom I have quoted more than once, endeavoured to strengthen the doctrine of Galileo by appending to it a very curious one of his own. He granted that cannon-balls, like other projectiles, ultimately began to describe in their course the parabolic curve—but that, before they did this, they continued to be impelled for a certain period in a perfectly straight line, which he termed "the line of the impulse of fire." In this state of uncertainty did this theory of projectiles remain, until Mr. Robins published, in the year 1742, his treatise, called "New Principles of Gunnery." The principles developed in this treatise were soon after confirmed by M. Euler, of Berlin; M. Leroz, of Paris;* and by Dr. Hutton.

It does not form part of the scheme of this book to detail the various experiments or mathematical calculations by which Mr. Robins arrived at his celebrated result. This much generally may be mentioned, however, that having devised experiments and made calculations, which at this day are admitted to be correct (at least in all their leading particulars), he proved that the parabolic theory, as applied to projec-

* Mém. Acad. Scien. for 1751.
tiles urged with slow velocities, was not far at variance with practice; but that the same theory, when applied to rapidly moving bodies, such as shot and shells, was utterly false; that the fallacy was occasioned by atmospheric pressure chiefly; and that the pressure in question increases with such enormous rapidity, compared with increase of projectile force, that the ratio between the two could not be calculated.

If this assertion be true (and no one at all conversant with the subject doubts it), what becomes of the opinions—the visionary hopes of those who think to accomplish unheard-of ranges by increase of projectile force? Granting that the atmosphere exerts a resistance increasing with the velocity of a ball, it is evident that a point at length must be arrived at, when both these forces, namely, the projectile force of the ball and the resistance of the atmosphere, are practically equal—beyond this no increase of projectile force can increase the ranges; simply because in the same ratio as an explosive material, be it gunpowder or anything else, urges a body forwards, the air forces it back. These are the limits of theory; but in practice we cannot go so far. I have supposed it possible to find cannon strong enough to withstand this projectile effort—balls strong enough to resist the shock without breaking—and gunpowder possessing just the required degree of force; neither more or less:—all this is out of the question.
These arguments have tended to prove the impossibility of accomplishing more than a given range, by any increase of initial power whatever; I do not assert that such range may not be increased by other appliances—this consideration will be reserved for a later period. Let me now proceed to observe, that the public, at least the non-chemical public, attach a very incorrect signification to the words "strong" and "strength;" for instance, oil of vitrol is said to be a strong substance, and water a weak one; yet a chemist has great difficulty to understand what is meant by such an application of the term.

The words "strong" and "strength" are, in point of fact, very fallacious; and, therefore, the notion which the public have of projectile weapons and projectile compounds, is, among other things, very incorrect.

An ounce of gunpowder fired loosely scarce makes a noise; a little smoke, a little fire, a little smell of sulphureous gas, and all is over;—yet the same ounce of powder, in a musket, would be an immense charge; far more than necessary to urge with deadly effect a heavy leaden ball.

An ounce of fulminating silver, on the other hand—nay, but who would dare to handle an ounce of such a substance?—say the ninety-sixth part of an ounce, or just five grains; well, five grains of fulminating silver are taken out of a paper, with much trembling;
touched with no hard substance, for fear of explosion; then gently laid on a piece of metal—say a penny-piece. Let us now suppose it ignited by means of a very long stick, with a match at one end, and—begging the operator's pardon—with a somewhat rash man at the other. What is the result? A terrible crash, which deafens the operator for some days; and the penny-piece is almost bent double! "How strong!" exclaims a non-chemical operator; "how well this will project a ball." He tries a small charge in a musket, and what are the results? Why, the gun is burst; the iron literally rent into threads, and fragments: the ball perhaps is projected, but to a very inconsiderable distance; if of lead, flattened as if by a hammer; if of cast iron, broken into fragments! Now, which shall we say is the stronger substance, gunpowder or fulminating silver? *

The force of all explosive bodies depends on the gases which are liberated during explosion, and the peculiar effects of their explosion depend on two separate circumstances; the total quantity of gas eliminated, and the rapidity of its elimination. Gunpowder, perhaps, compared weight for weight with

* Chemists are acquainted with two kinds of fulminating silver. The kind here alluded to is the white compound termed, in chemical language, the "fulminate of silver." It is far less dangerous than the dark or ammoniacal fulminating compound, which, when made, can scarcely be removed from the containing vessel, so prone is it to explode.
fulminating silver, liberates more gas of the two, but not so rapidly—the liberation is progressive, not instantaneous; hence its immediate disintegrating effects are not so considerable as those of fulminating silver, but as a projectile agent it is more efficient. I just think of one more case, which will tend to show how different are the requisites for mere impulse and prolonged motion. Suppose a railway carriage on the line, ready to move on the application of proper force; suppose now a sixty pound cannon-ball to be fired at it "directly aft," as the sailors would say; the carriage would have a tendency to move forward; yet, instead of moving forward, it is shattered to pieces. One single man, however, applying his force, pushes it forward with great ease. Which agent, then, is the stronger of the two, a man, or a sixty pound cannon-ball in full flight? The question is foolish; yet not more foolish than many others of its class often asked by the non-scientific public. I trust, then, it has been shown that not even is there a theoretical limit to the rate of motion of a projectile, but that practically this extreme limit even cannot be attained; partly because of the want of cohesive strength in cannon and cannon-balls; partly because the quantity of gunpowder necessary to effect this would be inconvenient; and partly because all other explosive compounds are inapplicable.

At this period it will not be necessary to point out
elaborately all the reasons which could be adduced to prove how incorrect is the "practical" application of the parabolic theory; the first and best, and only one necessary to disprove the doctrine, is, that practice will not confirm what theory pronounced to be true. In all cases this is evidence enough.

It is evident that if no resistance save that of gravitation impeded the flight of a projectile, the trajectory curve should be merely vertical; that is to say, supposing the projectile to be spherical, and homogeneous in such a manner that its centre of gravity, and spherical centre, would correspond. True is it that such correspondence is not possible to be effected; and, consequently, the trajectory curve may be partly vertical, partly horizontal; even supposing the ball to fly "in vacuo." Deviation, however, from this cause should be very slight; and should increase in proportion to the distance from the mouth of the piece only. This, however, is contrary to experience; the same piece which will carry its bullet within an inch of the intended mark at 10 yards distance, cannot be relied upon to 10 inches in 100 yards, much less to 30 inches in 300 yards. This has been proved beyond doubt by Mr. Robins, who found that a perfectly fixed musket barrel would, when fired, project a ball with an accuracy, at 180 feet, sufficient to hit a mark one-seventh of a foot square, 15 times out of 16; yet, at a distance of 700 yards, the balls not
only varied as to their vertical plane, but sometimes went 100 yards to the right or left of the intended line.

Although this great deflection has been attributed chiefly to the air, I have not said how it is occasioned. It is partly attributable to the fact, that balls cannot be made without inequalities on their surface, on which the air must, therefore, act unequally; but the chief cause seems to depend on the irregular whirling motion which the ball acquires on leaving the gun, and which causes the ball to present its surface to the air in a direction very different from what it would do if there were no such whirl. Deflections from the causes enumerated will occur even if the ball fit the barrel perfectly. But there is yet another usual cause of deflection, namely, "windage," as the space is called between the shot and the barrel. This will be adverted to hereafter.

All these remarks concerning the irregular flight of projectiles, came under notice incidentally in connection with the Galilean theory of the parabola. Before, however, returning to the historical portion of our subject, I will lay before the reader a table of atmospheric resistance, &c., to the flight of balls.

The first column in this table contains the velocity in feet of a 24-lb. shot, projected at an angle of 45 deg.; the second column shows the distance in yards to which the ball would go in vacuo on a horizontal
plane; the third column contains the distance to which it will range through the air, considered all of the same density as at the earth's surface; the fourth shows the same range corrected for the diminution of the air's density as the ball ascends, and is, therefore, called the corrected range; and the fifth column shows the height to which the ball rises in the air, or the height of the vertex of the curve above the plane.

**TABLE OF THE MOTIONS OF A 24-LB. SHOT PROJECTED AT 45 DEG. OF ELEVATION.**

<table>
<thead>
<tr>
<th>Velocity per second</th>
<th>Range in vacuo.</th>
<th>Range in Air.</th>
<th>Range corrected.</th>
<th>Height to which the ball rises.</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>415</td>
<td>320</td>
<td>330</td>
<td>100</td>
</tr>
<tr>
<td>400</td>
<td>1,658</td>
<td>1,000</td>
<td>1,019</td>
<td>300</td>
</tr>
<tr>
<td>600</td>
<td>3,731</td>
<td>1,891</td>
<td>1,419</td>
<td>400</td>
</tr>
<tr>
<td>800</td>
<td>6,632</td>
<td>1,687</td>
<td>1,719</td>
<td>464</td>
</tr>
<tr>
<td>1,000</td>
<td>10,362</td>
<td>1,840</td>
<td>1,787</td>
<td>515</td>
</tr>
<tr>
<td>1,200</td>
<td>14,922</td>
<td>1,934</td>
<td>1,978</td>
<td>561</td>
</tr>
<tr>
<td>1,400</td>
<td>20,300</td>
<td>2,078</td>
<td>2,129</td>
<td>606</td>
</tr>
<tr>
<td>1,600</td>
<td>26,528</td>
<td>2,206</td>
<td>2,264</td>
<td>650</td>
</tr>
<tr>
<td>1,800</td>
<td>33,574</td>
<td>2,326</td>
<td>2,391</td>
<td>694</td>
</tr>
<tr>
<td>2,000</td>
<td>40,450</td>
<td>2,438</td>
<td>2,510</td>
<td>738</td>
</tr>
<tr>
<td>2,200</td>
<td>50,155</td>
<td>2,542</td>
<td>2,622</td>
<td>778</td>
</tr>
<tr>
<td>2,400</td>
<td>59,688</td>
<td>2,640</td>
<td>2,726</td>
<td>816</td>
</tr>
<tr>
<td>2,600</td>
<td>70,050</td>
<td>2,734</td>
<td>2,823</td>
<td>852</td>
</tr>
<tr>
<td>2,800</td>
<td>81,241</td>
<td>2,827</td>
<td>2,916</td>
<td>887</td>
</tr>
<tr>
<td>3,000</td>
<td>93,262</td>
<td>2,915</td>
<td>3,002</td>
<td>922</td>
</tr>
<tr>
<td>3,200</td>
<td>106,111</td>
<td>2,995</td>
<td>3,085</td>
<td>996</td>
</tr>
</tbody>
</table>

It may be observed by reference to this table, how immense is the difference between the motion of pro-
jectiles in air and \textit{in vacuo}, especially at high velocities. It is seen that the ranges instead of increasing in a duplicate ratio of the initial velocities, as "\textit{in vacuo}," really increase much slower; in all cases of military service, and in the most useful cases, viz., from 800 to 1,600 feet, they increase nearly as the square roots of the velocities.

Had it been my intention to write a treatise on artillery, together with the manufacture of cannon, \\&c., the present portion of the book would be vastly extended; such an idea, however, is altogether foreign to my views. I have thought fit to omit altogether the description of those fanciful names which were originally applied to cannon, and do not think it necessary to describe \textit{all} the varieties of this arm which are used at present in the naval and military services of this and other countries. The carronade, howitzer, mortar, and Paixhans gun, however, are varieties which cannot with propriety be omitted. It is obvious that various requisites are necessary for different purposes to which cannon may be applied. For penetrating walls, we require heavy balls moving at great velocities, the range being inconsiderable; for dismounting cannon and slaughtering troops, longer ranges, larger angles, and smaller velocities are more efficacious. For field service, the portability of a cannon becomes a chief requisite; at sea this is not so essential. The reader will see, then, that cannon
must necessarily vary a great deal as to length, bore, and other details of construction. With such ques-
tions we have little to do: those who may wish to become acquainted with this subject, I must direct to systematic works. The kinds of artillery, however, just mentioned, involve not merely mechanical detail, but important principles.

I will first describe briefly the Carronade, which derives its name from first having been made at the Carron foundry. It is a short cannon, of large calibre, made as thin as possible consistent with safety; chambered* and intended to project balls or shells with small charges. Besides these essential peculiarities, the carronade is not mounted like common guns, but stands on a grooved platform. The advantages of the carronade are, that, from its exceeding lightness, it may be employed by small ships, and on their upper decks, where much weight of metal is inadmissible,—although the locality is most advantageous as an attacking position; and it requires fewer men to work it, is managed with greater rapidity than common ordnance, and on account of the small charge of powder employed in loading it,† the ball is urged

* Chambered.—This word may require explanation. All long pieces of ordnance possess a bore of equal size from mouth to breech; mortars, carronades, and howitzers, however, are chambered, i.e., that part of their bore which contains their powder is narrower than the rest.

† The original charge was one-twelfth the weight of the
with diminished velocity, and hence with greater shattering effect. It was owing to this latter circumstance, that originally this piece of ordnance was termed a "smasher." Two of the naval officers who first used them on board their ships, were Captain Keith Elphinstone, since Admiral Lord Keith, and Captain Henry Trollope, since Sir Henry Trollope, the latter of whom, by means of two carronades or smashers, which he had on board his frigate, the Glatton, beat off several of the enemy's; who were panic struck on seeing the size of some of the shot which he fired into them. The Glatton's lower deck battery was entirely of carronades, chiefly 68 pounders. It is of some interest to remember that hollow shot were generally fired from smashers, because solid shot would have been too heavy; and occasionally the hollow shot, being charged and fused, became shells. Here, then, was the germ of the system of Paixhans. In 1782, the Cambridge, 80, then one of Lord Howe's fleet, was provided with carcasses for two smashers, and fired them when engaging the combined fleets, then endeavouring to prevent the English from relieving Gibraltar.* The shell must have been furnished to

ball; subsequently this quantity was increased to one-ninth, but disadvantageously. The carronade ball is cast exactly the size of the gun's bore, and the only allowance for windage is that diminution of size effected by the contraction of the ball during cooling.

* Elkin's Naval Battles. Dahlgren Shells and Shell Guns, p. 2.
AND EXPLOSIVE COMPOUNDS.

some of the English ships; for, in 1799, they were fired from the smashers of the Tigre, 74, into the French storming columns at Acre.*

**The Mortar.**—Perhaps this is the most ancient of all fire artillery; although not originally applied to its present purpose of throwing shells. The mortar may be defined to be a short cannon of large bore, chambered, and usually fixed at an angle of 45 deg., adapted for projecting shells, and formerly shot. From the very nature and construction of a mortar, it is evident that whatever mathematical science can be rendered applicable to the practice of artillery, is here most especially requisite. Were I writing a systematic treatise on artillery, a minute description of the parts of a mortar would be, of course, necessary; treating, however, in general terms of the force of explosive compounds in urging masses from tubes, all this detail will not be required.

The invention of mortars is commonly ascribed to the Germans; who are said to have employed them for military purposes in 1435, when Naples was besieged by Charles VIII.; but it is not certain whether shells were thrown out of them on this occasion. It seems, however, pretty well ascertained that they were used for this purpose at the siege of Wachtendonk in Guelderland, by the Earl of Mans-

* Allen, i. p. 509.
field, in 1588; in which year Cyprian Lucas described the mode of charging them.

At present, the largest description of mortar used in our service is the thirteen-inch; if made larger, in one piece, they are difficult to transport, and, moreover, it is next to impossible to cast so large a quantity of metal without flaws and other imperfections.

Sea service mortars are stronger than land service mortars of equal calibre, and bear stronger charges, and their ranges are further. Appended are the charges and range of 13 and 10-inch iron mortars respectively.

**Range of Iron Mortars at 45°.**

<table>
<thead>
<tr>
<th>Mortar Type</th>
<th>Charge</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>13-inch, land service</td>
<td>9 lbs</td>
<td>2800</td>
</tr>
<tr>
<td>13-inch, sea service</td>
<td>10 lbs</td>
<td>2800</td>
</tr>
<tr>
<td>Ditto</td>
<td>12 lbs</td>
<td>3400</td>
</tr>
<tr>
<td>Ditto</td>
<td>14 lbs</td>
<td>3500</td>
</tr>
<tr>
<td>Ditto</td>
<td>16 lbs</td>
<td>3900</td>
</tr>
<tr>
<td>Ditto</td>
<td>18 lbs</td>
<td>4100</td>
</tr>
<tr>
<td>Ditto</td>
<td>20 lbs</td>
<td>4400</td>
</tr>
<tr>
<td>Ditto</td>
<td>25 lbs</td>
<td>4700</td>
</tr>
<tr>
<td>Ditto</td>
<td>25 lbs</td>
<td>4850</td>
</tr>
<tr>
<td>Ditto</td>
<td>28 lbs</td>
<td>4500</td>
</tr>
<tr>
<td>Ditto</td>
<td>30 lbs</td>
<td>4500</td>
</tr>
</tbody>
</table>

**10-Inch Land Service at 45°.**

<table>
<thead>
<tr>
<th>Mortar Type</th>
<th>Charge</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-inch, sea service</td>
<td>6 lbs</td>
<td>2400</td>
</tr>
<tr>
<td>Ditto</td>
<td>5 lbs</td>
<td>2800</td>
</tr>
<tr>
<td>Ditto</td>
<td>8 lbs</td>
<td>3400</td>
</tr>
<tr>
<td>Ditto</td>
<td>10 lbs</td>
<td>3500</td>
</tr>
<tr>
<td>Ditto</td>
<td>12 lbs</td>
<td>3800</td>
</tr>
<tr>
<td>Ditto</td>
<td>20 lbs</td>
<td>4500</td>
</tr>
</tbody>
</table>
AND EXPLOSIVE COMPOUNDS.

Much variety exists as to the form of the chamber in mortars. The Spanish mortars have spherical chambers; the French, German, and Dutch, conical and cylindrical ones. The Portuguese, parabolical, and the English, generally in the form of a conic frustrum or cylinder.

The Howitzer is a piece of artillery which is chambered, and somewhat short; in these respects resembling a mortar; but, unlike the latter, it may be elevated and depressed. It is a very useful arm, and may be applied to most of the purposes of a cannon or a mortar.

Howitzers were originally designed as a substitute for mortars in field operations. They found most favour in Germany; Frederick the Great having been amongst the first to demonstrate their powers. None were cast in France until 1749.*

The Petard is an arm never, I believe, used in the present day. It is a kind of very short gun, mounted in a peculiar way, and intended to blow down gates, &c., by being fired with its muzzle close up to them. In former times, various curious devices were employed for preventing this close propinquity between the petard and the gate; one of the most curious of which was a kind of enormous rat gin, set in such a manner as to close at once on the petard

* Thiroux, 57; Meyer Timmerhaus, 23, 24.
and the soldiers applying it.* The idea never occurred to ancient artilleryman of blowing in gates, &c., by the mere explosion of bags of gunpowder hung against them, according to the system now followed.

* See an engraving of this gin in Hanzelet's Traités Militaires, 1598.
ON ARTILLERY PROJECTILES.

HAVING said thus much of artillery, it now remains to describe their projectiles. Mere CANNON-BALLS are so simple in their nature and uses that very little comment will be necessary. The reader is probably aware that, in the earlier periods of artillery, cannon-balls were formed, not of iron, but of stone; a material which is still employed by many semi-civilised nations.* Fire missiles may be divided into shot and shells; of the former, round shot or balls are the most simple, most commonly used, and their flight is most easily reducible to mathematical calculations. Besides round shot, there are bar shot, chain shot, grape shot, canister shot, spherical case shot, and perhaps some other varieties.

BAR SHOT is similar to a dumb-bell, and its effects must be obvious to every one. I need not observe, however, that its flight must be very irregular, and that it is totally unadapted for long ranges; indeed, so

* In former times other missiles were shot from cannon. Bolts and quarrels were thus used in the reign of Henry V. (1413); these were succeeded by stones. In 1418 Henry ordered the clerk of the works of his ordnance to procure labourers for the making of 7,000 stones for the guns of different sorts, in the quarries of Maidstone, in Kent.—DR. MEYRICK, p. 118; ANDERSON'S Hist. of Commerce, vol. vi. p. 351.
questionable are its advantages, that it is now, as well as the variety next to be mentioned, no longer used in our service.

The Chain Shot consists of two hemispheres, joined by a piece of chain which fits into the hollow; thus the two halves, when placed in opposition, form one shot, which can be thrust into the gun as such, but which, on emerging, separates into two—the halves diverging to the full extent of the chain. Thus this variety of shot becomes most destructive against a column of troops, or for the purpose of disabling rigging; however, it is now but seldom or never used.

Grape Shot consists of a spindle or spike of metal, around which are tied or quilted several iron shot, of sizes varying according to the gun from which they are to be fired. This missile something resembles in general appearance a bunch of grapes—hence its name. Grape shot is most destructive to troops and rigging at short distances, the shots flying asunder immediately the bunch leaves the gun.

The Canister Shot is adapted to the same kind of service as the preceding, but differs from it in form; the balls, instead of being quilted round a spindle, are confined in a canister of iron plate.

Spherical Case Shot, or Shrapnell Shells, as they are more commonly designated, are an important modification of the canister shot; than which they are
available at much greater distances. A description of the shrapnell shell would be more intelligible had I previously described the bomb shell, which it very much resembles. It is a hollow sphere of iron, very accurately cast, and just strong enough to withstand the primary impulse of the gun which projects it. Within this shell are balls, larger than musket-balls, and powder just sufficient, when ignited, to burst the shell. Communicating with this powder is a fuse, which ignites by the flash of the gun; and, being calculated to burn a certain time, is intended to communicate its fire to the contained powder, when the missile has reached its destination. Thus constituted, the reader may form some idea of the terrific effects of this missile—combining as it does the long range of round shot with the scattering effect of grape and canister. Some idea, too, may be formed of the difficulties attending the use of this variety; how nicely must the distances be measured by the eye—how well apportioned must be the length of fuse to this distance—how well adjusted the charge of powder, &c. In fact, no variety of missile requires such delicacy of management as the shrapnell shell; but its effects are so terrific as to repay all the trouble employed in bringing it to perfection, and in its continued use.

The history of shrapnell shells presents some curious points of interest. Leaden balls were first employed to charge them with. They were found inap-
plicable, for the following curious reason. The specific gravity of lead exceeding that of iron, the impact, or force of discharge, drove the balls against the fore part of the shell, and squeezed them into one hard cake. Iron balls were next tried; but their lesser specific gravity is an objection; moreover, by striking the grains of powder, they frequently caused the shell to explode before the fuze had taken effect. The balls are now made of lead, hardened with antimony and zinc; and to guard against any chance of explosion of the bursting charge by concussion, the diaphragm shell has been devised. A portion of the shell being partitioned off by a diaphragm of sheet iron, two chambers are established, one for holding the balls, the other for containing the powder charge. It is found desirable to pack the spaces between the balls with some material. In our service, melted sulphur being poured in amongst the balls, solidifies around them. The Americans, who object to this practice, use a mixture of charcoal dust and mealed powder; believing that the scattering of sulphur-imbedded bullets is not sufficient for developing the full effects of the shrapnell system.

**Martin's Shells.**—This is a very ingenious substitute for a red-hot shot, to which, as far as experience has gone, it is much superior. It is an ordinary shell
furnished with iron screw stopper. Molten iron is poured into the shell, the stopper screwed in, and the missile discharged.

**Vertical and Horizontal Firing.**—Philosophically considered there are two systems of shell firing; vertical, and horizontal. Of vertical firing the mortar presents the type, though long guns may be sometimes used after the manner of mortars with advantage. In vertical firing the elevation is always about 45°, distance being regulated by charge alone. Whatever variety of shell, and however fired, its efficiency as a shell must necessarily depend upon their bursting at the exact moment of time. Shrapnell shells are intended to burst previously to their reaching the object aimed at; but all other shells subsequently to impact. The contrivance for igniting the charge of a shell is called a fuse. The fuse may be contrived on the system of burning through definite lengths in definite times; or the contrivance may be such that ignition of the charge shall only take place on or after final impact. Hence fuses admit of division thus:—

**Classification of Fuses.**

- **Time Fuses.**
  - Concussive.
  - Percussive (exclusively adapted to polar projectiles).

Necessarily the shrapnell fuse must be on the time principle; but in respect of other shells it is an open question whether concussion fuses, or time fuses
be preferable. We use both in our naval armament, but the Americans, who have gone more extensively into the shell system than ourselves, use time fuses in that service exclusively. Nevertheless, time fuses act not unfrequently as concussion fuses; their composition getting loosened by impact.

The Shrapnell Fuse.—Of all time fuses, that intended for igniting the shrapnell shell involves points of greatest delicacy. Inasmuch as the shell to prove effective must burst before reaching its object, and whilst yet travelling with a velocity not less than 450 feet per second*—it is a matter of not less difficulty than importance to insure the bursting of the shell at the proper time. Every nation using the shrapnell shell has its own variety of fuse. A sketch of that used in our service—Boxer’s fuse—is subjoined, of actual dimensions. To preserve it from air and moisture it is capped with tin like a bottle of pickles.

* Which is about the lowest killing velocity of a musket ball. A 6-pounder shrapnell has a velocity of about 470 feet per second at 1,100 yards.
AND EXPLOSIVE COMPOUNDS.

By means of a tape running underneath the cap the latter may be pulled away. It is graduated to seconds in two lines,* a dot corresponding with each figure. Assuming it to be desired for the shell to take effect after a flight of two seconds, the fuse is pierced through the dot corresponding with the figure 2, and similarly for all other distances. The mechanism of the thing is this. The fuse contains three longitudinal bores, one about three-tenths of an inch in diameter, holding hard-rammed composition, beginning at the igniting or outer end of the fuse and stopping short of the bottom: two, each of about one-fifth of an inch diameter, charged with quick match, beginning at the lower or bedded extremity of the fuse, and stopping short of the top. Such being the construction, it follows that whenever communication is established between the hard-rammed composition and either of the quick match tubes, the quick match will ignite, and explosion of the shell will be determined.

Time fuses for other than shrapnell practice are less complex. One central charge of hard-rammed composition being alone employed, communication between the fuse blast and the bursting charge being established either by sawing into the fuse, or piercing it, or boring it out.

The shrapnell fuse employed in the French service differs from ours. It consists of three separate

* Each 0.1 of an inch corresponds to a second.
columns of composition timed respectively to 300, 500, and 800 yards. They are individualised respectively by a white, blue, and red cap. Whichever cap is removed, the corresponding column ignites; hence, according to the French system, shrapnell shells may be fired with rapidity equal to round shot. The Belgian shrapnell fuse is very ingenious. It may be described as a sort of flat helix, protected by metal, and something like a catherine-wheel. According as more or less of this helix is cut off, the time of combustion varies.

For the sea service, metal fuses are generally employed. They are stronger than wooden fuses, but they are not all that could be wished. Not only are they prone to bend, and thus destroy the continuity of their charge, but when the charge is rammed in direct contact with the metal, the heat necessary to combustion is absorbed with undue rapidity, and injurious chemical reactions ensue between the metal, and its contents.

Concussion Fuses.—Seeing the difficulty of commanding explosion of a shell exactly at the proper instant—the idea of making the shock of impact the agent of explosion has long been worked upon. If a percussion-cap be stuck upon the peg of a boy's top, and the top projected to the ground, according to the usual rules of top-spinning, the cap explodes. But the spinning top is polar; accordingly, any projectile to successfully adopt this system, must also be a polar projectile, and rifle guns are the only polar arms we
use. Hence, shells on the percussion system, though efficient when used in connection with rifle guns, are efficient under no other circumstances. Percussion fuses differ from concussion fuses in this: whereas the former, to be efficient, must have polarity,—must strike at one particular end, or on one particular aspect—the latter are constructed so as to be efficient under every aspect of impact, which may happen to the shells, of which they are the appendages.

All concussion fuses that I am aware of, save one presently to be mentioned,—involve the use of detonating materials.

The most celebrated concussion fuse ever employed in the British service is that of Captain Moorsom. I am cognisant of the exact construction of this fuse, but perhaps the telling of it might be considered an act of bad citizenship; I, therefore, shall be content with remarking that it is so contrived that certain little hammers in the fuse are liberated at the moment of firing; and when the shell strikes, are jerked against a little detonating composition. This is quite enough to be generally known; and far better is it, honestly to intimate one’s determination to tell no more, than to mislead the reader, as is too commonly done, by diagrams and descriptions studiously false.

The Belgian Concussion Fuse.—Some years ago, M. Splingard, a Belgian, discovered a variety of concussion fuse which did not involve the use of
percussion powder. I know of few contrivances so ingenious in any department of applied science. It might have been imagined that a discovery so valuable would have been carefully guarded; nevertheless, the Dutch got hold of it, which the Belgians no sooner discovered, than, hating their neighbours most cordially—they published the invention to the world.

The composition bore of the fuse is hollowed out like the charge of a rocket. The conoidal hollow is next varnished with shell-lac, and filled with magma of plaster of Paris; into which a piercer being thrust, a central bore is established in the plaster. Thus the reader will perceive the fuse to consist of a plaster of Paris cone, supported by composition impacted around it externally. When a shell armed with this sort of fuse, first leaves the gun, the plaster cone being supported remains entire; but as the composition burns away, and the plaster cone gets denuded, it fractures by the shock of the shell striking against the object aimed at; and, of course, ignition takes place.

Common Shell.—We now come to ordinary shells
properly so called; the largest of which are understood to be shot out of mortars, but occasionally they have been rolled down inclined planes on an enemy; * and shells of smaller description, but in all other particulars resembling bomb shells, are shot from howitzers and large cannon. The shell, from whatever piece of ordnance it may be shot, is a most destructive weapon. The idea of the shell is exceedingly simple, although no branch of artillery requires so large an amount of practice and calculation as that which relates to the projection of these missiles. They consist of hollow spheres containing gunpowder; which ignites by means of a fuse, as in the case of the shrapnell shell, on attaining a certain distance. From shrapnell shells, however, they differ in being much larger, thicker, and in containing no balls. They are particularly efficacious in demolishing buildings and blowing up earth mounds; against which mere shot have but little effect — also in accomplishing the destruction of ships. Instead of being filled with mere gunpowder, they are sometimes charged with a mixture of gunpowder, tallow, and pitch; then they are called "carcasses," and are chiefly useful for their burning effects. Carcass shells are, however, not exactly like bomb shells, but are furnished with several orifices through which the liquid burning mass may leak.

* The Venetians did this against the Turks at Candia.
THE PAIXHANS SYSTEM.—About the year 1822, General Paixhans, having the navy of England in his imagination, directed his attention to the problem of devising a more efficient means than the firing of ordinary solid shot, for the destruction of ships. He devised what has since been called the "Paixhans," or naval shell, or incendiary system. The theory of this system is very plain. It involves the use of cannon of large bore, and for the most part chambered, and shells either charged with gunpowder alone; or, as in the French service, with gunpowder and carcass composition. The arguments for and against the Paixhans system, have been prolonged and violent. During the progress of it, however, the significant fact is undoubted, that the system is year by year more largely applied. The Americans have more fully adopted the shell system than any other people. The Merrimac, the Niagara, and their sister frigates, are armed exclusively with shell guns, on Dahlgren's construction. The Merrimac, on board of which the Dahlgren gun opposite was sketched, had not one solid shot. In point of fact, the use of solid shot is almost beyond the competence of the larger shell-guns, which would not stand the necessary charge of gunpowder. When a ship of war has been exclusively supplied with shell guns, she may be considered to have given a pledge of her desire to restrict her attentions to other ships—leaving stone walls alone.
Unquestionably, the Paixhans system lends aid to fortresses at the expense of ships.
Paixhans guns must necessarily be very strong to withstand the strain to which they are exposed, hence they became unwieldy; whence it is a point of great consequence to impart to them the necessary degree of strength, and no more. Commodore Dahlgren, of the United States, bethought him of the following ingenious expedient to ascertain the relative thickness necessary to be given to each part of the cannon. At right angles to the bore of an ordinary Paixhans gun he caused a row of holes to be successively drilled through one side, quite into the central bore. Each of these was of the proper size to contain a musket ball. The cannon after each successive hole was bored and charged with a musket ball, being loaded and fired—necessarily each musket ball was projected with a force proportionate to the force of gunpowder-blast from the cannon. These amounts of varying force having been determined by a ballistic pendulum, the elements of a curve were given, representing the decreasing thickness of the barrel, from breech to muzzle. The application of these deductions resulted in the “Dahlgren gun;” a very curious piece of ordnance indeed to look at; somewhat resembling a pear.

The “incendiary,” or “shell, system” appears to have well established itself; nevertheless, its adoption involves several points of weakness. Not only do the majority of shells not explode when required, but the
fuses of a considerable number never ignite. Again, as to those which do ignite—contact with water, concussion against the object aimed at, &c., extinguish many. Behold, then, a few of the consequences:—Frequently at sea, as on land, cannon-balls effect greatest damage not when directly striking the object aimed at, but when rebounding in playful mood from land or water, and bowling along. This is called "ricochet practice;" and it is unadapted to the genius of naval shells. Again, shell guns cannot efficiently throw red-hot shot;* they occupy much longer time than smaller guns to charge and discharge; their recoil is greater,† and being larger than solid shot guns, fewer of them can be borne by a ship; thence it follows that the chances of impact are proportionately diminished. Moreover, the flight of shells is less accurate than of solid shot, and less far.

Speculations as to the effect of the Paixhans system were greatly set at rest by the results of the battle of Sinope. The Russian ships were partly armed with shell guns. The Turks had none. General Paixhans, writing in the Moniteur, of February 21, 1854, on

* Nor double shot. Two hollow shot fired in one charge crush each other to fragments.

† The Dahlgren gun, as will be perceived, is devoid of hind truck. This is for the purpose of diminishing recoil, and it involves the use of tumbler handspike, as represented in the sketch. The sponge is made of bristles, and the shape of it, of course, makes apparent the shape of the gun's chamber.
this action, states that the Turks had no guns heavier than 24-pounders; that the shore batteries were weak and armed with guns of very small calibre. It is also stated on the authority of Paixhans that the Turkish officers attributed the conflagration of most of the ships to the destructiveness of shells.

Commodore Dahlgren in vindicating the superiority of the shell system, comments on the enormous quantities of solid shot a vessel has been known to receive without sinking. Not a ship, French or English, appears to have been sunk in action during the whole of the French war.* At Trafalgar the Belleisle is said to have been assailed, for at least an hour, by three French ships Achille, Ayle, and Neptune. The conflict was almost in the style of a general mêlée, and in it were mingled sixty of the largest ships in the world, engaged from one till four, delivering their broadsides at distances so short and at marks so large that very few shot ought to have missed; and yet not a single ship was sunk in action, and though horribly battered only one went down in the gale which ensued about thirty-six hours afterwards. The conflict which took place between the Guillaume Tell (afterwards the Malta) and the Foudroyant, 74; the Lion, 64; and the Penelope frigate, supplies another example. The Foudroyant

* Simmons.
ranged up alongside about 6 A.M.; approaching the French ship so closely that her spare anchor just escaped catching in the mizen rigging of the Guillaume Tell. The action was continued closely until 8.20 A.M., when the Guillaume Tell struck. On this occasion the Foudroyant expended

1,200 32-pound shot.
1,240 24-pound do.
118 18-pound do.
200 12-pound do.

Being a total of 2,758 shot fired at short distances, besides those fired from the batteries of the Lion and the Penelope; yet the Guillaume Tell was not sunk, nor so much injured as to be incapable of service soon afterwards in the British navy.*

I do not think it necessary to enlarge further on the effects of gunpowder as applied to the projection of missiles from tubes. I have studiously avoided saying anything concerning the distance or range to which such missiles, be they shot or shells, may be cast, thinking it better to make this a consideration of itself.

* Charwick's Life of Nelson.
THE WAR ROCKET.

We now come to the description of another variety of igneous missile, in the construction of which our military artisans stand unrivalled, and which, though not absolutely invented by us, as some imagine, was, nevertheless, brought to perfection by the genius and assiduity of our countryman. The Congreve, or war rocket, with tail, being merely a modification of the common pyrotechnic rocket, it is necessary to give the reader a general description of the latter. I will first of all, then, advert to the principles on which a rocket depends for its "propulsive," or (in reference to the effects of inflamed gunpowder on other missiles) "repulsive" power. All are aware of the mechanical axiom that action and reaction are equal, no matter what the agent may be. Hence arises the recoil of a gun. Now, it is not difficult to imagine a gun to be charged with a slowly burning gunpowder, so that the recoil shall be continuous instead of momentary; in which case the gradually increasing force of the recoil would become a very terrific power;—more terrific because, in addition to its penetrating force, it would
AND EXPLOSIVE COMPOUNDS.

carry with it a devastating blast of flame; rendering its whole flight visible; and terrifying and burning even where it might not touch. To those who are totally unacquainted with the nature and properties of a rocket, the foregoing general description will afford a tolerable notion: they will begin to think, however, that in order to change a gun so manifestly from its primary use, various modifications will be necessary,—that various contrivances, both chemical and mechanical, must be devised. This is indeed the case; the construction even of a common sky rocket evinces a great amount of ingenuity; and the Congreve rocket is a lasting evidence of the skill of him whose name it bears.

Let us commence with the description of a sky rocket. The case which contains the composition, a slowly burning powder, is usually made of paper rolled hard round a former; and pinched or choked at one end to a narrow opening. This case is next to be charged with composition; in doing which very peculiar management is required; inasmuch as it is found necessary to maintain a hollow cone in the very centre of the composition; the base of the cone corresponding with the vent, or small orifice, of the case; and the apex extending to within one diameter of its other end. Beyond the apex of the cone, the composition is solid. This hollow conoidal form may be effected in one of two ways: it may be made during
the formation of the rocket, by means of hollow rammers and a metal spindle; or the rocket may be rammed solid, and the conoidal chamber drilled out subsequently;—in either case the result is the same.

The construction of a rocket in its simplest form has been described without any appendage: that is to say, I have described the mere propelling agent. Whether it be made to carry with it ornamental fireworks, as in sky rockets, or shot, or shells, or carcasses, as in the Congreve rocket, still the principle remains unaltered. One more important addition, however, is necessary, otherwise the rocket would have no accuracy of direction, but would fly in a most irregular course: it must be furnished with some means of insuring a moderately direct curve of flight. This is accomplished in the common sky rocket, and also in the war rocket of Congreve, by attaching a long stick to serve as rudder, or guide. A diagram, showing a sectional view of a sky rocket and its stick, will explain all that is necessary to the full comprehension of our subject.

A. Paper cone added to the rocket, in order that it may readily cleave the air.

B. Chamber containing ornamental stars and bursting powder.
C. Layer of clay, wood, paper, or some other substance, perforated with a hole through which the fire reaches from the composition, or slowly burning gunpowder, D.

E. Hollow conoidal cavity, for the purpose of effecting rapid combustion.

F. Guiding stick, affixed to the side of the rocket, by means of wire or cord.

To fire a sky rocket, nothing more is necessary than to apply a light to the orifice or vent; which done, the composition immediately inflames, and fire rushing out with great violence, the rocket proceeds in the direction to which its apex is pointed.

Whatever doubt there may be as to the antiquity of guns, there is none as to the antiquity of rockets, which have been known in China and India from time immemorial; indeed, used in those countries, for warlike purposes. There might formerly have been seen, at the Adelaide Gallery, a Chinese war rocket, differing in nothing from the sky rocket just described, except that a barb is attached to the foremost extremity of the stick, which latter was made to project to the rocket's very extremity.*

* Directions for making and using rockets may be found in the following old works:—Robert Anderson, On the making of Rockets; Biringucci Vanuccio, De la Pirotechnia, 1540; Bate, John, Mysteries of Nature and Art, 1654; J. Hanzelet, Traités Militaires, 1598. In this book is represented a method of
Although the common sky rocket has very considerable penetrating force; and although, as we have seen, it has long been used as a warlike missile in Eastern countries; yet all who have witnessed the firing of a sky rocket must at once recognise imperfections, that would render it ill adapted to warfare between more civilised nations; who find it necessary to study the laws which regulate the flight of projectiles; and reduce the firing of them to some system. It is difficult to make two sky rockets exactly of the same weight; to fill them with exactly the same quantity of composition, rammed of the same hardness; and to supply them with guide sticks exactly corresponding in every particular:—yet, without some close approximation in these respects, the flight of such rockets could never be prognosticated with anything approaching to accuracy.

The first person in this country to whom the idea of using rockets as warlike agents seems to have suggested itself, was General Desaguliers. All his experiments being failures, he eventually abandoned the idea. Such an inselcitosus termination of the inquiry, however, did not prevent Sir William Congreve from being sanguine of success. He forthwith commenced a series of experiments on common employing the rocket in war, thus anticipating Congreve in Europe in the employment of this arm.—Nye, Nath., Treatise on Fireworks.
rockets, procured from various makers; and on others, constructed according to the Woolwich laboratory rules. He found, in the first place, that the range of these rockets was trivial in a military point of view; and secondly, that they were devoid of all necessary accordance amongst each other:—evils which he applied himself to remedy. His first material employed for making the cases was paper, but eventually he bethought himself of sheet-iron; a substance which, possessing greater weight or mass than paper, contributed much to extend the flight of a rocket. Sir W. Congreve, amongst other modifications, diminished considerably the length of rocket sticks, thus rendering the whole missile much more portable, and subject to less deflection than in its original state. The sticks, at this period, in the history of Congreve rockets, were still lateral, or appended to the sides, as in the common pyrotechnic rocket;—an arrangement which the slightest reflection will show must have considerably interfered with accuracy of flight; besides presenting many other minor objections: for instance, this arrangement did not admit of the stick being expeditiously fixed; neither could the rocket be shot conveniently through a tube. It was easier, however, to recognise the disadvantages attending this arrangement of the guide stick, than to offer a remedy. Congreve, nevertheless, overcame this difficulty, and succeeded in devising a plan for attaching the stick
centrally; thus giving the whole rocket the straightness of an arrow, and, consequently, increasing the accuracy of its flight; though much yet remains to be done in this respect, even viewing the present improved form of the weapon.

Having already given the reader a diagram of the common sky rocket, I may simply observe that the first war rockets were precisely similar in form; only their cases were of iron instead of paper, and instead of being headed with ornamental stars, they carried balls, shells, carcasses, &c., according to the use for which they were intended. The construction of the war rocket, as at present modified, will be rendered intelligible by the annexed diagram.*

The part A indicates the piece of iron attached to the end of the rocket, and serving as a shot:—it might have been a shell, a carcass, &c. B corresponds with the body of the rocket, filled with composition, and perforated as in a common rocket; the base of this conical opening expands, it will be observed, into a cham-

* The stick is represented somewhat short, for the sake of convenience. The actual length of the 6-lb. rocket stick is seven feet, of the 12-lb. rocket stick, nine feet.
ber F, which is absolutely necessary, in order to prevent the rocket bursting; although this necessity adds greatly to the mechanical difficulties which must be encountered. C represents a sectional view of a piece of gun-metal, a front view of which is shown by E. In this piece consists the great peculiarity of the Congreve rocket; enabling the stick, or rather the iron with which it is shod, to be screwed into the central opening, whilst the five peripheral orifices communicating with the hollow cone (of which the section of two only are seen in the diagram of the rocket), serve as vents to the flame; and correspond with the one central opening in the common sky rocket. When the rocket composition burns out, the shell charge is not ignited immediately; but takes fire through the intervention of a fuse; portions of which can be drilled out through a screw-plugged hole in the shell extremity of the rocket, and also portions of the rocket composition, if necessary, so as to time the explosion of the shell.

Such is an outline of these terrible weapons, once peculiar to ourselves amongst European nations, but now employed almost universally. Of course, the details of their construction are very properly kept secret; therefore I ought to give no more than a general description of their manufacture. They are not, however, difficult to prepare, as I have convinced myself by trial, although it is difficult to make two
which exactly correspond in every particular. It is imagined by some that the proportion of the ingredients is a great secret; this, however, is a fallacy. Knowing the object desired to be gained, the composition naturally suggests itself. The object is to compound of three ingredients—nitre, sulphur, and charcoal—a mixture of the greatest power compatible with duration of flight short of bursting the case: chemical science and a few trials soon lead to the desired end.

The manufacture of rockets as military weapons must always remain, notwithstanding its simplicity in theory, a matter in practice of very considerable difficulty. When we consider that the expansion and contraction of the iron cases render the composition liable to crack; when we reflect on the difficulty of preventing contact between the iron and the composition for any long period,* and of thus guarding against oxidation; or the difficulty in making every rocket of the same size, and to contain its due weight of composition; of ramming them equally hard; and of supplying them with sticks correctly planed,—these difficulties would almost bring one to the conclusion that rockets must remain mere elegant pyrotechnical

* The interior of a war rocket case ought to be lined with paper, glued to the iron, to prevent the composition touching the metal, and thus rusting it; a result which would entirely spoil the missile.
devices; or if used in warfare, not to be reckoned amongst the appliances of the well-trained and precise artillery of Europe. The superior dexterity of our artisans, however, has in great measure overcome these difficulties; and the rocket, although confessedly an erratic missile, is (when not pressed beyond its proper sphere) a most efficient and terrible weapon.

Like most inventors, Sir William Congreve was sanguine. He imagined that his war rocket would completely alter the practice of artillery; and would be all but universally applicable, whether for the purpose of battering fortifications or slaughtering men. He advocated the plan of furnishing rockets to every part of the army—cavalry, infantry, and artillery—and was opposed to the scheme of organising an independent body of troops, like the present rocket troops, for the employment of this weapon. The peculiar advantages of the rocket, as pointed out by Congreve, are, 1. magnitude unlimited; 2. portability; 3. freedom from recoil; 4. rapidity of discharge; 5. devastating and terrifying effects of fire in addition to its propulsive force.

Several circumstances conspire to restrain the size of common ordnance within certain limits: there is a difficulty in manufacturing large guns; when manufactured there is a difficulty in transporting them;*

* The weight of a 12-pounder gun is 18 cwt., while that of
and their missiles, be they balls or shells, are so unwieldy, as materially to interfere with their ready use. According to the testimony of Congreve, however, it is difficult to imagine the limit to the practicable magnitude of a rocket. The largest ever made for our service, I believe, weigh no less than three hundred pounds, and are about ten feet high; their extremity being furnished with either a shell or a carcass. Congreve did not think it would be difficult to construct rockets of a much larger size than this; but I am not aware whether he ever carried his idea into practice.

In field operations the rockets most usually employed are much smaller than the variety of which I have been speaking; the usual sizes being six, twelve, and eighteen pounders.

The rocket, urged as it is by its own impulse, and therefore requiring no ordnance to project it, has the advantage of great portability. Even a cannon no larger than necessary to project a six-pound ball, weighs several hundred pounds; and, therefore, is found difficult to be transported into mountainous regions. Six-pound rockets, however—indeed rockets of much heavier weight—may be transported everywhere. If, then, the flight of rockets could be rendered as accurate as the flight of shot, the trouble

a 12-pounder rocket tube, which projects the same weight of ammunition, and at least to the same distance, is only 20 lbs.!--Congreve, Op. cit., p. 37.
AND EXPLOSIVE COMPOUNDS.

and expense of conveying cannon to mountainous regions might be dispensed with.

The next great advantage of the rocket to be spoken of, is its freedom from recoil; which frequently becomes a serious impediment to the employment of common artillery. In most engagements, whether by land or sea, so great is the obscurity occasioned by smoke, that after the cannon have been pointed and discharged, the second round is fired more or less at random—recoil having disturbed the original aim, and the object being no longer visible. A rocket has no recoil; therefore, all circumstances being the same, a second rocket will follow the path of the first. Great as this advantage may seem at first, in practice it is entitled to very little consideration; on account of the natural irregularity of the flight of these missiles. There is another case, however, in which the absence of recoil in a rocket renders it a most valuable kind of artillery. It was formerly thought impossible to use mortars at sea, on account of the strain which they occasion by their recoil. This difficulty has long been overcome; ships having been made of a peculiar construction, purposely adapted for the service, so strongly built that the shock does not materially affect them until after considerable firing. It would be quite impossible, however, to use mortars in a boat; or even in a vessel not constructed on purpose. The objection does not apply to rockets;
which, although of the largest size, may be shot without difficulty, from boats just large enough to carry them.

Rapidity of discharge, and concentration of fire, are other advantages possessed by the rocket—requiring as it does merely to be placed in the intended direction, and ignited. Batteries of several hundred rockets may be planted against the enemy, and fired by the aid of quickmatch almost at the same instant. The particular methods of firing rockets in volleys will be mentioned presently.

The last specific advantage of the rocket which remains to be mentioned, is the devastating effect of its fiery train. Cannon-balls and shells rush on their objects unseen, or faintly visible; not so the rocket, which carries with it a long fiery tail, burning everything in its course, exploding ammunition wagons, mowing down troops, and producing amongst cavalry the most inextricable confusion. No horse, however well disciplined in regard to other artillery, will stand the hissing of a rocket; not even the horses of a rocket troop.

If the rocket could be endowed with the precision of which cannon are susceptible, it would indeed accomplish all that Congreve hoped; but such precision has not yet been attained, and this for obvious reasons. In the first place, the theoretical determination of a rocket's flight is a much more difficult affair
than the determination of the flight of a shot or shell; because in the former case we have a constantly diminishing weight (occasioned by the burning of the composition), producing a continued variation of the centre of gravity; whereas in the latter case the weight never varies, and its centre of gravity never shifts. So great is the care, however, with which our rockets are manufactured, that we might be warranted in entertaining the idea that the difficulty just adverted to might be overcome by the results of practice: unfortunately, however, there is a much more serious cause of error in the deflecting agency of currents of air. If such currents are capable of producing a manifest effect on the flight of shot and shells, bodies either homogeneous, or nearly so, how much greater must be this influence on a missile formed like the rocket, which departs as far as possible from the spherical form,* in regard to freedom from the interfering causes of atmospheric currents? Congreve considerably diminished the length of stick, and in this he accomplished much; he also endeavoured to dispense with the stick altogether, and attach in place of it a ball of iron. The plan, however, did not succeed, neither have many others, attempted at

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* I here limit my observations to all projectiles which are shot from non-rifled guns, or which, like the ordinary Congreve rocket, during their flight do not assume the rotatory or rifle motion.
various subsequent periods. The desideratum of enabling a rocket to be employed without a stick seems now to have been accomplished by Mr. Hale, concerning whose rocket I shall have to speak hereafter. I have called this deviation from the visual course an imperfection, and, doubtless, it materially diminishes the sphere of applicability of the rocket. If, however, this arm be employed for its true and legitimate purposes—that is to say, against large bodies of troops, or large masses of buildings, or shipping, then this same erratic course often becomes a perfection.

There are many cases in which shot and shell can be guarded against, owing to a knowledge of their general accuracy of projection. This cannot be said of the rocket, against which all common precaution is in vain. Once amongst a body of troops—once its original course departed from, and no one can tell whither it will go. It may seem to fly to the right, the troops give way to let it pass, and thicken on either side; on a sudden the missile encounters some impediment,—a stone, a little mound, a dead soldier,—and forthwith its course is changed towards the left. Hissing, plunging, darting like a meteor of fire, it rushes into the thickest ranks. What it fails to strike it burns. Its force now seems expended—already it has penetrated through a dense mass of living beings: for an instant it lingers; but its fiery elements
gaining new strength, urge it again forward with renewed and terrible force! This is, indeed, a fearful peculiarity of the rocket. Other projectiles being once impeded in their flight, cannot renew their power; theirs being merely a first impulse—the primary force of gunpowder: not so the rocket, which carries with it its own propelling agent, and thus literally "vires acquirit eundo."

It now remains to describe the apparatus which is employed for the purpose of directing rockets in their proper course. When first rockets were introduced into the army, Sir William Congreve employed either
grooved channels or tubes. The former means might have originally suggested itself to him, but it is certain he had been anticipated by Hanzelet; who, at page 38 of his *Traité Militaires*, published in 1598, gives a description and diagram of the military use of the rocket. A fac-simile of the latter is given, page 171.*

In the present day, when any apparatus is employed, this is invariably of the tubular kind; but

* The chapter is thus headed:—“*Comme l'on peut tirer droite-ment une fusee à fleur d'orizon ou autrement.*” Then follow a description and woodcut, given in the previous page. The rocket is directed by means of a groove. The very extraordinary perspective of the sketch, I beg leave to say, is M. Hanzelet's own—not mine.
in what is called "the ground volley." The present improved rocket tube is shown by the annexed diagram, which requires no minute description. It will be seen to be capable of elevation and depression by a contrivance which is obvious; any necessary angle of elevation is taken by means of a "hausse" or tangent scale.

Sir W. Congreve invented carriages, on each of which many such tubes were mounted. These carriages were intended to run into action like light field guns, yet pouring a discharge of metal from each tube equal to the effect of the gun as regards penetrating force, in addition to the devastating effect of fire. Such carriages, however, are now no longer employed; when rockets are required to be fired in great numbers simultaneously, the ground volley, as it is called, is found to answer every purpose.

This arrangement consists in laying any number of rockets on the ground at determinate distances from each other, connecting them by a quick match, and firing them in rapid succession; for which purpose only the end of the match requires to be ignited. If the ground be moderately smooth, the rockets proceed, for the first 100 or 150 yards, near the ground surface; afterwards, however, they rise more or less, become deflected, and rush about in a most destructive manner. The manner of firing the ground volley is illustrated by the following diagram.
Sir W. Congreve, as I have already observed, considered that the peculiar genius of the rocket lay in the facility of its general adoption by all troops. He was averse to the formation of specific rocket troops, and he particularly advocated the employment of the arm by cavalry; which he maintained might thus derive the power and force, without the weight and difficulty of transport, of artillery.

Annexed is a sketch of his proposed plan of carrying the rockets, which are represented to be arranged on each side of a kind of pack-saddle. The sticks, in two lengths, being carried in a box on the horse's back; when used, they were to be joined by a screw.

This scheme of Congreve's has not been thought available; the rockets are now carried in wagons on
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purpose; and upon the wagon is buckled the tube; which when used is removed and fixed on its tripod, as represented by the diagram at page 172.

Each man, however, of the rocket troop rides into action with some rockets already supplied with sticks, and ready to be fired; these he carries in buckets, attached on either side to his stirrup. Of six-pound rockets three are thus carried on either side, after the manner of a lance; and thus they are immediately available before the rocket wagon can be opened.

Such was the amount of development received by the rocket as a military weapon from the labours of Sir William Congreve; and although his ideas of their large sphere of application have been far from realised, rockets, on his construction, have always, since their introduction, constituted an important part of British artillery resources. The presence of the stick, however, continued a serious drawback to their general applicability; and numerous investigators directed their attention to the discovery of some means of abolishing the incumbrance. It was foreseen by all who had directed their attention to this subject, that if the stick of a rocket were ever abolished, the only available means of insuring accuracy of flight would consist in imparting to the rocket itself a rotatory or rifled motion. Now, theory only furnishes us with two classes of suggestions for accomplishing this in any projectile: either by shooting it
from a rifled gun, or supplying it with some cause of 
rotatory force within itself. The latter is the only 
idea apparently eligible as regards the rocket; which 
is not shot from a gun, but the course of which is 
dependent on its own recoil. All the earlier attempts 
to impart a rifled motion to rockets were based upon 
the idea of wings or vanes, attached to the rocket 
itself; or the idea of spiral grooves cut in the ex-
ternal portion of the rocket's case, against which 
grooves the atmosphere, exerting its pressure during 
the projectile's flight, should impart the necessary 
spiral motion. These attempts, however, all resulted 
in failure.

Within the last few years Mr. Hale has succeeded 
in accomplishing the flight of a rocket without the 
stick, by a very ingenious process. One of Hale's 
rockets appears at a first glance like one of Congreve's, 
to which the stick has not yet been attached. Nearer 
inspection shows that the peripheral apertures are 
also tangential, so that any flame escaping from them 
must impart rotatory motion to the whole rocket. 
These tangential holes do not give exit, however, to 
the chief portion of the ignited blast, which escapes 
through the central hole where the stick, if an 
ordinary Congreve rocket, would be. During the 
last or Russian war, rockets on Hale's principle were 
made at Woolwich for the first time. Not only were 
they filled by hydrostatic pressure instead of monkey
ramming, but they were filled solid, the conoidal piercing being subsequently done by a mounted centrebit.
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By dispensing with the stick, Mr. Hale has removed an appendix both troublesome and in many cases unnecessary; nevertheless, the Congreve rockets still hold their place. The greatest difficulty, perhaps, attendant upon the firing of any sort of war rockets is that of giving them a correct flight to begin with. When a rocket first sets out on its career its flight is weak; its head droops, and thus the line it should follow is apt to be departed from. Mr. Hale has ingeniously striven to overcome this defect by imprisoning the rocket, so to speak, until it shall have acquired not only force enough to overcome the inertia of its own weight, but the pressure of a strong spring as well. Not the least worthy of notice amongst Mr. Hale's inventions are the various forms of apparatus used by him to give due effect to his rockets. Amongst these contrivances, two may be mentioned; one a sort of cage in which the whole rocket is held prisoner until a certain initial force has been gained; when owing to the pressure of a spring the whole cage flies asunder, and the rocket finds itself unsupported throughout its whole length in mid-air. It now tends to fall bodily, indeed, obedient to the ordinary law of gravitation, but the far more objectionable drooping of its head and elevation of its tail, at the moment of egress from a tube, thus imparting a new angle of flight, is more or less effectually obviated.
The second ingenious device contrived by Mr. Hale, has reference to the use of his rockets from portholes of line-of-battle ships; for, like Congreve, Mr. Hale is enthusiast enough to believe line-of-battle ships will spit fire at each other instead of booming with the reverberation of big guns. Now, the back fire of one of Congreve’s rockets is no trivial affair. Even when fired from a boat, in which case the tube is fixed alongside, so that the missile may dart its back fire into the water, the Congreve rocket, until fairly under way, is an unpleasant neighbour. But the back fire of one of Mr. Hale’s rockets is still more terrific: as to permitting a broadside of them to dart back fire ’tween decks, that would be too preposterous a notion, even for the most sanguine of rocket enthusiasts. Filled with this conviction, Mr. Hale has devised a very peculiar tube for broadside rocket service. Let the reader fancy a large tubular letter U, resting upon one bend, with both its heels sticking out of a porthole, and he has the notion. The rocket, being stickless, can do what one of Congreve’s tailed rockets could not do—find its way round the bend of the U tube. By the above curious device, Mr. Hale so manages affairs that the dangerous back fire of his rockets, previous to their departure, shall be turned towards the enemy, when, acquiring strength and going head over tail,—turning a veritable summersault, in point of fact, they are supposed to
bend to the right about, and fly straight towards the enemy. Until a rocket broadside of this sort has been fired, nobody, perhaps, ought to dogmatise about the effects of it. Individually speaking, I should like to witness the sight of a broadside of rockets setting out on their travels, as a pyrotechnic display—*and from a convenient distance*.

Whatever doubt there may be as to the relative merit of Hale's and Congreve's rockets, there can be none whatever concerning the superiority of hydrostatic pressing, over monkey ramming. Not only do rocket cases hold more composition when stuffed by the former process, and are therefore rendered capable of burning longer, but the operation of filling them becomes less noxious, and less dangerous. Gunpowder dust flying about was prejudicial to the lungs of those who breathed it; and though the rammers used in connection with the percussive system were made of gun metal, yet the adhesion to them of gritty particles could not be always guarded against; hence danger of explosion was ever imminent, and too frequently supervened. When Mr. Hale first began to superintend the manufacture of his rockets at Woolwich, the laboratory authorities there wished him to employ gun-metal rammers. The latter could not withstand the enormous pressure applied. I witnessed some of them compressed just as softened sticks of sealing wax might have been if dropped partially into
a rigid tube and then leaned upon. Steel alone is competent to withstand this enormous pressure. To have employed steel rammers in connection with monkey driving would have been madness; but subjected to the enormous though tranquil hydrostatic pressure there is no danger.

Mr. Hale's rocket system has been narrowly investigated by a military committee of the Swiss confederation, also by a similar committee appointed by the American Government; the result of investigation in either case having resulted in their approval and adoption. The secret of their manufacture has also, it is said, been communicated both to the French and the Russian governments.

It may not be devoid of interest to present the reader with the reports, as regards the powers of Mr. Hale's rockets, published by the Swiss and American governments:

"The federate government of Switzerland caused extensive experiments of the power and advantages of this weapon to be made, under the superintendence of a committee of artillery officers, and a number of rockets were fired from a stand at 5, 10, 15, 25, and 27 degrees of elevation. A target was placed at 1,200 paces, and the rockets used on this occasion were 10-pounders, the smallest of Mr. Hale's invention, his largest being 100-pounders. One fired at 5 degrees went on like a serpent, and never rose above 6 feet from the ground. Another, at 10 degrees, made its
first graze at 500, the second at 1,300, the third at 1,900 paces, and without rising more than 9 feet from the ground during its flight. One discharged at 15 degrees first struck the ground at 1,200 paces, the second time at 2,200 paces, and when rising again the shell exploded; its greatest lateral deviation was about 50 paces.* A single 10-pounder rocket was fired at Woolwich by Mr. Hale, in the presence of some of his friends, on the 30th of March, 1849. A wrought-iron tube, moving on a cast-iron stand, was used on this occasion, and the rocket, being discharged at an angle of 20 degrees, without previously grazing, penetrated 10½ feet into wet, close, loamy soil, at the distance of 5,200 feet, which is scarcely less than the effect of a 12-pounder shot at the same distance.

"It is understood that the government of the United States, after testing the efficiency of Hale's rockets by a series of experiments made under the direction of a committee of artillery officers, purchased the secret, and used this instrument with the greatest advantage during the late Mexican war. The following are the official American documents regarding Hale's rockets:—

"'Washington, December 1, 1846.

"'Report of the joint Board of Officers of the Army and Navy, appointed by the Secretaries of the War and Navy Departments, for examining Hale's rockets.

"'The Board have tried by firing on land and water 2½-inch rockets, presented to them for that purpose by

* See the Army and Navy Register, March 1, 1849.
Mr. Hyde, by whom they were procured from the inventor Mr. Hale.

"From these trials the Board have arrived at the following conclusions:—

1. The effect of the rockets, with regard to range, force, and accuracy, is at least equal, and probably superior, to that of the ordinary Congreve rocket of the same size.

2. The fact of this rocket being without a stick gives it an incontestible superiority over the Congreve rocket, with respect to facility, convenience of service, and, especially, for use on board of armed vessels or boats.

3. It is, therefore, recommended that an arrangement be made with the proprietor for the purchase of the full instructions requisite for making these rockets.

4. The evidence of such information being fully and correctly communicated should be the making, under these instructions, of a certain number of these rockets, of at least two sizes (say ten each of 2-inch and 3-inch), which shall perform as well as those exhibited to the Board.

"Officers of the Army.

(Signed)  JOSEPH G. TOTTEN, Colonel and Chief Engineer.
G. TALCOTT, Lieutenant-Colonel of Ordnance.
A. MORDECAI, Captain of Ordnance.

"Officers of the Navy.

L. WARRINGTON, Commodore.
THOMAS A. P. C. JONES, Captain.
L. M. POWELL, Commandant.
A. B. FAIRFAX, Lieutenant.
Honourable JOHN Y. MASON, Secretary of the Navy."
"' City of Washington, December 9, 1846.

"' Sir,—The joint Board of Army and Navy Officers, appointed by us to examine Hale's rockets, have made a confidential report, of which a copy is enclosed. We are authorised by the President of the United States to submit, for your acceptance, the proposition recommended by the Board in the Report.

"' Will you be pleased to make known to us your determination. No delay which can be avoided will occur, if you accede to the proposition, in applying the proposed tests, and your communication in writing of the necessary instructions will be treated as confidential.

"' Respectfully,

"' Your obedient Servants,

"' (Signed) W. L. Macey, Secretary at War;

J. Y. Mason, Secretary of the Navy.

"' Mr. J. B. Hyde,

Now at Washington.'

"' Report of the trial of Rockets of Hale's patent, made at Washington Arsenal, January 5, 1847.

"' These rockets, presented for trial in pursuance of the former recommendation of the Board, were made at Washington Arsenal, under the direction of Mr. Hyde.

"' There were fifteen 3-inch rockets, two of them with shells in the head, and thirteen 2-inch rockets, four of them with shells; of these, the following were fired in the presence of the Board:—

"' Six 2-inch, with shot-heads.

Three ditto, with shells.

Four 3-inch, with shot-heads.

Two ditto, with shells.

"' At various elevations from 14 deg. to 35 deg.

"' The accuracy of direction and the ranges were, in all
respects, satisfactory, and the Board are of opinion that these rockets were quite equal to those before exhibited to them by Mr. Hyde, as having been made by Hale, the inventor; and that Mr. Hyde has, therefore, "fully and correctly communi-
cated the necessary instruction for making Hale's rockets." The trial of the rockets was witnessed by the members of the Board, whose names are signed to this Report.

"' Officer of the Army.
"' (Signed) A. Mordecai, Captain of Ordnance.

"' Officers of the Navy.
L. Warrington, for himself,
and T. A. P. C. Jones.
L. M. Powell, Commander.
J. B. Fairfax, Lieutenant.

"' Washington, January 6, 1847.'

"Amongst the documents printed for the use of the Senate of the United States of America, by a resolution of the 7th December, 1847, is the following short report by Captain A. Mordecai, commanding the Washington Arsenal:

"' MR. HALE'S ROCKETS.

"' In the month of December last, a war rocket, of a new kind, invented by Mr. Hale, of England, was offered to the notice of our Government, and a mixed Board of officers of the army and navy was appointed to test the invention.

"' Experiments were accordingly made with some of Mr. Hale's own rockets, and with others made at the Arsenal according to his specification; the results of these trials were so satisfactory, that, on the recommendation of the Board, the right of using the invention was purchased by the Government.

"' The peculiar advantage of this new projectile is that of having its directive force in the body of the rocket, thus dis-
pensing with the use of the cumbrous stick attached to the Congreve rocket. About 2,000 of these rockets, of the calibres of 2½-inch and 3½-inch, have been made at this Arsenal, and
the trials which have taken place, from time to time, seem to confirm the favourable opinion at first formed, that, in extent of range and accuracy of direction, they are equal, and perhaps superior, to the common rockets of equal size. A report of the trial of those which have been sent into the field is looked for with interest.’’

I shall conclude this account of rockets by enumerating some of the results which they have brought about on different occasions of their being used.

The first employment of rockets in European warfare was in the attack of Boulogne, October 8, 1806. “In about half an hour,” says Congreve,* “about two hundred rockets were discharged; the dismay and astonishment of the enemy were complete—not a shot was returned—and in less than ten minutes after the first discharge, the town was discovered to be on fire.” It has never been correctly ascertained how much of the town was consumed on this occasion, the French having given but vague representations of the calamity. The fire, however, could not have been inconsiderable, since it raged from two o’clock in the morning to the next evening; and a further proof to this effect is the caution with which Lord Lauderdale and his suite were guided through the town some few days after the attack, not one of them having been suffered to leave the inn at which they were placed, nor any one per-

* A Treatise on the General Principles, &c., of the Congreve Rocket System.
mitted to have communication with them; even in passing through the streets, they were conveyed in close cabriolets.

In 1807 rockets were again used with great effect in the attack on Copenhagen. Subsequently to this period a rocket troop was formed at Woolwich, under Captain Bogue. At the memorable battle of Leipsic, this rocket troop afforded the first proof of the military utility of their terrific weapons. They were the only English present on the occasion, and on firing a volley against a mass of French infantry, the latter, terrified at the devastation and slaughter effected by the new weapon, at once threw down their arms.

Such are a few of the memorable occasions on which rockets have been employed in actual warfare. Did our limits permit us to trace the progress of our arms in India, I might still further illustrate their tried efficacy. Enough has been said, however, to demonstrate their advantages and disadvantages; those who require further description of this weapon, and its application, we must refer to Congreve's interesting book; which has been more than once adverted to.
ON THE
APPLICATION OF GUNPOWDER TO
MILITARY MINING.

My remarks on this subject will be very few, inasmuch as the mere principles of mining operations, so far as relates to the operation of gunpowder, are simple enough, although the application of these principles to practice demands a great amount of mechanical, mathematical, and chemical skill. Modern engineers, particularly the French, have devoted especial attention to this subject, and have calculated the effects of gunpowder, at various depths and in various soils, with great accuracy. In England, the gunpowder for mining operations does not differ in composition from powders used for other services; its immediate force or rapidity of fire, however, might be diminished with much advantage. I have already observed, that a powder may ignite so rapidly that its power as a propulsive agent is materially injured, because a certain amount of continuity of action is desirable; the remark applies still more forcibly to the case now under consideration, and hence the fact, so well known to our mining communities, that damp powder is
more efficacious in the blasting of rocks than dry powder.

It is not my province to detail the operations of military mining; probably the only interesting part of the subject to general readers is the plan of communicating the fire to the charge. This was effected by means of gigantic quickmatches or leaders, made of long canvas bags, containing powder; now, however, military science has availed itself of the voltaic battery for this purpose. The use of this instrument is attended with many advantages where it can be employed. The charge, no matter how far situate from the operator, is fired instantaneously; the communicating agents, being merely wires, are more easily laid down than the canvas hose employed in the old operation. These are two great advantages, and the voltaic battery is by no means difficult to manage. It may not be unnecessary to state by what means the voltaic influence is applied to this purpose; the explanation is simply this: if the electric circuit be completed by a conductor of metal sufficiently small, the latter becomes hot: provided its size be sufficiently diminutive, it becomes red or white hot;—particularly if the metallic communication be effected by platinum, which is a very bad conductor of heat, and therefore rapidly assumes a very elevated temperature. Supposing, then, it is desired to fire a magazine by voltaism, all that is necessary is to transfix a cartridge with a
piece of platinum wire, each end of which is joined to a larger wire of copper, and the latter, on either side, is placed ready to communicate with the poles, or, as they are now called, the "anode" and "cathode" of a voltaic battery. This communication may be effected in an instant at word of command, when immediately the platinum wire becomes red hot, and the cartridge and whole magazine explode, blowing a large crater out of the earth, and hurling into destruction such works or troops as may be on the surface.

The application of voltaic electricity has, perhaps, been of still greater use in exploding subaqueous magazines—operations which, before its introduction, were accomplished by far more inconvenient methods.
THE HISTORY AND EMPLOYMENT
OF SMALL FIRE-ARMS.

Long after cannon, mortars, and other ordnance of fire had supplanted the more ancient balista, catapult, battering ram, and other mechanical engines of war—the long-bow, arbalest, and sling, maintained their undisputed sway. The reason of this is not difficult to assign; the construction of small arms, to be more effective than our own national weapon, the long-bow, or the arbalest of continental Europe, was a matter of no small difficulty. The mechanical ordnance of ancient times was either ineffective, or its power was achieved at the expense of vast mechanical skill, and expenditure of material; its transport was always extremely difficult, even for the purpose of siege, or garrison service; in the field, this difficulty rendered its employment almost unknown. Our ancestors, however, were much better supplied with small missiles: I have already spoken at some length of the force of the bow; mentioned special instances of its power and convenience. We have seen that it was in the powerful hands of our old archers a most
prompt and effective missile; the reader will still better learn to appreciate its valuable qualities, when he shall have directed his notice to the imperfect small fire-arms of our fathers. In proportion as the manufacture of small fire-arms improved, the advantages derivable from this kind of missile could not fail to be in some degree appreciated. Prejudice, nevertheless, amongst other causes, strongly operated against the general application of small fire-arms. Indeed the prejudice against even *cannon* was at first very strong; the iron clad knights had long managed to guard their own bodies against mechanical missiles; a good suit of armour would generally repel the blow of an arrow, and the horses, less fortunate, having grown mad with rage and pain from the thrusts of barbed missiles, and thrown their riders, the doughty warriors would roll on the earth awhile, and then retire with a few insignificant bruises—to engage in this innocent tilting another day.* The introduction of cannon was a sad blow to their chivalry: loudly did they protest against the

* In several battles about this time not a single knight was slain: when unhorsed it was difficult to penetrate the joints of their armour by the "*misericorde*" or dagger, and at the battle of Fournouë under Charles VIII., a number of Italian knights having been unhorsed, could only be killed after they had been broken up like so many lobsters with woodcutters' axes! This circumstance justifies the remark of James I., that defensive armour was a double protection,—preventing the bearer at the same time from being injured, and from injuring others.
villanous saltpetre; loudly they inveighed against such unknighthly modes of fight; the force of public opinion was, however, too strong for their prejudices—
the opinion had become prevalent, that warfare, consistently with its true genius, could not be rendered a gentle pursuit. Then many of those belted knights, finding that warfare had become so rough a pastime, quietly seceded from the ranks, and betook themselves to arts more worthy of their blood; others grew accustomed to the cannon and risked their chance of death. But when the ungentle musket began to supplant the bow, what a terrible innovation was there:—
deep and loud were the execrations of the knights; low the mutterings of the armourers, who began in near perspective to see their occupation gone. For a period the strength of armour was increased: breastplates acquired the thickness of anvils; helmets became like iron cooking pots; horses tottered under their heavy loads—knights were not infrequently smothered in the fray! It was useless any longer to affect disgust at innovations; the day of chivalry had passed; knights felt they were no longer the strength of an army, nor did their armour secure them any immunity from injury and death. Gradually, then, manual weapons of fire were universally employed; the soldier threw away his armour, the knight relinquished his lance; rapid evolutions succeeded to the slow but ponderous charge, and the whole system of war changed.
VARIEDIES OF SMALL ARMS INDIVIDUALLY CONSIDERED.

Doubtless, cannon soon after their discovery were occasionally reduced in size, so as to render them adapted for particular purposes; at length, after passing through many metamorphoses and gradations of diminution, a diminished cannon became a mere manual weapon of fire. It is impossible to say, then, when or where such small fire-arms were invented, but we pretty nearly know the period of their introduction to various European armies. "They appear to have been thus introduced into the English army in 1471, when Edward the Fourth, landing at Ravenspur, in Yorkshire, brought with him, among other forces, 300 Flemings, armed with hand-guns. This is fifty years before the date usually assigned for their introduction; Mr. Anderson and other writers placing that event at the siege of Berwick in 1521, soon after which they were generally adopted in England."

In 1555 the Spaniards, under Philip the Second, are said to have employed small fire-arms; but they were of a very unwieldy description. It had also always been considered difficult to protect archers against a resolute charge of cavalry, and the difficulty was greatly increased in the case of musketeers. The weapons and ammunition of an archer were light, his arrows flew in quick succession, and he was subject to no other cause of failure than the breaking of his bow or string.* Far different was it with the musketeer; his weapon was most unwieldy, exceedingly tiresome to charge and discharge, and subject continually to the chance of missing fire. Having fired their weapons, a host of musketeers were rendered for a time defenceless, and cavalry might pour down and put them to the rout; this was a sad disadvantage under which the musketeer laboured, and to overcome which various means were devised, the most common of which consisted in making the rest an arm of defence, appending to it a concealed dagger, which flew out on touching a spring, or affixing a spike to the head. Rests thus armed were called the Swedish or swine's feathers.†

* Hence it was not unusual to have two strings to the bow; and hence our common proverb. See Ascham's Toxophilus.

For a comparison of the several merits of archery and fire-arms, consult Humfrey Barwick's Discourse concerning the
The greatest change which fire-arms have undergone relates to the method of discharging them. At first they had no lock whatever, but were discharged by the manual application of a match; then followed the matchlock, afterwards the wheel or pyrites lock, next the flint lock, and, lastly, the percussion lock, under one of its many various forms; this seems to be the extreme limit of perfection, leaving nothing more to desire.

The Matchlock was a very obvious and simple contrivance for dashing the lighted end of a piece of rope, soaked in nitre, upon gunpowder contained in a little pan communicating with the charge. This means of firing guns was, on the whole, very efficacious, and is still employed in most Eastern nations. The match, however, is liable to be extinguished by rain, and is very dangerous to be carried in such close proximity with gunpowder as it necessarily must. The ancient European musketeers used generally to carry their lighted match in a little iron cylinder perforated with holes, but in rainy weather they carried it in their hats.

The Pyrites, or wheel-lock, seems to have been

Force and Effect of all Manual Weapons of Fire; Smythe (Sir John, Knt.), Concerning the Force and Effect of Weapons. Lond. 1590; Sir Roger Williams's Brief Discourse of Warre. Lond. 1590; and the various treatises on archery already referred to.
introduced into England about the reign of Henry the Eighth. It continued in use until the time of Charles the Second, when the flint-lock became general. This wheel-lock, now obsolete, but once universal in European armies, it may not be amiss to describe. The original idea of the contrivance may be recognised in an old "büchse" at Dresden, which has a piece of pyrites fixed opposite the touch-hole, which is intended to be rubbed with a file for the purpose of eliciting sparks to ignite the powder. In its improved form it consists of a small grooved steel wheel, to the axis of which a chain or swivel and powerful spring is attached; this being wound up by means of a spanner, a key is retained in that position by a spring-catch connected with the trigger. A piece of pyrites is firmly screwed into the cock-head, which on being pulled forward rests on the circumference of the wheel, which enters the bottom of the pan. On pulling the trigger the wheel is disengaged, and spinning round in contact with the pyrites, it produces a stream of sparks close to the touch-hole."

*FLINTLOCKS appear to have been introduced into our armies about the third or fourth year of William

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* Wilkins. Probably fowling-pieces came into vogue shortly after the introduction of the wheel-lock. Benvenuto Cellini relates how being at Rome when he was about 23 years old (i.e., about 1520 A.D.), he amused himself by shooting doves with a gun. He records, however, that he employed a single ball.—MEYRICK'S Hist. of Small Fire-arms.
the Third (1692-3), since which time they remained in use, with very little alteration, up to the period of the discovery of the percussion principle by the Rev. Mr. Forsyth. It is quite unnecessary to describe a contrivance so well known as the common flintlock; just as unnecessary is it to describe the common percussion lock of the present day,* although it has undergone many changes of form since the discovery of Forsyth. Suffice it to say, that the advantages of the percussion over the flint principle are now universally established, and muskets involving the percussion system variously applied, are either already introduced, or about to be introduced, into every European army.†

I have hitherto designated small arms, in contradistinction to artillery, by the general term "musket"; this, however, was merely for the sake of convenience; various are the appellations that have been given to manual fire-arms, some of which deserve notice. The

* It may be as well to state that the powder originally used for charging percussion caps was a mixture of chlorate of potash and sulphur. This was, however, found to destroy or corrode the lock, and now the "anti-corrosive powder," or mixture of fulminate of mercury, is universally employed.

† All European nations, save Prussia, use the percussion cap. The explosive agent of the Prussian Zündnadelgewehr, is fulminating powder imbedded in the base of the projectile. The Americans employ in their military and naval service the Maynard pressure, which is a flat helix studded with detonating dots, one of which at every act of cocking is brought immediately over the nipple.
first small fire-arms were called Hand-Cannons, and were fired on a rest by the manual application of a match. When the weight of these instruments was reduced, and a lock appended, so that they might be fired without a rest, they were called Calivers.

It is supposed that the most ancient kind of fire-arms mounted upon a stock was the Arquebus,* and the invention of it is placed about the year 1500. These instruments succeeded the hand-cannons, or culverins, in field service, and restricted the use of the latter to sieges. Such hand-cannons were afterwards called "arquebusque à croc" (arquebus, with hook), in consequence of being provided with an appendage of that kind. In our statutes it was called "arquebus," "haquebus," and "hagbut." The term "musket" was originally applied to a fire-arm larger and heavier than the caliver, and therefore supported when fired by a rest. The Petrinal, or Poitrinal, was an arm shorter than the others mentioned, and of larger calibre; it was fired resting against the breast, and hence its name.

**Pistols** are so called from Pistoia, in Etruria,

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* There appears to be no just ground for considering the harquebuss and caliver as different weapons. "It is supposed by many" (says Barwick, p. 8) "that the weapon called commonly a caliver, is another thing than a harquebuz, whereas in troath it is not but onely a harquebuz, sauing that it is of a greater circuite or bullet than the other is of, wherefore the Frenchman doeth call it a peece de calibre, which is as much as to say, a peece of bigger circuite."
where they were manufactured anterior to 1544, in the reign of Francis the First. The German horsemen called "Reiters" were the first who extensively employed the pistol, having discarded, in favour of this weapon, the long-used lance; and incurred for that reason much censure, and even abuse; the innovation being considered to some degree dishonourable, and opposed to the established laws of chivalry.*

Anciently, not only were fire-arms large and small used to project bullets, but wooden arrows, called "sprites," and steel quarrels were also employed.† The recent Musket is so obviously the derivative from the ancient small fire-arms, that all description of its construction will be unnecessary.

A few remarks, however, concerning the weapon which has acquired such celebrity, and which figures so largely in our military history as does "Brown Bess," must be offered. The last improvement destined to be received by that renowned arm of fire, was the percussion lock; beyond which, improvement could not further go, the smoothness of bore which constitutes a musket being retained.

Above all things it is necessary that a military arm shall not readily get out of order. Everything must

* Might not carbines be discarded entirely, with advantage, in favour of revolver pistols?
† See Sir Richard Hawkins's account of his voyage to the South Sea, A.D. 1591, p. 164, sect. xvi., where he mentions shooting arrows from muskets with great success.
cede to this. What would it avail the soldier that he possessed an arm which, when in order, could be charged and discharged say once in three seconds; if it frequently got out of order, and then could not be discharged at all? Little was expected of "Brown Bess;" she did that little well. The musket could make decent practice at distances from 100 to 150 yards; beyond its rude lock there was no machinery which could get out of order: though very foul it might still be loaded; and in any case it was a good handle for the bayonet. It is the fashion to abuse "Brown Bess" now, but I think unjustly. The fire-arm which helped to win the battles of Marlborough and old Fritz, of Wellington and Napoleon, did well in its day. It is most unreasonable and unfair to institute comparisons between Brown Bess and the Minié, or Enfield, or one of the many other varieties of the rifle, as rifles are now. A comparison, to be fair, should be as between the modern rifles on one hand, and the old-fashioned rifles on the other hand; which comparison being made, Brown Bess, if she were a reasoning creature, would have the laugh on her side. The fact is that the old military muzzle-loading rifle employed in connection with a round ball, tightly fitting, and only to be got down on the powder by considerable force,—never was employed, and never could be employed, by troops generally. Had the musket been set aside, the question arises, What was to have taken its place?
AND EXPLOSIVE COMPOUNDS.

The following table of shooting, as between the old percussion musket of 1842 and the Minié, may be interesting; it took place at Hythe, and was communicated to Sir Howard Douglas by Colonel Hay. Twenty men fired ten rounds each, five in file, and five volley firing, against a target six feet high, and twenty feet broad; equal in front to eleven file of infantry, or twenty-two men. The muskets were 4 feet 6 inches from the ground.

PERCUSSION MUSKET, 1842.

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<td>Yards.</td>
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<tr>
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<td>7</td>
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<td>260</td>
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<td>300</td>
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MINIÉ RIFLE MUSKET, 1851.

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<tr>
<td>Yards.</td>
<td></td>
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<tr>
<td>100</td>
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<td>200</td>
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<td>400</td>
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"Colonel Hay remarks, that the shot from the common musket which missed the target, fell from 20 to 50 feet wide of it; whereas the Minié shot which missed fell within two or three feet only of the target. The same officer, in a letter to the author, observes that, with careful training, soldiers of the line may be made to put half their shot into such a target at 400 yards, and two-thirds at 300 yards.

"September 17, 1853, at Hythe, practice was made with the regulation Minié musket by four men, each of whom fired ten rounds, at distances from the target varying from 700 to 200 yards. The target was 16 feet long and 6 feet high.

"The men advanced in skirmishing order, according to regulation; fired kneeling, and exercised their own judgment respecting their distances from the object. Of the 40 rounds fired, 8 hits took place in the bull's eye; 16 in the central part (a circle 6 feet in diameter), and 4 beyond, but very near the central part; in all, 28 hits, and 12 misses. Of the hits, 18 were below the centre, and 10 above; 16 were on the right, and 12 on the left. The wind was blowing strongly, and the atmosphere was cloudy. The same day similar practice was made by four men with the musket having an elliptical bore, at the same distances from the target, the men advancing in skirmishing order, and kneeling. Of 40 rounds fired, 6 hits took place in the bull's eye;
22 in the centre circle, and 6 beyond it; six shots only missed the target. Of the hits, 25 were below the centre, and 9 above; 15 on the right, and 19 on the left.”
POLARITY AND POLAR WEAPONS.

Whatever subject be under investigation, it is a desirable thing to pause now and then, and reflect upon the principles which it embraces.

Projectile weapons admit of a strictly philosophical division into two classes; according to the manner of their flight: they may, like the arrow, keep one end foremost throughout their flight, and strike on that end first; or they may, like a stone thrown from the hand, or a round shot, large or small,—travel with any, or all sides in succession first, and strike indeterminately.

When a quality is two sided or two ended, so that one side or one end is the exact reverse of the other, philosophers call such two sidedness, or two endedness, "polarity;"—thus, magnetism is said to be a dual or twin joining of polar forces. There is a north-pointing extremity of the suspended magnetic needle; there is also a south-pointing extremity; hence the propriety of the designation—"polar."

With equal propriety may the designation be applied to missive weapons. Those which pursue their
flight through the air, always keeping one end or aspect foremost, are "polar projectiles." Those, on the contrary, which do not, are "non-polar projectiles."

This distinction is not drawn for the mere sake of introducing a new word to the military vocabulary; but to simplify the consideration of projectiles. Knowing whether any particular missile be polar, or the contrary, we can better adapt such missile to its intended purposes. Thus, of what avail would it be to furnish an arrow head with a barbed point, if no dependence could be placed on the arrow head being the part of the arrow to strike first? Of what avail would it be again to contrive an explosive shell that should be ignited by the percussion of a cap against the object aimed at, if we had not determined beforehand whether or not the shell by virtue of some polarity (how conferred we need not inquire just now) could be depended upon for striking with its capped aspect foremost?

The distinction into "polar" and "non-polar," embraces the widest principle I know of in relation to projectiles. When clearly apprehended, it shows how the greatest possible correctness of flight may be obtained for each variety ofmissive weapon; and teaches us the limits within which artillerists may hope for success from the application of percussion shells.

Seldom can a better way be devised for teaching
what has been done in any particular line, than to assume nothing of the sort already done, but remaining to be done.

Suppose, then, a piece of sheet lead were given to an operator accompanied by the request that he (the man to whom the lead is given) should fashion the lead into such form as—according to his judgment—would go straightest towards a target—when fired from an ordinary, or smooth bored gun.

Guided by that knowledge of common things, which most of us possess, to some extent,—we know not how or why,—ninety-nine men out of a hundred (I should say, perhaps, indeed, the hundredth too) would fashion the lead into a sphere, or ball. A common smooth bore arm of fire, whether large or small, is not what I will venture to call a “polarizing weapon;” it does not impart to its missile the tendency of keeping one particular end foremost throughout the line of flight.

The circumstance need not be pointed out that no such form as a perfect sphere was ever manufactured by the hands of man, or ever can be. Irregularities of form in round projectiles there must always be; and even if perfect sphericity be gained, the chances are enormously in favour of the supposition that the metal will be more compressed in one part than another; so that the centre of gravity will no longer correspond with the mechanical centre of the sphere. A very elegant demonstration of the above is deduced
from the experiment of floating cannon-balls in quicksilver; which may readily be done. If a cannon-ball thus subjected be not heavier on one side than another, any aspect of it placed uppermost in the bath of quicksilver will remain there. Very few, if any, cannon-balls will stand this test.

Yet, by every deviation from complete sphericity alone; and from correspondence between the centre of gravity and spherical centre—by so much, proportionately, is the flight of the ball disturbed:—so that, by way of testing the fact by an extreme case, if a hole be bored into a cannon-ball, then the hole plugged with wood and fired, the aberration, or mistaken path, of such cannon-ball will be very great indeed.

For this reason partly is it, that un rifled shell guns (other things being equal) can never shoot as truly as un rifled shot guns.

Finally, as a corollary of what has been stated above, when a ball has been made as nearly spherical as it can; when the distribution of metal within such ball has been so effected that the centres of sphericity and of gravity correspond as near as can be; no further aid to correct flight can be imparted to the ball itself. Care in respect of the piece from which it is fired, so that the bore may be smooth and nearly fitting to the ball, contribute something more; and a
chamber, or patent breeching, by means of which the gunpowder charge is lighted well under the centre of the ball, also help to achieve such amount of correctness of flight of which a spheroid, or "ball," properly so called, shot from a non-rifled gun is susceptible.

Before going further it will be well here to observe, that the only form which is at all compatible with the correctness of flight of a "non-polar" weapon, is the spherical form.

The subject of polar weapons does not admit, perhaps, of being more conveniently introduced, and explained, than through the medium of a boy's peg-top.

If a peg-top were given to any person, accompanied by the request that he would drop it from the window of an upper floor—in such wise that the peg end of the top should strike the ground first—how might this be done?

Firstly, a peg-top is, when simply thrown from the hand, or let drop, not a "polar" projectile. It might strike on the peg, or it might strike on the very reverse aspect; or, in short, on any aspect. How can it be polarised?

Firstly, something might be attached to it which, by offering resistance to the air, should act like a parachute, or a vane; thus virtually, though not absolutely, rendering the part of the top furthest away from
AND EXPLOSIVE COMPOUNDS. 211

the peg end the lightest part. Thus, one long straight feather might be stuck into a hole drilled into the upper part of the top, thus converting the top into an arrow; or several feathers might be stuck laterally into the top, as represented above; thus converting it into a shuttlecock.

Or, finally, instead of imparting a virtual lightness to the upper end of the top by means of the aërial resistance of feathers, we might attach a simple stick to it as below; thus rendering it a compound projectile, absolutely heavier at one end than at the other.

Now, if the reader will, for the instant, exclude rifle bullets, he will not fail to perceive that all other polar projectiles, ancient no less than modern, acquire their polarity by variations, more or less closely followed, of the expedients represented above. As for the first, it converts the top, almost literally, into an arrow; as to the last, it is at once the type of the "javelin" in all its varieties, and of the "Congreve rocket."

But the simplest means of insuring impact between
the peg of the top and the ground, would consist in projecting it from the hand, in the ordinary way that peg-tops are projected; that is to say, having a spinning movement imparted to it by the rapid unwinding of a cord.

No person ever yet saw a peg-top standing upon its peg, otherwise than when in motion; yet, if a top were so accurately formed that its absolute centre of gravity existed in its geometrical axis, it assuredly would stand on its peg, if accurately set down upon it; even though not in motion. This feat has never been accomplished, and never will be; seeing that a top so absolutely correct in its parts as we have assumed, cannot come from the hands of man: but the ease with which a top when spinning stands on its peg, shows how completely the spinning motion of the top counterbalances the unequal distribution of its parts. Not only will a peg-top fly spinning through the air peg foremost, if thus launched to begin with; but it will continue to stand on the peg after reaching the ground; until the rotatory motion decreases below a certain limit.

Directing our attention now to ascertain the reason of this, the explanation is obvious. A peg-top is a thing of unequally distributed weight; and unequally distributed shape; in other words, it lacks symmetry. Fashion it with all possible correctness, some one side will always be heavier than some other
side. But the effect of rapid rotation is virtually to so make up, and to distribute, real inequalities that the result is virtual equality.

The London wayfarer may now see in the course of his rambles through the streets, a new development in the art of peg-top practice; which, if he ever reflect on the subject of percussion shells, may cause him to look with interest on the boyish pastime. I advert to the practice which some boys have of fixing a percussion cap upon the peg. Inasmuch as the peg strikes foremost, because of its imparted polarity, the cap explodes; and if the peg were converted into a perforated nipple, leading to a chamber filled with explosive material in the body of the top—the boy would have unconsciously constructed a veritable "polar rifle" percussion shell. The shells exploded near the carriage of the French Emperor, January 14, 1858, were "polar percussion shells;" polarity being determined by making one end of the shell heavier than the other. They appear to have been made of cast steel, lathe turned; to have been cylindrical in the middle, each having two truncated conoidal extremities. The extremity of impact of each is screwed into the body; the other extremity being slid in. Explosion was determined by twenty-five nipples, each primed with a percussion cap. The charge is said to have been fulminate of mercury. Such a missile would be inapplicable in a military sense.
ON RIFLE GUNS.

If a common musket barrel be fixed in a vice, in such a manner as to prevent all motion, loaded and fired several times in succession at a target situated at one hundred yards distance, the bullets will err from the line of sight much more considerably than might a priori have been imagined. Instead of hitting the exact point aimed at, some will impinge above it, some below, some on each side. Nor will the errors be trifling under these circumstances, but may amount to two feet, or even more.

It is evident, then, from a consideration of this fact, that with an aim so radically defective, quickness of eye in the soldier is a quality of but limited application. If we remove the target successively to greater distances, the errors of deflection increase to an amazing degree; so that at a distance of six hundred yards a musket-bullet frequently wanders from its aim to the extent of many hundred feet.* This is no new discovery—it was known to that accurate experimenter Robins, who mentioned it in his work on

* Vide page 129.
and explosive compounds.

Gunnery, written in the year 1742; but the fact has never gone forth with the emphasis it merits, much less has it been taken cognisance of as an accepted axiom.

The reason of this inequality of flight is not difficult to explain,—being referable to the ever-varying conditions under which a bullet flies through the atmosphere when shot from a common gun. In the first place, though intended to be spherical, no bullet is absolutely so; and in proportion as it deviates from perfect sphericity, so will the atmospheric reaction encountered during its flight cause it to deviate from its calculated path. Then, again, a further amount of deflection will be determined by the condition under which it leaves the gun. Should it, for instance, touch the right-hand side of the barrel last, it then will rotate on a vertical axis towards the right, and its line of deflection will also be to the right of the calculated path. Should it happen to touch the left side of the barrel, the reverse of these conditions will obtain; and so on for the varying conditions resulting from its final contact with the upper or lower side of the barrel.

The rifle gun is an ingenious contrivance for converting the undefined and irregular motion of fire-arm projectiles into one predetermined and regular; by imparting, in point of fact, a spinning-top like motion to the bullet, and thus insuring its continuance in a
vertical trajectory curve. It is strange, however, that although the rifle principle is founded on the idea of a spinning-top; yet, until very lately, the spinning motion was imparted to a round bullet merely; and not to projectiles fashioned like a top.

The general aspect in which an ordinary rifle differs from a common gun is this.* Whereas the latter has a smooth cylindrical bore, the former has a bore not smooth, but cut into grooves or indentations. This is the sole peculiarity a first glance will disclose; but if the observer unscrews the breeching of a rifle gun, and looks through the barrel, the grooves in question will not be found to proceed straight from nozzle to breech, but to assume the direction of a very wide spiral; the screw of the spiral making one turn in about forty diameters. Now, it is evident that a bullet, or plug of lead, closely wedged into a barrel of this kind, and made to pass along the bore, must (except an extraordinary degree of violence be applied) follow in its course the direction of the spiral; and if propelled through the barrel by the force of gunpowder,—must fly through the air in a spinning or top-like manner. This is the effect of the rifle gun: and this is the mode of flight of a rifle ball.

The great correctness of a rifle over a common gun is too well known for comment. I need therefore

* I say ordinary rifle, because Lancaster's oval rifle has a smooth bore.
not expatiiate on this subject; but will proceed to examine more closely the philosophy of the instrument; the laws which regulate its action; the causes which have tended to limit its application; and how they have been overcome.

In the first place, it will be evident that the rifle, except some particular device be adopted, must be considerably more difficult to load than a common gun; also, that the act of loading must occupy a longer time. The very principle on which the instrument depends implies that the bullet should fit tightly; and this tightness was for a long time solely accomplished by employing a bullet slightly larger than the bore; the bullet being first driven in by a mallet, and finally rammed home by a powerful ramrod. Unquestionably, then, the rifle in this form is a much more troublesome weapon to manage than a common musket; more tedious to charge and discharge; less adapted, therefore, for pouring in upon masses of troops volleys quick, and unflagging. Hence, almost coeval with the first invention of the rifle was the attempt to charge by an orifice at the breech; and various contrivances for this purpose may be observed in rifles of early construction. Generally speaking, none of these contrivances have realised the hopes of their suggestors; chiefly because of the difficulty of making the necessary joints impervious to the gases resulting from inflamed gunpowder. Indeed, the same ob-
jection applied until lately to every variety of breech-loading gun; but it may be questioned at this time whether the objection have not been obviated.

It would be out of place here to describe the means by which the rifling of gun barrels is effected; but enough will have been said to convince the reader that the engraving of these long spirals is a matter of great delicacy; and that if these spirals be not absolutely parallel one with another, the object for which they were made will have been lost; and the rifle (falsely then called) will have become something worse than a common gun. A rifle, in point of fact, is a somewhat delicate pneumatic instrument; unfit for clumsy hands, and only efficient when treated with care.

With respect to the number and height of the rifle ridges—lands, as they are called—and depth of grooves, this is a matter of taste, to a great extent, if solid non-expanding projectiles be employed.* Provided the theory of the rifle be kept well in mind, so that loading be accomplished in such a manner as shall insure the bullet acquiring the spiral turn—provided that the rifle has, in the first place, been truly grooved (without which all care is thrown away)—almost any rifle may be made to shoot with sufficient correctness for

* With expanding projectiles, an uneven number of grooves is better than even numbers. A groove should be rather opposite a land, than opposite another groove.
military purposes; that is to say, may be made to hit a man, when fired from a vice or other fixed object, infallibly, at a distance of four hundred yards. For military purposes, however, rifles having small delicate grooves were always objectionable; being subject to injury from the iron ramrod employed: and moreover being liable to the accident of allowing the ball to “strip,” as it is called technically—viz., to issue straight from the barrel without assuming the spiral turn.

There is little need, however, for insisting upon the impropriety of rifles, having delicate grooves, for military purposes now. The era of rifle-balls (properly so called) has departed; never to be revived. Elongated, or conoidal, projectiles will soon be the only ones that any sensible man will shoot from his rifle; and inasmuch as all bullet-shooting small firearms will henceforth be rifled, a round leaden small-arm bullet will be a curiosity in a few years.

Delicate grooves do not succeed in connection with the new system of elongated projectiles. With expanding projectiles, such as the bullets of Minié, Pritchett, &c., they do not answer at all.*

Whatever the diameter of the bore, or calibre of the piece, may be—whatever the length of the barrel—which the other peculiarities, the first thing to

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* The Americans term the new elongated projectile conoids, “pickets;” and a very good term it is.
be borne in mind in the purchase of a rifle is, that the rifling itself be accurate. With a view of testing this, it is a custom in some parts of Germany to proceed as follows. Into a short cylinder of rifled barrel, corresponding to that of the gun itself, lead is cast, so that when withdrawn cold it forms a rifled cylinder of lead, which being oiled, thrust into the barrel, and forced through it, the relative degree of ease with which it passes enables the operator to judge of the correctness with which the rifling has been made. If the leaden cylinder meets with no impediment in its way, but goes equably through the barrel from one end to the other, the gun is provisionally accepted; if, on the contrary, any irregularity of motion or obstruction be encountered, it is rejected. This mode of testing a rifle barrel should only be regarded as provisional; the experimentum crucis is this. Supposing a single-barrel rifle to be in question—(and single-barrelled rifles are always, cæteris paribus, more correct than double-barrelled ones)—proceed as follows:—Load it properly (full directions for loading will be given by and by); then, having fixed it securely between the chops of a vice, securing the barrel from damage by two sheets of lead, point it accurately to the bull’s-eye of a target, at a short distance, say 80 yards, or whatever may be the distance of the first sight, then fire the charge. If the bullet go straight to its mark, and if, repeating the experiment again
and again, the same result occurs, the barrel may be considered so far good. The operation should now be repeated at progressively increasing distances, say 100 yards, 150 yards, 200, and 300 yards. 100 yards may be considered as the average point-blank range for rifles, beyond which distance the bullet, although it never ought to depart from the vertical trajectory curve, will strike below the line of sight, extending from the level of the breech to the level of the muzzle. In other words, the barrel must be elevated in proportion to the distance of the shot. Now, this elevation is determined in rifles by sights of various lengths. We will suppose the experiment of firing from a fixed rest to be afterwards repeated at 200 yards, or at any other distance corresponding with that engraved on the sight. If the bullets hit the bull's-eye at this distance the gun is of good quality; or if the bullets strike in the same vertical line, somewhat over or under the bull's-eye, there is no radical defect. If the bullet strike over the mark at this distance, but accurately at the distance of the short sight, whatever this may be, then the error may be presumed to depend on the sight in question being too high, and therefore giving too much elevation. The remedy for this is simple and obvious—the sight should be made shorter.

If the bullet shoot invariably right or invariably left of the mark, then the error probably depends on the sight being not exactly situated in the median line
of the barrel; the remedy again in this case is obvious. If the bullet strikes below the bull's eye, but in a line vertically coincident with it, then the error may arise from one of two causes—either the sight is too short, or the charge of powder is too small.

In this way the rifle should be tried for every distance marked upon the sights, after which practice may be made at intermediate distances, so that the rifleman may at length acquire a thorough confidence in his weapon; based on a knowledge of its range and power.

The remarks hitherto made are general, not specific; they apply to all guns on the rifle principle. Some remarks will now be offered on rifles individually.

Muzzle-loading Rifles and Round Bullet.*

Notwithstanding all the contrivances which have been had recourse to for the purpose of loading rifles at the breech, the muzzle-loading rifle is still most general; and though the era of bullets or spherical rifle projectiles has quite gone by, elongated conoids, "pickets," having justly taken their place, yet, if only for old acquaintance sake, we must not quite pass over the old system of muzzle-loading, with a ball truly so called.

The hammer being yet on the nipple—the latter

* i.e., ball, properly so called.
without a cap—or at half-cock, charge the piece with the quantity of gunpowder previously ascertained to be proper; then, supposing a leaden bullet to be the projectile to be employed, proceed as follows: lay flat on the muzzle of the gun a piece of linen, silk, or glove leather, greased on the side touching the muzzle, and in size just equal to the exterior diameter of the barrel. On this piece of linen, silk, or leather, lay the bullet, and force the whole down upon the powder. This is effected usually by the aid of a little mallet, to force the bullet into the barrel, and a ramrod to drive it home. The mallet, however, may be dispensed with. The gun is now capped as usual.

Great care should be taken with all rifles not to injure the grooves, and lands, during the operation of ramming down the ball. Sportsmen have long abolished the use of iron ramrods, on account of the damage they thus produced; but military rifles, ever in the rear of improvement, still have this instrument, so destructive to the accuracy of their pieces. If it be necessary to retain the ramrod of iron in the military service on account of the strength of this material, the end should at least be tipped with brass. However, since the new principle of using expansive conoids has been adopted in military service, the iron ramrod cannot work such injury as in times gone by.

Some people are in the habit of loading old-
fashioned rifles without the "patch" above described; but supposing a ball, not a conoid, to be used, the plan is reprehensible.

This would seem to be the best place for advert- ing to the most vicious system of rifle-loading pursued in some of our London galleries, where, for the sake of economising time, the bullet, without any patch, is violently forced down upon the powder by an iron ramrod, provided with a heavy iron knob at one end. Rifles thus treated are totally ruined in a short time; their grooves becoming torn, ragged, and faulty.

ORDINARY RIFLE USED WITH CONOIDAL PROJECTILE (PICKET).

Notwithstanding that conoidal projectiles are best adapted to rifles having large and shallow grooves, still they may be used in connection with any rifle, if proper care be taken, and provided the conoids be not on the expansive principle. In Germany, rifle matches are, as is well known, far more common than here, and the shooting is usually excellent. I have been present at several of these matches, and seen conoidal projectiles shot with rifles having many varieties of small groove. Some used patches, others not; and the charge of powder was low. I imagine that the charge should always be low for this sort of rifle, employed in this manner; otherwise the conoid would be liable to strip.
AND EXPLOSIVE COMPOUNDS.

As regards expanding conoids, to be treated of presently, their successful use in connection with small-grooved rifles is hopeless.

DEVELOPMENTS OF THE RIFLE GUN.

From what has already been written concerning the rifle gun, the latter will be seen to be a firearm so constructed, that, by imparting a spinning or top-like motion to its projectile, it causes the latter to pursue a polar flight.

The rifle gun has been described in its simplest form. Let us now consider what may be called its developments. These may be conveniently subdivided under the heads of development of principle, and development of form.

I am not aware that anything, which can properly be called a development of the rifle principle, can be said to have occurred, either in respect of rifle guns and their projectiles, between the period of the first discovery of the rifle, and the introduction of solid, and of expanding conoidal projectiles. Doubtless, several modifications of the rifle have occurred, and are still occurring; one manufacturer thinks one certain pitch of twist should be given; another manufacturer chooses another,—yet the rifles of each may, perhaps, be made to shoot equally correct. Certain rifle-makers consider that the pitch of screw should be an increasing pitch; almost nothing towards the breech end, but
increasing subsequently. No principle is involved here; all is matter of opinion. Generally speaking, however, we may say that, since the introduction of conoidal pellets—solid or expanding,—rifle grooves have been made fewer, and shallower, than heretofore; and the rifle twist less abrupt.

During the last war, Mr. Whitworth, of Manchester, working under the aid of a parliamentary grant, devoted much attention to the principles of rifle construction. Mr. Whitworth may be regarded as fortunate. He commenced his labours in this field, knowing nothing whatever about rifles. He ended with discovering what rifle-makers knew already, i.e., that maximum range demanded maximum practical elongation of projectile. This is not said to the disparagement of Mr. Whitworth’s labours; on the contrary, it is a point of some value that his deductions are precisely those which rifle-makers had arrived at, from an independent series of experiments. Mr. Whitworth has certainly not advanced the construction of rifles by one iota; and the way in which his experiments came before the public was not quite satisfactory. For example, when the vast penetration of the Whitworth picket was treated of, the collateral point was omitted; that the projectile in question was not of lead, but of pewter—hard metal—which never could be combined with the expansive principle,* and, for

* The excavation at the base of the Whitworth picket is barely one-eighth of an inch.
that and other reasons, never could come into general military use. To have omitted to set forth this point, might have been policy, having regard to the agitation in Parliament of pecuniary remuneration to the inventor; but it was hardly accordant with the usages of science. I am aware that Mr. Whitworth proposes to use a leaden picket for military purposes; but the leaden picket was not the one provided; not the one whose penetration was discussed, whilst Parliament continued to sit. Mr. Whitworth's rifle bores are hexagonal; there is nothing new in that. I possessed, when a boy, an hexagonal rifle, of Spanish make; it was taken at Trafalgar.*

The accompanying diagrams represent the celebrated hexagonal hard-metal picket of Mr. Whitworth, his leaden picket, and a third larger picket; the latter

* Why was it that all who tendered designs for the British small arm weapon, save Mr. Whitworth, were limited to the Enfield ammunition, the limitation being waived in his case?

p 2
purpose desired, is interesting as throwing light upon the course in which that gentleman's ideas have been travelling. He appears to have set out by using rifle twists of extreme abruptness, and pickets of considerable diameter; he ended by diminishing the transverse diameter of the picket, also the abruptness of the rifle twist. Had the present military small arm, the Enfield, been of equally small bore with the Whitworth rifle, it would have made shots equally long, and of equal penetration. But, for military purposes, it is not considered desirable to diminish the bore less than we have it in the Enfield; the gun would foul too rapidly, a matter of greater weight than the ability to make enormously long shots. It would have been well had all these points been stated. The material of the Whitworth barrel is steel; the weight of it one pound heavier than the Enfield (pattern, 1855).

The annexed figures comprise other particulars of the arm and its projectile:

<table>
<thead>
<tr>
<th>Description</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter of polygon from side to side</td>
<td>0.438</td>
</tr>
<tr>
<td>&quot; from angle to angle</td>
<td>0.490</td>
</tr>
<tr>
<td>Length of picket</td>
<td>1.450</td>
</tr>
<tr>
<td>Windage</td>
<td>0.010</td>
</tr>
<tr>
<td>Length of barrel, 3 feet 3 inches</td>
<td></td>
</tr>
</tbody>
</table>

Here may conveniently be given the diameter (bore) of the musket, the Minié, and the Enfield rifle respectively.
MUSKET (pattern, 1842) ... ... ... .753
Minie ... ... ... ... ... .702
Enfield ... ... ... ... ... .577

LANCASTER'S OVAL BORE RIFLE.

If we conceive a rifle with two grooves, as below, to have the edges of its grooves continually eased away, an oval bore will at length be the result, in the course of which, though no grooves whatever can be seen (for in fact, none will remain), the oval bore, nevertheless, will turn on the usual rifle axis, and a closely fitting ball emerging from it, will be made to assume the rifle spinning motion. Though the oval shape of the bore, altered as it is to the two-grooved rifle, can hardly be said to embody a principle; yet the means by which such oval boring is conducted is exceedingly ingenious; and such rifles are most accurate.

In Lancaster's recently made oval rifles, the oval is so slight that no person unacquainted with the nature of the gun would perceive the existence of it: for this reason an oval bore rifle can be used as a fowling-piece with good effect; the small shot not being much influenced by the rifling. The pickets now employed are excavated at the base to take advantage of the expansive principle, concerning which a few remarks will be offered presently.
INCONVENIENCE OF MUZZLE-LOADING RIFLE—EXPANSION PRINCIPLE.

Looking at the principle and construction of the rifle gun, seeing that it is a hollow screw, into which the projectile, a solid screw, accurately fits—the fact will be evident that the act of cutting a screw on a bullet, "picket," or projectile of any shape, must require some exercise of force. Now, the old way of loading a rifle gun involved the cutting of such a screw. The ball, something larger than the rifle bore, was forced down by manual labour. Even when the rifle was clean, and in good order, and employed in all the tranquillity of a sylvan park, or a shooting gallery—this labour was such as every shooter would readily avoid if possible; and on the field of battle, when a rifle barrel grew foul, the act of loading could not be accomplished sometimes except by some such aid as battering the stiff iron ramrod against a tree or on the ground: the consequences of that were most ruinous to the barrel, as well as most inconvenient.

So intolerable was this necessity, or assumed necessity, for hammering down a rifle ball, that long ago, whilst flint locks were still in the ascendant, and mechanical execution far less considerable than now; means were devised for loading rifle guns at the breech,—by one of many contrivances. Some of them
answered moderately well for a few rounds, but few or none stood the test of continuous firing;—so the idea of making efficient breech-loading rifles for military purposes was never entertained until long subsequent to the invention of percussion locks. Whether the problem of "breech-loading" may be considered as solved affirmatively even now, for all varieties of small arms, is a moot point. That it succeeds for pistols, and carbines, no one doubts; that breech-loading fowling-pieces are as safe and more convenient than mouth-loading shot guns, there can be as little doubt. One breech-loading system, at least, that of Col. Greene, seems to leave nothing to be desired when applied to carbines; but as to the fire-arm representative of Brown Bess, whatever it may be, whether the breech-loading system can be adopted with perfect efficiency in its case, is still a moot point. The Prussians have tried it in their celebrated zündnadelgewehr, or needle gun, the rapidity of charging which, when in good order, leaves nothing to be desired; but the needle gun, after long firing, loses flame at the breech joinings to such an extent that the soldier firing it, is seriously inconvenienced. In the course of the Prussian campaign against the Holsteiners, so completely out of order did some of these needle guns become, that they could no longer be fired from the shoulder, because of the back stroke of escaping flame. I have frequently seen
the Prussian troops at target practice with the needle gun, and they have generally made good shots; the principle of ignition, of course, does not influence the correctness of shooting, either one way or the other. But I have also witnessed the extreme difficulty experienced by the troops in opening their "breeching gear," as I may call it. I have seen them strain, and twist, in so many ways, each according to the necessities of the case, and the operator's ingenuity, as no drill manual would have permitted, if the strainings and twistings had not been a sheer necessity.

The needle gun is here mentioned, because it is the only variety of breech-loading small arm of the line which has been brought into extensive military practice hitherto. I thought better of it once than now. The frightful danger of this weapon alone is a point against it. Not long since I barely escaped with my life, owing to the accidental discharge of a needle gun—not handled by an inexperienced person, but by the inventor of it. I need not say the inventor was very sorry for the accident, and I was not less glad to have escaped. He explained exactly how the thing occurred; and conveyed the satisfactory assurance that if he had not done something that he did do, the needle gun would not have gone off. Exactly; but upon the wall, uncomfortably near to where my head had been, I perceived a little hole, and remembering that the needle gun did go off, I conceived, from that day
forward, a salutary dread of the treacherous weapon. The proprietor wished me to accompany him to the fields, that I might see practice with his gun, and that he might vindicate its claim to safety, as well as range and penetration. I did not go; nor had I reason to regret staying at home: that very day a cow was killed, and by the zündnadelgewehr.

Hereafter the zündnadelgewehr will again come under our notice. It was necessary to introduce it in this place, the better to illustrate what I have to say in reference to the expansion principle embodied in Minié and Enfield rifle pickets, by adopting which, breech-loading rifles for rank and file, seem hardly to be a desideratum; the seemingly impossible problem having been accomplished of dropping a leaden projectile loosely into a barrel, and causing it to adapt itself to the barrel,—to cut its own screw, in point of fact, on emergence.

Before, however, describing this beautiful system, a few words must be prefaced respecting the variety of rifle which immediately preceded it in our military service, and which still lingers, I perceive, in the home dépôt of the 60th Rifles. I advert to the rifle with two grooves, and belted ball.

The inconvenience of forcing a plain leaden ball into the grooves of a rifle barrel, was found to be so intolerable at last, that English, and French, and Prussian military authorities, almost at the same time,
set themselves the problem of discovering a substitute. We diminished the number of our rifle grooves to two, and made projectiles (leaden balls) with projections; or rather one projection in the shape of a surrounding belt to fit these grooves. This done, the labour of loading such a piece was indeed diminished; but the slightest consideration of the shape of the projectile will show that it was very ill adapted for cleaving the air. A high charge of powder was required, so that recoil became considerable, and the range of a belted ball was not proportionate to the charge. On first emerging, the belted side of the projectile went foremost; but, very soon, obedient to ordinary mechanical laws, it began to revolve on its shorter axis, presenting the large area of what we may call its "flat side" to the air. Now, even a dairymaid knows that a cheese can be thrown further, edge foremost, than broadside on; yet broadside on, through the air, go these belted balls.

What the Prussians did I have already intimated; they prosecuted experiments which resulted at length in the celebrated needle gun. Still more interesting were the French developments in adapting the rifle gun to its military requisitions.

Napoleon never seemed to have thought much of rifle guns. If I mistake not, there were no French rifle corps in the imperial armies. It was not until
just previous to the French conquest of Algeria, that attempts were seriously directed by that nation to the improvements on the rifle principle which eventuated in the arm of Minié. To drop a projectile loosely into the barrel,—tightening it when there,—that was the problem. The word projectile is used advisedly, because balls in their true sense—I mean spheres—were speedily to be cast aside; and now that rifle-balls are things of tradition, never to be used again by sensible people, it does seem extraordinary that their employment was persisted in so long. Perfect sphericity is a sensible thing to aim at so long as bullets are not shot from a rifled barrel, and no means are at command for imparting to them a polar direction; but why a ball should ever have been chosen for a rifle projectile, it is difficult to imagine. If perfect sphericity was the main consideration, the very act of loading and firing a rifle gun, charged with a spherical leaden ball, destroyed that sphericity. By the time that a ball was thrust down upon its charge of powder, what with being flattened under ramrod blows, and jagged by compression into the grooves, it was anything but a sphere. I speak now of the ordinary muzzle-loading rifle. As regards some of the varieties of breech-loading rifles, the disproportion between the size of the ball and the bore of the gun was often preposterous; so that the projectile, on leaving the muzzle of the gun, was
sometimes elongated to a greater length than many of the conoidal rifle projectiles so usual now. This preference shown for the spherical ball during so many years, is to me inexplicable. Even at last, it seems to have been abandoned, not because the spherical form was thought disadvantageous, but because that shape of projectile would not square with the requisitions of the expansion principle.

Inasmuch as small-arm projectiles are made of lead, it is evident that a leaden mass of any shape—say a ball small enough to roll into a rifle barrel loosely—can be flattened by sufficient hammering until it fits quite accurately the rifle grooves. But to expand a ball or spherical lump of lead, such prolonged hammering would be required, that a greater inconvenience would be substituted for a lesser—hence arose the necessity for modifying the kind of projectile; a form was sought which could be readily squeezed or expanded.

Now it must be remembered, that the proposition was not to expand a pellet of lead against the breeching of a barrel, uncharged with powder;—wherefore of course the ordinary plug breeching would not suffice for giving effect to the expansion principle, so long as the expansion was effected by hammering. Most men, I presume, who think it worth their while to read these pages, know what patent breeching means, and will at once see that such breeching is calcu-
lated to offer a partial resistance to a bullet of lead. However, for the benefit of those who are considering the subject of projectiles for the first time, I append a diagram representing the construction of patent breeching, showing how the ball may have been supposed to be flattened by strokes of an iron ramrod upon the ledge of the breeching, leaving the gunpowder grains unbruised.

The result, though unsatisfactory in many respects, demonstrated the correctness of the principle. But a ball was soon found to be the very worst form of projectile that could be employed. Not only is it difficult to compress, but when compressed and fired it emerges flat side foremost; thus offering the greatest possible resistance to the air. Conoids, or pellets, formed like sugar-loaves, were next tried; thus at length bringing rifle projectiles to very much like the shape which the peg-top might have suggested from the very first.

I have seen very good practice made with conoidal projectiles (it would be incorrect to say "balls," the Americans call them "pickets"), treated thus by compression on the ledge of patent breechings; indeed, any rifle can be made to shoot any ball or picket with satisfactory results, if only the rifling be correct. The
rifle amateur has only to humour his piece—to study its character and disposition—to consider the pitch of its rifling—the depth of its groove—the charge it can bear without stripping the projectile—and such little matters, and any rifle can be made to shoot satisfactorily. But dealing with military fire-arms, one has to put to himself the question, not "how can I make it do satisfactorily?" but—"how can I make it do unsatisfactorily? what contingencies of war are there which can put it out of order?"

Any military man will perceive many reasons for condemning the practice of compression against a patent breech. Firstly, patent, or contracted breeching, fouls rapidly; for which reason, it is unadapted to the purposes of warfare, however applied. Then, as regards the use of it in connection with the expansion principle, the projectile, as will be seen, is not supported just where it ought to be supported, so as to get the full benefit of ramrod strokes, _i.e._, in the middle; on the contrary, its central part is found practically to be somewhat beaten in, forming a boss; which, when the chamber gets foul, and its area therefore gets contracted—squeezes down upon the gunpowder, and bruises the grains of the latter.

The next idea was a very ingenious one, and led to the formation of a somewhat celebrated rifle, namely, the "carabine à tige," that is to say, _carbine with a stem_. 
AND EXPLOSIVE COMPOUNDS.

Now, the tige is a sort of little anvil growing like a stem, as it were, out of an ordinary flat breeching, so that the gunpowder charge, instead of resting centrally, as in the ordinary patent breeching, is distributed all around the tige. The intended use of this anvil is evident enough. It enables the ball to be compressed in the middle; and when the conoidal pellets with deep grooves were used in connection with this form of rifle, the trouble of hammering was further diminished.

But the stem principle has great military defects. It is even more prone to fail than ordinary patent breeching; and however hardly tempered the tige may be at first, continued exposure to heat makes it soft and yielding. After a little while, the stem bends either to one side or the other, and ceases to be effective.

Still the carabine à tige is extensively employed by the French infantry even now—the Minié rifle, contrary to the general notion, being only partially used in that service.

Inasmuch as the hammering of an iron ramrod was found adequate to compress longitudinally, and, therefore, to expand transversely, a leaden projectile—would not the explosion of the gunpowder charge be so? Such was the next question which suggested
itself. It was found to do so on a bar or a "picket;" not on a spherical projectile of course; but, for many reasons, the reign of small-arm spherical projectiles had come to an end.

Mr. Wilkinson, of Pall Mall, adopted the system in his stadia rifle, the projectile of which, is a cylindro-conoidal pellet, indented with three deep furrows;—a construction which may be at once seen to be favourable to compression longitudinally; and, therefore, expansion laterally.

Minié's principle.—Captain Minié devised the beautiful expedient of hollowing out the base of the projectile, and placing therein a small iron thimble, larger than the cavity itself; which, therefore, can only fill the latter when the whole projectile has been transversely expanded. Now, the blast of gunpowder discharge drives the thimble completely into the hollow, and infallibly expands the picket; indeed, if the relative power of charge, and strength of the sides of the projectile be not well adjusted, the iron thimble is apt to go quite through the latter, converting it into a hollow leaden cylinder; which remains in the barrel. On next page, is the exact copy of a Minié picket, which has been the subject of that accident.
AND EXPLOSIVE COMPOUNDS.

The present regulation-arm used in the British service, called, from the place of its manufacture, the Enfield, is a sort of modified Minié. Like that arm, its grooves are shallow; the projectile is cylindro-conoidal and hollow. But whereas the Minié bullet is plugged with an iron thimble, the plugging substance in the Enfield is a truncated conoid of hard wood.

By adopting the Enfield rifle, the following advantages have been obtained:—

1. A saving in weight of about three pounds for every soldier has been effected, although the new "picket" itself is thirty grains heavier than the old spherical ball.

2. The sixty rounds for each man have been retained.

3. The strength of the musket has been very much increased.

4. The accuracy of shooting of a musket which only costs (without bayonet) about £2 10s., has been improved; so that, at the distance of 300 yards, a good marksman can generally hit a bull's eye with a six-inch radius.

5. The manufacture of the projectile has been
very much simplified;—the Minié bullet originally adopted with the Minié muskets, having been altered from an inconvenient form and a compound of lead and iron, requiring great care in the preparation, to a simple form of lead only.

6. An indirect advantage of the new rifled musket is, that any of the improvements that are constantly being made in the form and composition of elongated projectiles, will be more easily adapted to a barrel of this diameter than to one of the former size.

The exact shape of the projectile used in the Enfield is due to the investigations of Mr. Pritchett; and here it must be remarked that points relative to the adjustment of parts of a bullet round the centre of gravity, though inappreciable to the ordinary eye, are of great practical importance. The first desideratum in a rifle projectile is that its axis of rotation and line of flight shall be coincident. Now, if from any cause either extremity of the projectile have a tendency to droop on account of predominance of weight (to use a popular expression) at that extremity, then, the desideratum, if fulfilled at all, will only be so in spite of conditions, not because of them, as the appended diagram will illustrate, which represents the curved line of flight pursued by an elongated projectile. Numbers 1 and 2 set off in their course accurately aimed. In pursuing that course, number 1 droops base downwards, and number 2 head down-
wards, because of the predominance of weight at these respective ends. Evidence of gun-makers and military authorities, both here and abroad, is now available, to prove that the elongated, or cylindro-conoidal system, demands for insuring success the following requisitions:—

1. Minimum transverse diameter of projectile, urged with maximum charge of powder.
2. Minimum pitch of rifling to insure accuracy for the particular sort of bullet to be used.
3. Shallow grooves with rounded edges.
4. Whenever, as the resultant of causes in operation, a solid elongated rifle projectile would overturn; losing coincidence between axis of rotation and line of flight,—it may be prevented by channeling the projectile with grooves; the sharper the edges of which are, towards the wind, the better.
5. That mere expansion under the direct blast of gunpowder, is ample to insure success, if due relation between bore of barrel, elongation of
projectile, depth of grooves, and goodness of powder, be kept in view.

6. That in order to obtain maximum flight, the projectile should be elongated as much as possible without begetting a tendency to droop; and urged with the largest charge the barrel admits of, without suffering injurious recoil.

The following particulars relative to the small arms of the British service, are quoted from "The Hand-book for Field Service," by Captain J. H. Lefroy, F.R.S., R.A.

SMALL ARMS OF THE BRITISH SERVICE—1854.

1. Percussion Musket, Pattern 1842.—Barrel—length, 8 ft. 3 in.; diameter of bore, .753 in. Musket—length, 4 ft. 7 in.; weight, 10 lb. 2 oz. Bayonet—length (beyond muzzle), 1 ft. 5½ in.; weight, 1 lb. 1 oz.Arm complete, with bayonet—length, 6 ft. ½ in.; weight, 11 lb. 3 oz.

Ammunition—bullet (spherical)—weight, 490 grains, or, 14½ to the pound. Powder—4½ dr. F. G. Weight of 60 rounds of service ammunition with 75 caps, 6 lb. 10 oz.

This is the smooth-bored musket introduced into the service in the year 1842, and carried by the line generally. Its effective range is 200 yards, and about 60 rounds may be fired in 30 minutes with proper aiming.
2. THE VICTORIA CARBINE.—Barrel—length, 2 ft. 2 in.; diameter of bore, .733 in. Arm complete—length, 3 ft. 6 in.; weight, 7 lb. 9 oz.

Ammunition—bullet, same as Percussion Musket. Powder, 2½ dr. F. G. Weight of 20 rounds of service ammunition and 25 caps, 2 lb. 3 oz.

This carbine is carried by the cavalry and horse artillery. Its effective range is about 150 yards.

3. REGULATION RIFLE MUSKET, PATTERN 1851.—Barrel—length, 3 ft. 3 in.; diameter of bore, .702 in. Rifling—grooves, 4; spiral, 1 turn in 6 ft. 6 in. Musket—length, 4 ft. 7 in.; weight, 9 lb. 9½ oz. Bayonet—length (beyond muzzle), 1 ft. 5½ in.; weight, 15½ oz. Arm complete, with bayonet—length, 6 ft. 0¾ in.; weight, 10 lb. 8½ oz.

Ammunition—bullet (Minié), weight, 696 gr.; diameter, .690 in. Powder, 2½ dr. F. G. Weight of 60 rounds of service ammunition with 75 caps, 7 lb. 0 oz. 8 dr.

This is the first rifle musket introduced into the service. In 1851, 28,000 of these arms were ordered, which are now issued in a certain proportion to nearly all the regiments in the army. It is sighted to 1,000 yards, and is effective at this distance. The cartridges are greased, and reversed in the loading. Should the grease melt away, it is sufficient to moisten the cartridge in the mouth in the act of loading. The round ball can be fired with advantage
from the Minié musket, but it rapidly fouls. (Lane Fox.)

4. ENFIELD RIFLE MUSKET, PATTERN 1853.—
Barrel—length, 3 ft. 3 in.; diameter of bore, .577 in.
Rifling—grooves, 3; spiral, 1 turn in 6 ft. 6 in. Musket—length, 4 ft. 7 in.; weight, 8 lb. 8 oz. Bayonet—length (beyond muzzle), 1 ft. 5½ in.; weight, 11 oz. Arm complete, with bayonet—length, 6 ft. 0½ in.; weight, 9 lb. 3 oz.

Ammunition—bullet (Pritchett, expanding without a cup), weight, 530 gr.; diameter, .567 in. Powder, 2½ dr. F. G. Weight of 60 rounds of service ammunition and 75 caps, 5 lb. 8 oz. 4 dr.

This rifle musket was adopted for the service in the year 1853, after the experiments with rifle arms, carried on at the royal manufactory, Enfield Lock, in 1852. But few of these arms have yet been made; but it is proposed to adopt universally the 24 bore, or .577 of an inch. The practice of this rifle is good up to the same distance as the regulation rifle musket, viz., 1000 yards; but it is only sighted to 800 yards, that being considered far enough for any rifle to be used. The cartridges are greased, and reversed in the loading.

The inside of all fire-arms should be wiped with an oil-rag after use, and great care be taken that no grit or dirt gets into the cartridge-box. About 45 rounds may be fired in 30 minutes with proper aiming.
5. Artillery Carbine, Pattern 1853.—Barrel—length, 2 ft. 0 in.; diameter of bore, .577 in. Rifling—grooves, 3; spiral, 1 turn in 6 ft. 6 in. Carbine—length, 3 ft. 4½ in.; weight, 6 lbs. 7½ oz. Sword-bayonet (beyond muzzle), 1 ft. 10½ in.; weight, 1 lb. 12 oz. Arm complete, with sword bayonet—length, 5 ft. 3 in.; weight, 8 lb. 3½ oz.

Ammunition—bullet (Pritchett, same as that of Enfield Rifle Musket). Powder, 2 dr. F. G. Weight of 20 rounds of service ammunition with 75 caps, 1 lb. 12 oz. 10 dr.

This carbine was adopted for the artillery about the same time as the Enfield Rifle Musket for the army. Its practice is good up to 1000 yards; but it is only sighted to 300 yards, it being considered that artillery only require to use a carbine at short distances. The cartridges are greased, and reversed in the loading.

Several of the percussion muskets, Pattern 1842, have been rifled with 3 and 4 grooves, and sighted to 1000 yards. A Minié bullet, weighing 848 grains, is fired from them with a charge of 3 drachms F. G. powder. They are used in the navy, and are issued in a certain proportion to the marines.

The authority quoted above (Capt. A. Lane Fox) adds the following directions for aiming with the Minié musket: In firing in the ranks, or for a less distance than 100 yards, the men should be taught to use the
firelock without raising the flat of the sight. At 150 yards take the sight full. At 200 yards align the point of the foresight with the object, and see the barrel over the top of the back-sight, as far as the second loop. At 300 yards see the barrel as far as the third loop. At 400, take the elevation from the top of the nose of the cock, when at full cock. At intermediate distances the soldier must use his judgment in taking elevations intermediate to these.

BREECH-LOADING PRINCIPLE.

The principle of breech-loading, under some one of its numerous modifications, has been mainly suggested by two considerations; namely, the difficulties attendant upon ramming home rifle bullets in the ordinary way, and the desirableness of quick firing.

Any person who takes the trouble to investigate the mechanical conditions of the case, will perceive that before the application of the percussion principle, the employment of breech-loading contrivances must have been far more difficult than now. Still, the endeavour must have been made, very early in the history of small fire-arms. There may still be seen a breech-loading fire-arm, in the revolver variety of the breech-loading principle, in the Tower. It belonged to Henry VIII.

There is no space here to present a history of breech-loading arms. I must be content to describe
such as have been successful to a moderate extent, at least.

**Varieties of Principle.** — Four varieties of breech-loading construction may be recognised in modern small arms.

1. The slide system.
2. The hinge system.
3. The screw and trap-door system.
4. The revolver system.

1. The *slide system* finds its most prominent representative in the Prussian needle gun, and the cavalry carbine of Col. Greene. The latter is now being introduced to our cavalry service; and is, I conceive, as near a perfect weapon* as can be imagined. Unlike the revolver system, which is scarcely adapted for larger arms than pistols, I see no reason wherefore the principle of Greene's carbine should not be adopted, if required, in the construction of small arms of infantry of the line. I believe it would necessarily be adopted if the expansion principle, already detailed, did not fulfil, at a lower cost, almost every requisition.

The peculiarity of the Prussian needle gun, as far as loading is concerned, consists in the drawing back of a plunger or slide, out of the barrel, into which a cartridge being thrust, the slide is returned and fastened with a catch. The slide in question is perforated with

* I. e., for a cavalry carbine.
a small hole, just large enough to admit the sharp spill of iron called the needle; which, when the trigger is pulled, darts through the hole and the powder, perforating a large cap which is imbedded in the base of a cylindro-conoidal picket; and the cap, being thus exploded, ignites the powder anteriorly.

The disadvantages of the Prussian needle gun are —First, The ammunition, containing, as it does, the explosive material, can be ignited in store by firing even a small-arm bullet amongst it. Second, The gun, in most of its varieties, admits of no half-cock; and a mere prick of the needle, even without concussion, fires the cartridge. Third, The difficulty of opening and charging it when a little foul. Fourth, Leakage at the breech after considerable usage.

Perhaps the greatest difficulty gun-makers have had to contend with in devising efficient breech-loading arms, is that of preventing gas leakage. As to pistol and carbine charges, the difficulty in question has not been great. The real trial of the principle comes when infantry small arms have to be dealt with. Colonel Greene manages, by a very ingenious contrivance, to cause an exploded charge to effect its own tightness; and, as in Sharpe’s rifle—presently to be mentioned—an ordinary cartridge is employed.

The Greene carbine is furnished with a pair of triggers. The foremost one being pulled, the barrel is unlocked from the breeching; when a twist to the
left and a forward pull cause it to slide on a pivot, far enough, when bent a little on one side, to admit a cartridge (an ordinary one), when the barrel is returned and locked by a reverse motion.

With regard to the method employed for restraining the gunpowder blast, it is as follows. Inside the barrel is a sliding tube, not cylindrical, but conoidal, as in the diagram annexed; but in the diagram the conoid is purposely exaggerated. The pressure of gunpowder blast necessarily forces back this short sliding tube, or ring; and, necessarily too, the stronger the blast, the stronger the pressure.

The ignition part of Colonel Greene’s carbine must now be detailed. An ordinary cartridge is used; which is a great point gained for a military arm. The means of ignition are as follows:

Projecting into the middle of the barrel, from the breech, is a perforated metallic spill, being a continuation of the nipple; and which, therefore, conducts from the latter the detonating blast, quite into the middle of the cartridge, which is punctured by the
spill when the barrel is returned tight against the breeching. Like all other small arms, except pistols, employed in the United States military and naval service, Greene's carbine is furnished with the Maynard primer, the description of which has already been given at p. 199.

2. The Hinge System.—On this principle is founded Sharpe's American carbine, also designed to use an ordinary cartridge, of which the posterior aspect is nipped off at the time of closing the hinges. The disadvantages of this weapon are, the readiness with which the piece fouls at the hinge, and the uncertain measure of cartridge nipped off in the act of loading.

Granting that a cartridge of peculiar construction may be used, of somewhat expensive construction, there would not be the least difficulty now in applying the hinge system of breech loading to rifle guns; but by the adoption of one or other variety of the expansion system it is hardly rendered necessary.

In fowling-pieces, however, the system has been applied with full effect. In France and Belgium breech-loading fowling-pieces have been used many years, in connection with a cartridge represented on next page. It consists of a paper case, having a brass or copper extremity, into which an ordinary percussion cap is, in a manner, built; so that being struck by a metal plug acted on by the cock, explosion is determined.
This form of cartridge has its disadvantages. In consequence of the ends of the plungers being exposed the cartridges are apt to explode untowardly; and it is not easy to get the empty cartridge out of the gun.

Mr. Lancaster, in the construction of his breech-loading fowling-piece, has obviated these bad qualities. His cartridges are devoid of any external accessory to ignition; the percussive material is lodged in a cavity within the cartridge, in such manner that no flat blow will ignite the charge; nothing short, in fact, of the means employed—indentation. I have never seen one of these cartridges fail in practice, and I have never seen one explode under the severest tests which could be devised.

8. The Screw and Trap-door System may be frequently seen in the old rifles, constructed even before the application of the percussion principle. Some varieties of this mechanism answer well enough for sporting guns, used by careful people; but all of
them are unadapted to the construction of military arms.

4. The Revolver Principle.—It is no great feat of mechanism to associate several entire barrels round a central axis, and bring them successively by the hand underneath the same cock. Accordingly, on this construction pistols and carbines were made sometimes, not many years since. Then followed contrivances for causing the associated barrels to revolve by the act of cocking; and in some pistols for obviating the necessity of cocking, and rotating the barrel at all; by causing the trigger-pull to rotate the barrels, and to discharge them.

Now, firstly, no small arm can be worth much, of which the whole length of each barrel revolves. The weapon becomes too heavy and unwieldy. Before revolver pistols could become efficient military arms, there was a necessity for so arranging matters that the breeching should alone be multibored, and alone revolving; each separate breech-bore presenting itself exactly opposite to, and in correspondence with, the barrel at the time of firing; so close, that no practical amount of gas should escape. This effected, as it was, the question next arose, not whether the breeching should be revolved by hand, but whether it should require hand cocking, or should be discharged, as well as rotated, by a mere pull at the trigger. Each plan had its advantages, and disadvantages. With
pistols on the hand-cocking system, of which Colt's was the very best that had ever appeared, the trigger pull is easy, and the best aim can be taken; but Adams's pistol, in which the trigger-pull not only rotated the breeching but exploded the barrels, was decidedly better adapted to the exigencies of close quarters.

Whatever doubt there might have been as to the relative merits of Colt's and Adams's pistol, is now set at rest in favour of the latter; since the recent improvements which have been effected upon the arm. It can now either be used, as Colt's, for taking correct aim, or, by continuous pulls at the trigger, at close quarters. It seems to embody the ultimate perfection of which a revolving pistol is susceptible; leaving nothing more in the way of improvement to be desired. I doubt whether the revolver system admits of efficient application to infantry small arms, or even to carbines. If made strong enough to restrain a larger charge than that of a pistol, the weapon becomes too heavy. As regards revolver pistols, I understand that recent military experience demonstrates the small or pocket size of Adams's revolver to be the best. Being carried in the pocket, not in the holster, it is available after the bearer of it has been dismounted. This is a great consideration.
ON THE KINDS OF GUNPOWDER TO BE USED IN RIFLE PRACTICE.

It is a very common, but most erroneous opinion, that very fine grained gunpowder is necessarily the strongest. Nothing can be further from the truth, as regards small-arm practice. In order to decide this question, let us examine the extreme case of the employment of mealed powder, i.e., gunpowder reduced to an impalpable state. In this condition, if removed tightly into a barrel and ignited, it does not explode suddenly, but by degrees, after the manner of a squib. In point of fact, the main condition of effecting rapid explosion is the presence of a certain amount of atmospheric air throughout the charge of gunpowder, and between its grains. Of course a medium must be followed in this. The grains may be so large that they shall in parts be projected without ignition; and the other kind may be so small, so close together, that their ignition shall be too lingering for the generation of a projectile force. As regards flint-lock fowling-pieces, probably small grained powder is the best, but assuredly it is not for percussion small-arms, whether shot guns or rifles.
SUBSTITUTES FOR GUNPOWDER AS A CHARGE FOR ARMS OF FIRE.

Although no compound has yet been discovered at all competent to supersede gunpowder, various materials have been employed as matters of curiosity. Accordingly, in the gunmakers’ shops of France and Belgium, and occasionally in England, we see pistols and small carbines designed to propel their bullet by the mere explosive power of a very large cap, ready attached to the bullet or cone; and the latter being inserted at the breech, the act of charging is conducted with great rapidity.

When the calibre of the fire-arm is very small, such, for example, as of a pea-rifle or a pocket-pistol, the contrivance in question answers very well; and as the result of explosion is totally devoid of smoke, and, moreover, leaves no residue, fire-arms on this construction are well adapted for practice in close apartments. Viewed, however, as a means of propulsion, for rifles and pistols of larger bore, the plan just described is totally useless; and, if not useless, would become highly dangerous in practice.
The substance gun-cotton, immediately after its discovery, was thought capable of superseding gun-powder as a propellant; but repeated experiments have demonstrated, what any one conversant with the law of fire projectiles could have predicted—the total inadequacy, no less than danger, of gun-cotton.

Moreover, if this substance could be used with safety, and if its power were adequate, the great argument for its employment, viz., its non-destructiveness to the barrel, still remains invalid. Gun-cotton, it is true, yields no smoke; and therefore to a non-chemical eye it would create the idea of not damaging the barrel; but it yields fumes of nitrous, and nitric acid, both eminently destructive to iron.

I do not know whether any one has been rash enough to try gun-cotton as a charge for artillery, but its powers have been adequately tested in small fire-arms of various calibres, and the experiments have resulted in its complete abandonment. Its employment, also, when largely diluted with ordinary cotton, has been attempted in the manufacture of war rockets; but a frightful accident, which occurred during the operation of charging one of these missiles, led to an abandonment of the material. It has been also tried in the operation of rock-blasting; for which it presented the great advantage of not clouding the narrow shafts, and outlets, of the mine with smoke.
Even in this limited sphere of application, however, I believe gun-cotton has been found too dangerous for continued use, and, so far as I know, its complete abandonment has been the result.*

* Gun-cotton of peculiar make, different from Schönbein's material, is said to be employed in the military service of Austria for special artillery purposes.
ON THE FORMATION OF RIFLE CANNONS.

HAVING already described the principle on which the rifling of small arms depends, and the mechanical difficulties connected with the act of charging them, it will be easily understood that still greater difficulties will be encountered in applying the principle of rifling to cannons.

In the first place, we have seen that a rifle projectile must, almost of necessity, anterior to the discovery of the smooth oval-bore rifle, have been made of lead, or some other yielding metal; and it will at once be recognised that leaden cannon projectiles (balls or bolts or pickets) would be unfitted for all purposes of battering down walls. As a counterbalance, however, to this objection, leaden projectiles, being heavier than iron ones, would afford a longer range for an equal calibre of gun; hence they would be superior in effect against ships, and against troops. One may, therefore, safely assert, that the mere necessity of making cannon-balls of lead would not have prevented the use of rifled cannon, under some
exceptional circumstances, if other difficulties had not interposed.

The greatest of all difficulties consisted, doubtless, in the loading of such cannon. To force down the bullet of a small rifled fire-arm requires a considerable expenditure of mechanical exertion; how much more difficult must it necessarily be to perform a similar operation in loading a rifled cannon? Indeed, supposing the employment of rifled cannon to be determined on, there would appear to be no resource open to the inventor but that of either breech-loading, or the expansion principle. Now, breech-loading in ordnance is an operation so difficult to be achieved, that when a Swedish breech-loading cannon was shown in the Great Exhibition, artillerists hurried to examine it with wonder and admiration. But the theorist may here interpose, by the remark that, "the problem having been solved, it can be now practically turned to account,—that what has been done once may be commonly done." I doubt it: the Swedish gun was made of wrought iron, and may be regarded as a triumph of successful welding.* A cast-iron breech-loading gun of equal size would, I imagine, be eminently unsafe; and brass or gun metal would be far too soft to admit of the necessary joints being retained

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* I by no means adopt the opinion that the problem of making a thoroughly efficient wrought-iron gun has been solved. Reasons will be offered by and by.
air tight. I am sceptical, therefore, as to the possibility of using breech-loading cannons in active service.

Hence we are driven to adopt the mouth-loading principle; which, until the discovery by Minié of his expansive bullet; and until Mr. Lancaster’s most ingenious device of employing an elliptical bore, might be pronounced hopeless. It will be seen that the adoption of the expansive bullet is limited to the employment of lead or compound metal as a projectile; whereas, there seems no difficulty in recognising the possibility of employing projectiles of cast and wrought iron, supposing cannons to be rifled on Lancaster’s oval-bore principle. If ever the problem be solved of constructing rifled ordnance, and making them work efficiently, I conceive it must be accomplished by adopting the oval-bore principle of Lancaster. That system alone is compatible with the projection of a missile wholly of iron; and the accumulated experience of all who have tried ordnance projectiles of compound metal—partly lead, and partly iron—have resulted in failure. Mr. Bashley Britten has recently devised rifled ordnance and ordnance projectiles on the latter system, but the result was unsuccessful. Fifty per cent. of his projectiles flew to pieces on leaving the gun; and a still greater number were so bruised by the jolting of the ammunition wagon, that they could no longer be got into the
gun; this too notwithstanding the greatest care of packing them in sawdust.

But rifled cannon, however perfected, must always be exceptional weapons. A small-arm projectile when it has gone straight toward, and hit its mark, has done all that could be expected of it; not so the projectile of a cannon; or, more properly speaking, not so any variety of projectiles which ordnance are expected to throw. I have already explained the meaning of ricochet firing. Now ricochet practice cannot be efficiently prosecuted with the projectiles from rifled cannon. They will ricochet indeed; but because of their rotatory motion on the axis of flight, they no sooner touch the ground than they first turn aside, and then proceed so wildly as to defy calculation. Moreover a rifled or rotatory discharge of grape or cannister would be an absurdity; and a rifled shrapnell still more absurd.

I am aware that certain newspaper partisans of rifled cannon deny much of this; stating that grape-shot, canister, and shrapnell may be projected with some efficiency from rifles. Yes—but how? By merging the rifle principle; by using projectiles smaller than the gun; so that the rifling may not take effect. This is no other than turning a piece of rifled ordnance into a bad ordinary cannon. I conceive the true application of rifled ordnance when perfected (as they assuredly will be perfected), should consist in taking
advantage of the polarity of their missiles; of using them in connection with percussion shells—a sort of Jacob* system on the large scale. Thus used, as exceptional weapons, they would be terrible indeed; but it is hard to say how, supposing their manufacture ever so easy, they could displace ordinary cannon.

Rifled cannon may, I doubt not, be turned to account under certain special conditions. Our coast defences, for example, may be supplied with cannons of this description; the projectiles of which might be made effective against adverse fleets, at distances and with a degree of accuracy far beyond anything we at present know of. By this means, ships may possibly be sunk long before they could fire an effective shot in return.

* Colonel Jacob, of the Bombay Service, who employs percussive rifled pickets for small arms. Indeed, he has developed the use of small-arm rifle shells to such an extent that they will assuredly be employed, more or less, in future warfare. They are especially useful for exploding ammunition wagons.
MONSTER GUNS.

Experience has proved that ordnance of cast metal, whether of brass or iron, can hardly exceed the dimensions of 10 inches for long guns, and thirteen inches for mortars.* Previous to the siege of Antwerp the French constructed a mortar of much larger diameter than 13 inches, as is well known; but it burst after a few times firing. If, therefore, pieces of ordnance considerably larger than those ordinarily employed, be constructed and made efficient, they must be the result of some peculiar device. It would seem to be a necessity that they should be made of wrought iron, either welded in one bar, composed of many bars hooped together, after the manner of old artillery, or, lastly, of hoops alone.

Several attempts have been made to construct large pieces of ordnance of wrought iron, but hitherto with indifferent success—I will not even except the monster cannon presented to the Government by the Mersey Iron Company. It has never yet been fired

* I.e., if fired with full modern charges.
with a full charge, and the wrought iron of the touch-hole consumes so rapidly, that the gun requires to be "bouched" after every nine discharges. There is small parallelism between the tenacity of large and small welded masses. In the former, a crystalline condition is apt to supervene; rendering the mass even less to be depended on than a cast-iron mass of equal size. In the construction of heavy ordnance, a compound metal seems to be required, combining the hardness of cast-iron, and the toughness of wrought metal. An American proposition, that of Mr. Daniel Treadwell, would seem to promise a solution of the difficulty. He proposes to cast an interior bore or shell; screwing over it concentric and alternating bands of wrought iron. These bands are to be screwed on hot; by which treatment they will necessarily contract on cooling, and in this way contribute to strength. As regards field-pieces, I believe my country is destined to see a metal introduced, at no long time distant, infinitely superior to bronze: more it would be injudicious to say at present.

Mallet's Principle.—The monster mortars recently constructed by Mr. Mallet, of separate compound hoops, must be regarded as a triumph of constructive skill. Each mortar takes a shell 30 inches in diameter, holding a bursting charge of 480 lbs., and weighing, when charged, no less than
1½ tons. Up to the present time, January 21, 1858, the extreme charge used has been 70 lbs. of powder; though the papers have erroneously stated 150 lbs.

**PARTICULARS OF MR. MALLET’S GREAT MORTARS.**

The inside of the chase consists of three cylinders, or compound rings—the mortar being completed by a wrought-iron chamber (forged at Liverpool) let into a huge mass of cast-iron.

No. 1 ring (next to the breech piece) is composed of **seven** rings, each of these seven rings being in three rings, rabbed together.

No. 2 ring, fitting on to No. 1 (and termed centre ring), is composed of the similar number of pieces as No. 1 ring.

No. 3 (or top ring) is composed of five rings, each of these five being in three rings, rabbed together.

There are two light rings acting as a sort of key ring for the 6 bolts (or staves), the bolt-head resting on the muzzle ring, and secured with steel collars in the cast-iron mass, cast round the breech piece.

The whole, without bed, weighs 42 tons.
Weight of bed, 8 tons.
Average weight of shell, 24 cwt.
Charge of empty shell, 480 lbs. of powder.
Value of shell charged, about £25.

Owing to error of manufacture, the bore of these mortars is slightly elliptical.

| Major axis | 36.01 |
| Minor axis | 36.99 |
| Out of truth | 0.02 |

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<td>Length of chamber</td>
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<td>Bore, top</td>
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<tr>
<td>Bottom</td>
<td>0 14</td>
</tr>
<tr>
<td>Length to top of chamber</td>
<td>8 0</td>
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PARTICULARS OF THE MONSTER WROUGHT-IRON GUN OF THE MERSEY STEEL AND IRON WORKS.

Length, 13 feet.
Calibre, 13 inches.
Weight, 21 tons 17 cwt.
Weight of carriage, 5 tons.
Full charge of powder 50 lbs.

The extreme range of this gun, oddly enough, was at 1° of elevation; the ball ricocheting alone to the distance of 5,200 yards.

PARTICULARS OF THE MONSTER MORTAR OF ANTWERP.

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<th>Inches</th>
<th>LBS.</th>
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<td></td>
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<tr>
<td>Diameter outside</td>
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</tr>
<tr>
<td>Calibre</td>
<td>24·5</td>
<td></td>
</tr>
<tr>
<td>Length of chase from top of chamber</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>Depth of chamber</td>
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<td></td>
</tr>
<tr>
<td>Diameter of chamber</td>
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<tr>
<td>Weight</td>
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</tr>
<tr>
<td>Weight of bed</td>
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<tr>
<td>Weight of empty shell</td>
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<td></td>
</tr>
<tr>
<td>Charge of shell</td>
<td>99</td>
<td></td>
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</table>

The chamber would hold 30 lbs., but about 12 lbs. were found sufficient to throw the shell 800 or 900 yards.

The mortar was ultimately burst with a charge of 19·845 lbs. of powder.

Friction Tubes.—The percussion system was too good a thing not to be adopted in ordnance practice; but considerable difficulty was experienced in its adoption. No sort of large analogue to the small-arm cap, struck directly with a hammer, as in small arms, could
be used on account of the strength of the escaping blast. In small arms, the jet of inflamed gunpowder escaping from the nipple is sufficient in weak spring locks to drive the hammer back to half-cock; in ordnance, the machinery of the lock was shattered to pieces. At this time, when ordnance gun-locks are rendered unnecessary by the use of friction tubes, it is hardly worth while to explain difficulties overcome in the way of making percussion-locks for cannon.

The friction tube is a contrivance borrowed from the idea of an old-fashioned lucifer match; such as would not ignite as the congreves do at present, by

![Friction Tube Diagram]

merely gentle friction, but required a good sharp pull through a doubled band of sandpaper. Instead of sandpaper on the friction tube, the igniting material
is attached to a fillet of metal having a saw edge, and fixed at right angles to a tube fitting the touch-hole. The denuded extremity of the metallic saw-like fillet is perforated so as to admit a cord, which being smartly pulled, the tube is exploded.

For land service, every part of the friction tube is made of brass; but the portion of the friction apparatus which goes into the touch-hole of ship guns is made of quill; simply because tubes of fractured and lacerated metal lying on the deck would cut the feet of the sailors—shoeless as they commonly are during action; and thus interfere with their fighting.
THE BAYONET.

This weapon seems so plainly indicated as an addition to the musket, and is so simple, that our wonder is at first excited at its application having been delayed until a comparatively late period. Not much reflection, however, is required to show that until the weight of the first small fire-arms had been considerably diminished, the bayonet, even in its present improved form, would have been a useless appendix. The idea of the bayonet originated in the practice which once prevailed of thrusting the handle of a short dagger in the muzzle of a gun after its discharge; thus it might be made to act as a pike. Such bayonets,* or daggers, as these were, according to Père Daniel, introduced into France about 1671.

The present mode of fixing the bayonet was a late discovery, having first been applied by Marshal Catineat in 1693, at the battle of Marsaglia, on which occasion the slaughter was immense. Notwithstanding this success, it was not until two other great victories had been achieved by them—namely, the

* So called from having been originally manufactured at Bayonne.
battle of Spires in 1703, and that of Calcinata in 1705—that they were adopted by other nations. The introduction of this weapon led to the disuse of the pike, which was abolished by royal ordinance in France in 1703, with the advice of Marshal de Vauban. I do not know the exact period when pikes were laid aside in England, but I believe about the same time.

When small fire-arms were first introduced, those who bore them seem to have carried their ammunition and charged their pieces just as pleased themselves. Some used cartridges, some flasks, and all were under the necessity of employing for priming mealed powder, then called "touch," "tutch," or "serpentine" powder. As for the ancient method of charging small fire-arms, an old writer intimates that all good musketeers, caliverers, &c., thrust in paper, or something equivalent, between powder and ball, but more particularly on the ball. He attributes a frequent failure of shots to the circumstance that, for want of paper thus thrust down upon the ball, the latter frequently rolled out.* We learn, then, from this,

* It may not be uninteresting to present the reader with a quotation from William's Discourses of Warre, descriptive of the management of ancient small fire-arms. "But here it may be demanded what I doo call the well charging of pieces of weapons of fire? Whereunto I answer that I doo allow neither harquebuxe nor mosquet for well charged in services of the fielde, unless they bee charged with convenient charges of powder, and with soft browne paper, or the refuge ends of matches,
that the practice was anything but universal, and we may judge how ineffective must have been the shoot-

or something else to restrain the same, and likewise upon the bullet the like or more quantity to keep close, and restrain the bullet; or when, at the least, I would that some such thing should be thrust upon the bullet with the skewering stick, to keep the same close to the powder." Then he proceeds to advise that the bullets should not be too small, but should fit the barrel exactly.—P. 136-7.
ing. In the reigns of James and Charles the First, was introduced an appendage for facilitating the charging of muskets, called the "bandalier." It was a broad belt thrown over the left shoulder, and hanging down on the right side. This not only served as a support to the fire-arms, but had suspended from it a dozen boxes; each of which contained one charge of powder, and also a bag for balls. The bandalier, however, was both cumbersome and dangerous; often would its boxes get entangled; not unfrequently they would ignite and explode; while their rattling against each other often betrayed the soldier to the enemy.
ON NOVEL APPLIANCES OF WAR.

Having attended to most of the circumstances which limit the range of projectiles, I purpose now to state, as shortly as is consistent with truth and justice to the subject, the means which have been proposed to increase this range; also the results of these suggestions, so far as they have been carried into practice; and will discuss the probability of the existence of methods said to be kept secret, and the chance of the discovery of others.

The common supposition has already been adverted to that chemical science may present the artilleryman with some substance that is, in common parlance, "stronger" than gunpowder, and that by this means a vast increase of range may be effected. The futility of this opinion has been shown; I have shown how chemists disclaim any such knowledge; I have demonstrated that if they should claim to be the depositories of such a secret, the mathematician and practical artilleryman would treat the statement with unbelief; and justly, too; because it is in opposition to incontrovertible laws. As well might a chemist say
that he could annihilate the attraction of gravitation, as that he could elaborate such a peculiar composition, or gunpowder.

It may be said that chemistry is a field whose treasures are but little known; that although such explosive compounds as chemists generally are aware of may be inferior in propulsive force to gunpowder, this mere fact is not sufficient in itself to warrant a supposition that some peculiar composition, of exceeding potency, may not be discovered and held in secrecy by one favoured individual; still the objection applies not the less. There is a point beyond which no increase of primary force can increase the range of a projectile, and this point is far within the limits which circumscribe the force of gunpowder.

We are justified in asserting, then, that far advanced as are all sciences connected with military engineering, in the present day, very little increase of the range of common ordnance (cannons and engines of that class) will be effected; and that this little will be accomplished, not through any new composition of gunpowder, but as a consequence of improvement in the mechanical construction of missiles, and their projecting ordnance; the increased size of guns, &c.

The longest range and greatest velocity ever accomplished by any ordnance, ancient or modern, up to the period of 1840, is 5,720 yards, or just three
miles and a quarter. The whole time of flight was only thirty seconds and a quarter, which is estimated at 2,100 feet, in the first second of time. The piece of ordnance used on this occasion was a fifty-six-pounder cannon, cast on the principles of Mr. Monk; who suggested the propriety of removing a considerable proportion of useless metal from the gun before the trunnions, and adding it to the breech, where alone increased strength is desirable. This arrangement permits the use of a larger projecting charge of gunpowder, without risking the calamity of bursting. The quantity of powder employed in the experiment adverted to was ten pounds, and the ball weighed sixty-two pounds and a half; a circumstance which requires some explanation; seeing that I have stated the gun to be a fifty-six-pounder. The explanation is this: the momentum of a projectile is the product of its mass and its velocity; by increasing that mass, therefore, or in other words, by adding to its weight without adding to its size, we acquire a proportionate increase of momentum, and a consequent increase of range. The shot on the present occasion was an iron shell filled with lead; hence its weight of sixty-two pounds and a half.

Nearly the same range was accomplished by the French during the Peninsular war, who threw shells into Cadiz, rather more than a distance of three miles. They, however, used enormous mortars, one of which
AND EXPLOSIVE COMPOUNDS.

is at present in St. James's Park, and employed the largest charges of gunpowder ever known in modern times; the missiles projected, moreover, were shells nearly filled with lead, the remaining space containing gunpowder ignitable by a fuse, as in the common shell. The very longest range ever accomplished (up to the beginning of 1858) is, I believe, 7,270 yards.

The fact that leaden balls accomplish a longer range than iron ones, seems to have been discovered, at least once, by chance; the discoverers being totally ignorant of the principles on which the circumstance was founded. It is related that during the war an American ship having expended all her cannon-balls, and being unable to procure others of a similar kind, had some prepared of lead; when on employing them in a subsequent action, her captain and crew were surprised at their long range and efficacy. Sir Howard Douglas is so satisfied of their advantages on peculiar occasions, that he recommends their introduction in the navy.*

Amongst the suggestions which naturally present themselves for increasing the range of a shot, a very obvious one seems to be the diminution of its "windage," or the space which exists between it and the inside of the gun. Thus is reduced to a minimum the loss experienced by the escape of the gunpowder around the

* Naval Gunnery, p. 60.
sides of the ball. That short kind of ordnance, the
carronade, is made to embrace this amongst other prin-
ciples; and the result of practice fully warrants, in this
case, the justice of the theory. To long guns, however,
the rule does not universally apply,—a fact which may
seem strange at first, but which can be easily ex-
plained. With very great velocities, and long guns,
there is a large column of air to be displaced before
the ball leaves the gun, and which is condensed with
great rapidity by the force of the ball, to which it offers
immense resistance if it fit the gun closely. If, how-
ever, the size of the ball be reduced, the air has more
space to rush round it, and the ball more easily escapes.

Believing as I do that no considerable increase of
range, from un rif led guns of the sizes at present in use,
will ever be acquired, the question still remains un-
answered whether such increased range may not be
achieved by other means. For the sake of precision,
let us assume this increased range to be six miles, and
ask whether such can be accomplished by any method,
or combination of methods? It would not seem to be
totally impossible; I see no primary law of nature
against it, although there are difficulties so grave, and
so numerous, as to check even the wild excursions of
fancy. And I am not theoretical enough to forget that
even the mere possibility of this range granted, its
military application is quite another thing;—involving
considerations of facility, expense, and amount of scientific acquirement; all separate from the original question. As to the possibility of such a range, stripped of all accessory and contingent difficulties, my opinion is in the affirmative; although aware that the investigation of others, more practically conversant with these matters than myself, does not lead them to a similar conclusion. If a cannon-ball, when its flight was nearly expended, could meet with some aërial gun to urge it forward again,—if, in other words, its flight could be made to depend on two or more consecutive impulses, instead of one primary shock, its range would be evidently increased. Now, in reality, these desiderata are to a great extent accomplished by the rocket; which carries its own propelling agent with it. The question, whether a cannon-ball, of the largest present size, can be shot six miles, involves a primary law of nature,—a law which must be suspended before the question can be answered in the affirmative, and which therefore is an impossibility. The question, whether a rocket can accomplish this distance, involves no such suspension of a natural law; no such impossibility. The rocket presents us with certain theoretical conditions necessary for the end in view; it remains to ascertain whether they can be sufficiently elaborated.

But in thus ideally suggesting a probable range of six miles, we need not assume the necessity of any in-
crease of range either of gun or rocket. Let us suppose a missile to be formed of a combination of one ball and two or more rockets; this missile first to be projected from a gun, during which a fuse is to be ignited, and to burn during its trajectory course, in such a manner as to ignite the first rocket. This rocket is now to free itself from the ball, which falls; the rocket proceeding in its course, and eventually igniting the other rocket; this last accomplishes the termination of the distance.

All this may be assumed as possible, although involving thousands of difficulties to which I do not require to have my attention drawn. In short, I am not visionary or sanguine on the subject; and could fill half a dozen pages with difficulties and objections to the scheme,—yet I see no reason why it must be regarded as impossible.

The attention of the public was some years since on the qui vive about long ranges; being directed to this subject in consequence of the circumstances disclosed by Mr. Warner; who probably had in view the very plan of accomplishing a six-mile range already mentioned; inasmuch as he asserted that a two-pounder gun, made on a peculiar construction, would be sufficient to accomplish it. Now, we well know, that, ceteris paribus, the longest range will be accomplished by the largest gun, and that a two-pounder cannon is smaller than any in our service. Without
intending any disrespect to any one, then, it may safely be asserted that to project a ball six miles from a two-pounder by the mere primary force of gunpowder, is a physical impossibility; and that if such a range be accomplished, and a two-pounder cannon be instrumental in accomplishing it, this can only be effected by some such plan as that described. There is another reason for presuming Mr. Warner to have intended this to be the plan,—he disclaims most pointedly ever having asserted that he could project by means of a two-pounder a cannon-ball six miles; but he avoids stating that the two-pounder is not to be instrumental in projecting a missile of name unknown to that distance, and he requires a two-pounder peculiarly constructed.*

Leaving this part of the subject, let us proceed to the consideration of some other improvements which have either been introduced or are proposed to be introduced to the warlike art. The mere projection of missiles by the force of gunpowder was a great discovery; the application of the same substance to the bursting of shells was an ingenious and useful extension of it, adding to the mere projectile force of the ball the devastation and the consequent terror of fire; together with the primary explosive power and disin-

* Mr. Warner's long range has, since this paragraph was written, turned out to be accomplished by a balloon bearing shells in its car!
integrating influence of gunpowder. When first shells were thrown from mortars, pyrotechnical science was not sufficiently advanced to render the period of their bursting at all certain; neither were the principles or practice of their firing well known. They were ill-constructed, ill-managed; and moreover a prejudice existed that the fuse must be lighted before the charge was fired, which added considerably to the danger as well as the trouble of mortar practice. These defects are now, to a great extent, overcome; shells are cast of equal weight, and their fuses correspond so well amongst themselves as regards time of burning, that, the distance of projection being known, the time of bursting can be calculated with wonderful accuracy. When, however, it is considered that a small fraction of a second is on some occasions a matter of considerable importance, and that such an amount of accuracy is hardly possible to be expected from the use of the fuse, it will be evident that any simple and at the same time safe and effective plan of procuring the explosion altogether independently of the fuse, would be a desideratum. The various substances known to chemists as capable of exploding by percussion, favours the idea of a substitute. Could not a shell be filled with gunpowder, as is usually done, and furnished in some manner with an appendage—such as the copper percussion-cap, for instance—which might explode when the shell struck the object, and
thus ignite the contained charge?* Instead of a shell furnished with a percussive appendage, could not the percussive material form part of the shell? These are amongst the most obvious questions which present themselves, and at a first glance they seem easily answerable in the affirmative; but a little consideration will develop many difficulties, some of which have already been noticed. There is no difficulty experienced in making a shell explode on percussion, but it is exceedingly difficult to make it explode when wanted. The primary impulse of the charge of the gun is in itself a strong percussive agent; and hence percussive shells as frequently explode immediately on leaving the gun as on striking their object. This is a very great disadvantage, although perhaps not insuperable; another is the difficulty and danger of keeping such shells, and conveying them from place to place, not under peculiar scientific charge, but subject to all the shakings, blows, and other contingencies of military and naval transport. This remark certainly does not apply to those shells which are furnished with a percussive appendage; but they are open to other grave objections. In a shell of this kind some provision must be made to insure the striking of that part of the shell which is furnished with the percussive appendage,—a matter in itself of

* For a shell thrown by hand, nothing more easy. For a shell projected by gunpowder, few projects more difficult.
no small difficulty as regards un rifled cannon, and which (the remark still applying to un rifled cannon) has yet only been accomplished by departing from the spherical and assuming the pyriform shape in the construction of the shell; under which circumstances the large end will point forward, and consequently strike the object first. Now, the united testimony of practical men is against the employment of non-spherical missiles, so far as relates to every variety of un rifled gun, and at long ranges; as being so exceedingly irregular in their flight that their use becomes most uncertain, and defies all calculation. At short distances, however, and especially for sea service, bar shots are, under particular circumstances, recommended. A small gun may thus be made to project great weight of metal, and thus to acquire a great increase of destructive power.

The remark only applies to cannon, and plain small-arms: so far as relates to rifles, the difficulty has been entirely overcome,—or more correctly speaking never existed. An elongated or cylindrical body, properly fitted to the rifle and shot from it, maintains during flight that end forward which first emerged from the barrel; the reason of which is attributable to the rotatory motion it acquires. If, then, a hollow cylinder of lead, fitted to a rifle-barrel, be filled with gunpowder and furnished with a copper percussion-cap, or some equivalent contrivance, it will act very
efficiently as a percussion shell. Captain Norton has availed himself of the principle; and, in allusion to the contrivance, Mr. Wilkinson of Pall Mall, in his work on engines of war, p. 115, states,—"I never found one (i. e., of these shells) fail to strike on the foremost end, and explode at all distances, from 50 to 300 yards. In one experiment I fired at two thicknesses of inch and a half elm, lined with sheet-iron, and containing between them a stratum of four inches of water; the shell passed through the whole at sixty yards' distance, and exploded a box of gunpowder on the other side." It will be seen, then, that so far as relates to rifled small-arms, there is no difficulty. Col. Jacob has fully carried out the idea.*

Mr. Pasley, many years since, proposed a very safe and ingenious plan for making a percussion shell, the explosion of which was dependent on the fact, that air suddenly compressed liberates heat sufficient to inflame gunpowder. His shells were pyriform, for reasons already mentioned;† and a cylindrical cavity terminating at the large extremity of the shell, was partly filled with gunpowder, and closed with a tightly-fitting iron bar; projecting considerably beyond the surface of the shell, but which a sudden blow could force down after the manner of a piston, and thus ignite the powder. These shells were tried at Wool-

* See note, page 264.
† In order to give excess of weight at the striking end.
wich, and condemned chiefly on account of their departure from the spherical form; although it would not be difficult to point out other disadvantages. For instance, the quantity of gunpowder such a shell could hold would be very insignificant; and the bar would be very liable to get fixed from rust, &c.

It has hitherto been supposed that the shell is to be filled with gunpowder, and that a percussive explosive substance is to be merely an agent for igniting this gunpowder. Gunpowder, in fact, provided we have the time of its explosion under control, will do all that is desired; and if it do not, no assistance nor increase of power would be derivable from any of the chemical explosive agents; whilst the danger to all parties having anything to do with such shells would be immense. Were it our object to speculate on the possible number and arrangement of chemical substances, with which a theoretical percussion gun-shell might be filled, our task would be longer than interesting or profitable,—suffice it to say, that no class of persons expect so little actual advantage from such combinations, in a practical point of view, as chemists, and it would seem that their opinion might claim for itself some amount of respect.

From the remarks already made, it will be obvious that I consider the two greatest difficulties which stand in the way of the percussion shells as fired from guns, mortars, &c., to be,—1. The danger of explosion from
the primary shock of the ignited charge; 2. The difficulty of causing any given side of the shell to impinge on an object, except the spherical form be abandoned. A slight consideration will be sufficient to show that neither objection applies to shells which are projected by the force of a rocket—consequently, if those missiles can ever be made to take a more direct course, so as to be more effectually amenable to calculations, the limit to their application will be greatly extended;—nay, even in their present state, I imagine the percussion shell would, in the event of another war, be for some services, appended to them.*

* The shells dropped near the carriage of the French Emperor, January 14th, 1858, appear to have been charged with fulminating mercury. It seems to have comminuted the metal of the shells almost to powder by the force of its explosion. Gunpowder would only have caused the shell to separate into gross fragments.
RELATIVE POWER OF SHIPS AND FORTRESSES.

Notwithstanding the tendency of an Englishman not to discard one notion he may have acquired, relative to the power of his wooden walls, I believe it will be difficult for a candid inquirer to avoid arriving at the conclusion that ships, properly so called, must abate in that respect some of their pretensions. A civilian need not hesitate to state his conviction in this respect, fortified as he is by the direct testimony of Sir Howard Douglas, and the inferential testimony of Commodore Dahlgren. As regards the "Paixhans," or incendiary principle, which has been adopted so largely of late, its very genius obviously lies in the damage it can do to wood work. The shells of long guns are not heavy enough to compensate for the battering effect of solid shot against stone walls; whilst stone walls, by attacking shell ships with their own weapons, become proportionately redoubtable: so the question is, whether in times to come ships armed with solid shot guns will be allowed to get near enough to a fortress to work its demolition. Still, the question of sea offence versus
land defence is a very difficult matter to decide upon. Floating batteries have done well, so far as they have been tried; and it remains to be seen how far the system of hooped compound mortars, as devised by Mr. Mallet, is applicable. Against ships the vertical firing of mortars would be almost powerless; whilst as against fortresses there seems to be no limit to the application of such mortars—once satisfactorily made. Hence it would seem that fortresses, in time to come, will have to be demolished from sea-board,—not by broadside firing, but by bombardment. It was proved by the experimental attack on Sweaborg, that ships of the line, of present armament, could work little damage on well-constructed granite walls at greater distances than 500 yards.
ON METHODS OF SUBMARINE ATTACK.

From the very infancy of naval warfare, it has always been an object much sought after, to inflict an injury on an adverse ship under the line of immersion. To secure this end the ancient galleys of Greece and Rome were armed with sharp subaqueous beaks; which being driven by the aid of the rowers against an advancing vessel, inflicted the most dangerous fractures and perforations. The genius of naval modern warfare did not admit of the employment of such methods of attack; and it has consequently been long relinquished:—about 1850, however, Mr. Nasmyth, the inventor of the steam-hammer, has submitted to the consideration of the Admiralty the plan of an iron steamer bomb-proof, which (he says) "will effectually destroy any ship or squadron. She is to be propelled by the Archimedean screw, and when going at the rate of six knots an hour she will run stern on to a ship, and make a hole in her many feet wide beneath the surface. It is, in fact, the power of two ships coming into collision with each other at the rate of six knots
an hour, placed by mechanical means in the hands of not more than three men."* 

Still more ingenious was the contrivance of the American, Fulton; who actually constructed a boat capable of diving, and progressing, under water. In the Annual Register for 1802, is an account of this diving-boat, taken from the relation of Citizen St. Aubin, a man of letters at Paris, and a member of the Tribunate: it confirms the inventor’s statement of the success of his experiment. "I have," says M. St. Aubin, "just been to inspect the plan and section of a nautilus, or diving-boat, invented by Mr. Fulton, similar to that with which he lately made his curious and interesting experiments at Havre and Brest. The diving-boat, in the construction of which he is now employed, will be capacious enough to contain eight men and provision enough for twenty days; and will be of sufficient strength and power to enable him to plunge 100 feet under water, if necessary. He has constructed a reservoir for air, which will enable eight men to remain under water for eight hours. When

* The fate of the sword-fish, which, after perforating the ship’s side, finds it impossible to withdraw its weapon, and only escapes by its sacrifice, might have furnished a useful hint to Mr. Nasmyth. Granting that he could thus approach a ship and perforate it, he would find himself literally, and absolutely, in a fix. But, his machine would be sadly hammered about by cannon-balls, and interfered with by the ship’s boats, long before the somewhat amusing catastrophe could occur.
the boat is above water it has two sails, and looks just like a common boat. When she is to dive, the mast and sails are struck. In making his experiment at Havre, Mr. Fulton not only remained a whole hour under water with three of his companions, but kept his boat parallel to the horizon at any given depth. He proved that the compass points as correctly under water as on the surface; and that, while under water, the boat made way at the rate of half a league an hour, by means constructed for that purpose."—Vol. xliv.

However visionary may seem the idea of applying such a subaqueous boat to the uses of actual warfare, Earl Stanhope (no incompetent authority) entertained an opinion of the feasibility of the plan; and in the year 1803 he stated in the House of Lords, that he had laid before the Admiralty a contrivance for protecting ships against such an assailant. It is said that our Government purchased the neutrality of Mr. Fulton, fearing lest he should impart his secret to the French; and that in consequence of this bribe he returned to America, and the invention was not further divulged.

The question of the possibility of subaqueous attack by means of a projectile weapon, acquired extraordinary interest during the summer and autumn of the year 1844, in consequence of the secret of an invisible shell, claimed by Mr. Warner, and the effects
of which were illustrated by him, near Brighton, on the John of Gaunt.

Far be it from me to disparage the merits of any inventor, or even by implication to underrate the value of discoveries to which he lays claim; much less would I join that section of a noisy and thoughtless populace, who, without proper means of forming a correct judgment, disbelieve everything they cannot understand. I am amongst those who believe in the possibility of destroying a ship at a far greater range than 300 yards, by the agency of a subaqueous projectile. This is an opinion, which, like any other mere opinion, is not infallible, although deduced from many experiments. Thinking thus, I regret that Mr. Warner pursued a course of operations which could not but excite suspicion; and which would have enabled him to employ one of several trickeries, had he so desired. It is not meant for an instant to be implied that the experiment was not a bonâ fide one, and that no projectile was used; I have already recorded an opinion that the use of a projectile under the circumstances was possible,—nay, that such was not difficult; all that is meant to be said is this: that the use of such projectile was not demonstrated, and can merely be received as a matter of faith. Mr. Warner should neither have had the John of Gaunt in tow, nor should he have approached her previously to the explosion. The mere presence of a tow-line would have afforded
several means of explosion: it might be made to spring a lock, and thus explode a magazine of powder; still easier might it have been the medium of concealing two voltaic wires, which would have furnished the means of instantaneously igniting a magazine, no matter how far distant. The explosion, again, might have been occasioned as described by Sir G. Cockburn, in the House of Commons, on Wednesday, July 31:—"He would state exactly how the experiment had taken place. He had an officer in a boat close to the two vessels, and the officer distinctly saw the one blow up. A rope with two buoys attached was thrown across her cutwater, the vessel then going at the rate of about three knots an hour; these two buoys, by the impetus of the vessel, were forced under water, and the tension of the rope attached to them either struck a hammer, or excited by other means the igniting power, and then the vessel blew up." The officer, who had reported to him, said he considered that "the explosion was the effect of two barrels of gunpowder." M. Jobert, of Brussels, suggests that a Congreve rocket headed with fulminating mercury was the missile employed,—fired on a level with the water's surface. M. Jobert could not have tried the experiment. A rocket, under these circumstances, sinks almost immediately on touching the water; besides, its flight must have been visible. I incline to believe, however, as the result of some experiments, that a purely sub-
aqueous missile can be constructed, safe in its use, and easy of application.

**Infernal Machines.**—The Russian infernal machines employed during the progress of the last war, are a new contribution to the resources of subaqueous attack and defence. They may be described as buoys restrained underneath the water's surface by anchoring, and so contrived that a vessel passing over them and touching them should press down a rod upon some detonating material, and thus ignite a mass of gunpowder.

It would seem that the idea of such machines is good; and that the latter may hereafter be elaborated into powerful engines of warfare.
ON THE BEST ARMAMENT FOR A VOLUNTEER.

These pages are not written with a political intent—not, therefore, to discuss the relative advantages of standing armies and volunteers. My main object has been to set out from the starting-point of regarding the subject of fire-arms under a philosophical aspect, to develop their peculiarities, illustrate their principles, and make known the conditions under which they produce their maximum effect. I conceive it to have been sufficiently demonstrated in the course of this volume, that, as regards the employment of the highest elaborations of small fire-arms, volunteers possess considerable advantages over regular troops;* a circumstance which, when taken into connection with the excellent configuration of Britain as regards its geographical surface, viewed as a means of defence; as also, with the fact admitted by late writers on military

* British archery could never have acquired its pre-eminence under the system of a standing army. Every archer possessed a bow, not handed to him at random from a military store, but accurately fashioned to his own requirements.
tactics, that recent improvements in fire-arms add greatly to the powers of defence over those of offence;—demonstrate to us that, of all nations, we English are best adapted by nature to repel unjust invasion, by volunteer resistance.

What, then, should be the armament of a volunteer? This question let us proceed to consider.

As to the infantry volunteer,—he of course must have a rifle: no one would think of arming himself with a common gun. As to the kind of rifle,—any that will stand the tests already mentioned, is not to be contemned. Is the rifle to be muzzle-loading or breech-loading? I would prefer the former, used with expanding pickets; and, all things considered, the Enfield pattern can hardly be improved upon.

Should the rifle be double-barrelled? Generally speaking, I think not. In the first place, double-barrelled rifles, except those of exceedingly high price, are far less likely to be correct than single ones, owing to the difficulty of placing two barrels in exact parallelism. Then, taking into consideration the chance of mistakes, during the heat of an engagement; of leaving one barrel unloaded, of doubling the charge, of touching the wrong trigger,—added to the tendency created by the presence of a second barrel towards slovenly firing,—all these circumstances considered, I do not advocate the universality of double rifles; although those who have them, and are used to them, doubtless
possess a slight advantage. In deer-stalking, the most successful shots are often second barrel shots; for deer generally come to a dead halt for a second on hearing the report of fire-arms; thus giving the sportsman time for a deliberate aim. No such argument applies in military practice. As regards the sword, attached bayonet fashion to the rifle, or dismounted for use in the ordinary manner of a sword, volunteers would do well to consider what pattern they shall select. As a general rule, volunteers are better acquainted with rapier practice than that of the cutting sword; and whenever this is the case, a rapier should be the selected type. It is lighter than any other kind of sword; and although very delicate looking and fragile, is also, in moderately skilful hands, a far more deadly weapon. As regards pistols, there are none comparable with the repeaters of Adams.

Turning our attention to cavalry volunteers,—I would premise with the remark, that modern improvements in fire-arms have so diminished the utility and the sphere of operations of cavalry, that a distinguished artillery officer, Colonel Chesney, says, in future they will be rather considered in the light of mounted infantry;—namely, using the horse as a means of rapid locomotion to any given point, where they may be destined to fight on foot.

Their arms should be revolving pistols, breech-loading carbines—(Col. Greene's are now partially
adopted by our cavalry)—both rifled—and swords. If I am asked the reason of recommending a breech-loading rifled carbine for cavalry, whilst other weapons for infantry are advocated, the answer is simple. The breech-loading motion, although perfectly compatible with the small charges of powder necessary for pistols and small carbines, is scarcely strong enough for safety when applied to larger guns; such as foot volunteers must have to enable them to effect those long shots which the rifle is now capable of accomplishing. The opinion begins to prevail that carbines (even for regular cavalry) are bad weapons, and should be thrown aside in favour of the revolver pistol.

These remarks on the armament of volunteers must not be concluded without adverting to the war rocket as a missile especially adapted to their conditions.

Congreve no sooner elaborated the rocket, than he strongly advocated its general employment, both by cavalry and artillery, as well as infantry. His advice was never adopted in this country; but in Austria foot rocketers have been established. They acted with terrible success against their Hungarian opponents in 1848 and on subsequent occasions. I do not know whether the rockets employed on these occasions were the stick-tailed ones of Congreve, or the rifle-rockets of Mr. Hale; but the latter present so many advantages over the former, even in the way of portability, that if rockets in the days of Congreve were desirable, by
infantry, they are now desirable in a much higher degree. A great deal of mystery has been connected with the manufacture of war rockets; but their formation is by no means a matter of difficulty; indeed, they were formerly extensively manufactured in England as a means of killing spermaceti whales. I had a loaded whaling rocket in my possession, but soaked it in water, and thus destroyed it; having one morning discovered a servant girl in the act of using it as a fire poker.
CONCLUSION.

The task originally proposed draws near to its conclusion. During many periods of its progress, my regret has been that several interesting documents bearing on the subject must be so summarily dismissed. The mere change of form and power, which arms of all kinds have undergone, is in itself a matter of great interest. When taken in connection with the states of society which called them into being, the interest is greatly enhanced. Clubs and wooden spears are emblems of savage life,—of men scarce a step removed from the prowling denizens of the forest. Bows, and slings, are symbols of a higher grade,—of men whose minds have begun to expand and grasp the first principles of mechanical science. Great was the advance made in the art of war when the arbalest was discovered; greater that which prompted the construction of the vast artillery of old;—the aries, the balista, and gigantic catapult. Now, wealthy cities rise before our view; with walls and lofty towers. War is no longer carried on with the petty rancour of individuals, but as the agent of facilitating some
great, perhaps laudable policy. Greatest of all was that advance consequent on the application of gun-
powder. No longer do we trace the mere progress of the art of war,—no longer are we the mere narrators of the flights of missiles, and the terror of their effects; we become insensibly carried away in the torrent of a great political revolution! The discovery of printing, the mariner's compass, and of gunpowder, are referable to nearly the same date. Agents of equally revolutionary power it would be impossible to suggest; and it is difficult, at this epoch, to say whether the first or last has been most instrumental in altering the constitution of society.

Amongst other consequences resulting from the use of gunpowder, we may especially enumerate two. The claim of might is more likely for the future to reside with those who have the better claim of right;—with the best educated, and consequently the most enlightened states. Brute force now avails but little: science in modern warfare is all in all. The dis-
covery of gunpowder, again, has greatly tended to the decline of feudal sway. So far as relates to the chances of danger, there can be no longer a privi-
leged class of warriors, whom swords may smite, and arrows strike in vain. No doughty knights smothered in buff coats and iron plates; figuring during peace in harmless fray; begetting a spurious sentimentality in the bosoms of our daughters and our wives, yet inca-
pable in actual fight of being injured, and often, from their unwieldy arms, of injuring others. The time for such vagaries, thanks to villainous saltpetre and its black offspring, "gunpowder," are gone. None who now go into battle can claim immunity from danger and death. Some whizzing ball, some blazing shell, or erring rocket—all very indifferent respecters of personal dignity—may lay a general in the dust, as well as the humblest drummer!*

I really beg pardon of the ladies for thus slightingly alluding to their friends, the knights of old, with whom they have associated such ideas of romance. But on the first introduction of fire-arms they certainly did quake and complain much more than men so brave by reputation, and so petted by fair ladies, should have done. They guarded themselves, too, by such unwieldy mail from the annoying bullets, and must have looked so grotesque—so ungainly, whilst their poor steeds shuffled forward to the charge, groaning and snorting under the unconscion-

* The equipment of knights and their men-at-arms was totally unadapted to the genius of warfare, after the employment of small fire-arms had become general. Each man-at-arms ought to have five horses, one on which he rode to the charge, and hence called a charger; the others to carry his trappings, and to bear him on the march. Some attempt was made in Germany to diminish this unwieldy retinue by allowing each man-at-arms only one horse, but a wagon to every twenty men. See the "Arts of Warre," by Machiavelli; translated by Peter Whithorne.
able weight of their riders, that I am sure, had modern ladies seen them, their feelings would be more allied to mirth than chivalrous love. Then, what a most unromantic death was it to be cracked to death with a sledge-hammer, like a huge lobster! But I do not wish the ladies to feel any other interest in warlike pursuits save the very proper one of regret at the existence of such an evil. I object to that exhibition of mock valour—that mawkish, silly, sentiment which the system of tournaments long kept up; and therefore trace, with peculiar satisfaction, its downfall to the introduction of fire-arms.
NEW RESOURCES OF WARFARE.

CHAPTER I.

At no period since the discovery of gunpowder has the application of science to purposes of destruction been more arduously attempted, or more successfully achieved, than during the past ten years; and as if to afford another illustration of the providential co-ordination of all things, some of the most deadly applications of science to swell the resources of warfare are (so to speak) matters of to-day; just when Europe seems destined to be set on fire, for the purpose of throwing a new light on some disputed readings of the treaty of Vienna.

Perhaps never, in the whole history of projectiles, has an arm of destruction, large or small, awakened for itself so great an amount of popular, or lay attention as the Armstrong cannon; now formally adopted into our service. *I am able to supply, for the first time, a full explanation, accompanied by correct draw-
ing*

of that gun; a matter of no little interest, it is assumed, at the present epoch. The rifled cannon of Cavalli (of the Sardinian service), and the Swedish or Wahrendorff rifled ordnance,† are also described; —and, lastly, the system of rifled ordnance now being worked upon in France is brought under notice.

Not merely have rifled cannon been advanced some steps higher in the estimation of military men since my treatise on projectile weapons was issued last year, but rifled or rotating war rockets have also been improved. In promoting their accuracy of flight, and extent of range, some ingenious modifications have been adopted. Particulars of the latter are stated at page 362 et seq.; gathered from reliable sources, and, for the most part, the result of personal inspection.

Some, I know, there are, who would feel inclined to censure me for giving publicity to what may be called a scientific state secret. Objectors of this class

* I am aware that a technical illustrated journal has published drawings of the Armstrong gun. The editor very fairly stated that he could not vouch for their perfect accuracy; and, indeed, they will be found to differ from my drawings of the gun (obtained from a reliable source, and which I can depend upon) in some important particulars. To cite an example:—The breech screw of the Armstrong gun is perforated as described at p. 343, whereas the journal referred to depicted it solid. Other particulars of discrepancy will be discovered by reference.

† Stated, by mistake, to be a wrought-iron gun. It is a cast-iron gun.
were probably born a century too late. The era of scientific state secrets has gone by for ever. To assume the possibility of guarding them within the four walls of an arsenal is to offer an insult to the spirit of inquiry. Reticence on these matters can be only expected on behalf of scientific men in office. One like myself, not in government employ, owes no allegiance (on scientific ground) but to the spirit of inquiry, and the force of truth. I experienced no difficulty in collecting all particulars necessary to the full exposition of the Armstrong guns. Their weight, number of rifle grooves, pitch of rifling, and peculiarity of sight adjustment, as given at p. 337 et seq., may be relied upon as correct.

If any lingering doubt had existed in my mind as to the propriety of making known these facts to the British public, the doubt would have been set at rest by the consideration, that before these pages are issued the secret which our Government would affect to guard so carefully will have been known even, to all its details, by the governments of France and the United States.

Sir William Armstrong was necessarily associated with others in elaborating the piece of ordnance which bears his name; and I am informed that a dispute of a pecuniary nature having arisen, two malcontents immediately set off, one to France, the other to America, with drawings, and all particulars relative to the gun.
§ ON THE BALANCE OF DESTRUCTIVE RESOURCES.

If the successive steps of discovery in any physical department be investigated, and traced, they will usually be found to have been stimulated by some latent idea of supposed advantage or assumed necessity. Vague though the developments of invention may often seem, they will generally be found to have some implied reference to a tangible suggestion. The oscillations to and fro of an established system, in obedience to forces acting upon it, not unfrequently create an idea of weakness, when the phenomenon, adequately understood, means power. A pendulum hanging free, and oscillating, will speedily come to rest, whilst a pendulum actuated by motive clockwork, will go on oscillating, so long as force is transmitted from within.

What means the oscillation to and fro of the system of European armaments, that we have seen during the last four or five years? France initiated the perturbation. The very antitype of conservatism—her national genius prone to seize on new aspects of things, and arrive at rapid conclusions, what is the reason that France of late has been continually altering her system of armament, both on land and at sea? This apparent unsettlement of purpose—this undoing of much that had previously been done, will be found, if investigated, not to depend on any weakness or insufficiency
of human judgment, but upon the forces of physical discovery pressing from within; evolving new phases of application and competence; disclosing new trains of resources; rendering measures that were the strength of yesterday the weakness of to-day. Other nations were gradually, but inevitably, brought into the vortex of military revolution; and thus the oscillation of armament-systems has been steadily kept up; to the surprise of those who only take a superficial view of things; but easily explicable to the comprehension of such as explore beneath the surface of influences at work. The oscillation to and fro—the seeming lack of means directed to one unswerving end—are referable to the force of discovery acting upon the agencies of destruction.

As long as popular clamour is accepted as the interpreter of the comparative value of systems of military and naval armament and defence, so long will the changes rendered necessary by progress of discovery (and therefore inevitable) be laid to the perceptive insufficiency, and the vacillating indeterminate-ness of those in power, by whom armaments are willed. To alter the whole armament of a nation is in no case an easy matter. The philosophy of finance has to be consulted, as well as the science of those physical forces on which the resources of modern warfare are based. It will surprise many who have come to regard England as personifying the genius of
impassibility, when informed that this country, though in point of fact she habitually accepts modifications of armament more slowly than our neighbour over the way, yet when once accepted, and it comes to be a matter of putting them rapidly into execution, the steady *vis viva* of British gold is more than a match for Gallic fast volition. In the matter of rifled small arms we have an illustration. About the year 1835 the French military authorities conceded that a particular form of rifle, the *carabine à tige*, was radically bad; still, for lack of financial means the major part of the French infantry is armed with the defective weapon at this very time. On the contrary, not until the year 1850 was it, that rifled small arms were conceded to be desirable for infantry of the line in England; but now, before nine years have elapsed, the British army is fully supplied with rifles. The Minié has been supplanted by the Enfield; and the latter, I believe, is destined to be supplanted in no long time by the oval bored small arm of Lancaster's invention; now demonstrated, by trials conducted in the British army, to be incontestably the best.†

The seeming vacillation of opinions in respect of the principles of British armament, finds an apt illustration in the mutations which, of late years, our navy

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* See ante, page 239.
† For evidence, see Report of Colonel Lane Fox.
has undergone. To superficial thinkers, it seems inexplicable that the most efficient system of naval construction, and naval armament, cannot be agreed upon once for all, and persisted in. Wherefore it should be that ships of the line should be one year in the ascendant, frigates in the next, and gun-boats afterwards in quick succession:—Wherefore the spar-headed prows of antiquity should next find their advocates; and lastly, why the idea of mailed defence should be revived, and partially carried into effect, as a protection for the sides of ships, seems, at a first glance of it, unaccountable. But this sudden changing of opinion—this seeming vacillation of purpose—is readily explicable when studied in relation to certain developments of the resources of destruction, presently to come under notice. Similarly, the mutations, capricious and unmeaning to ordinary observers—which land artillery has undergone, and is still undergoing, fall into order, and explain themselves, when viewed in connection with a few dominant conditions. Just previously to the last Russian war, the French had wrought out an organic change in their whole system of field artillery. The guns were shortened almost to the condition of howitzers; and the bore was made uniform to a calibre of a twelve-pound spherical iron shot. At the present time, so far as I can learn,—and I believe my information correctly represents the state of the case—the French are bringing their
field artillery to one uniform standard of a four-pound bore.* This seems unreasonable at first, but it will be perfectly comprehensible as our investigation proceeds. All these changes are only to be regarded as oscillations caused by the powers of attack, and powers of defence, mutually dominating over each other: preparatory to a final state of more nicely-balanced equalisation, to be at length established between them.

* It may be necessary to remind the general reader that a four-pounder gun, in ordinary language, is a gun capable of being fitted by a four pound spherical iron shot. But rifled guns need not employ spherical shot; they usually are charged with elongated projectiles. So the common spherical estimate does not correspond to the weight of projectile actually used.
CHAPTER II.

AGENCIES WHICH HAVE DETERMINED CHANGES OF ARMAMENT IN NAVAL AND MILITARY SYSTEMS, SUBSEQUENT TO THE WARS OF THE FRENCH REVOLUTION.

Though the powers and characteristics of warlike projectiles, and the types of armament introduced since the termination of the wars of the French revolution, have been so numerous and diversified, yet their development can be traced to two primary adoptions; namely, the Paixhans, or incendiary system of horizontal shell firing, and the rifled small arm, regarded as a general weapon for the line.*

§ CHANGES OCCASIONED BY INTRODUCTION OF THE PAIXHANS SYSTEM.

Anterior to the wars of the French revolution, the principle which regulated sea-combats were of the simplest description. Of gunnery, properly speaking, there was but little. The wind, and nautical skill, had far more to do with the issue of sea fights than gunnery. Each rival belligerent endeavoured to place...

* It is not considered necessary to enter much into detail concerning the philosophy of the rifle principle here, full consideration having been given to that matter already—p. 224 et seq.
himself within sure reach of his adversary as rapidly as possible; to fire at such close distances that his broadsides were not likely to miss their mark; to take up a raking position, if possible; and thus, by sheer force of iron against wood, to batter the enemy in such fashion that either he would be compelled to strike to the crushing force of artillery, or to yield, if more obstinate, after a hand to hand encounter with boarders. Nelson, as is well known, first taught to what extent this mere exercise of physical force might be improved upon by the manœuvre of "breaking the line;" and with this it may, in a manner, be averred that the developments of naval manœuvring ended.

It would be presumptuous for one who neither belongs to the naval nor the sister service, to linger over the description of matters which he necessarily cannot well understand; such as the value or importance of special sea manœuvres. As regards the physical forces concerned, however, the case is different. One may be a civilian, and yet perfectly well comprehend their agency. A cannon ball, though a very unpleasant object to encounter whilst in motion, is harmless enough to contemplate when lying at rest. That same iron messenger, speeding on its death-errand a moment ago—crashing through timbers, dismounting guns, or tearing to fragments the bodies of men, is a very different sort of thing to that torpid lump of metal, motionless and innocent, when the moments of its flight are sped.
Some reflection of this sort appears to have crossed the brain of the French general, Paixhans, about the year 1822; and the most inexperienced reader in these matters will have no difficulty in following the French general to his conclusion. It will be evident to the most superficial thinker, that, if instead of the tranquil, motionless, solid shot assumed by us, a hollow shot were substituted—that if the hollow shot should happen to contain a few pounds of gunpowder—if further in connection with the gunpowder there should happen to be a fuse rapidly burning, and guaranteed to explode the powder charge at the expiration of some short moments, a new and very terrible sort of power would be superadded to the mere shattering force exercised in travelling, by a mere solid shot. The substitution of shells for solid shot in the naval service is what we understand by the Paixhans, or incendiary system. I have no desire here to go into the merits of priority of discovery. I am aware, and have already stated that the employment of such shells had been adopted by ourselves, and therefore we may, in some sense, claim priority over General Paixhans. We, however, only used these missiles exceptionally, and only discharged them from carronades; * whereas to Paixhans the merit is due of having constructed a species of long heavy gun specially adapted for their

* Ante, p. 184.
use, and of proposing their adoption as an ordinary, if not the exclusive artillery, of the naval service.

Here the first subject for reflection is this:—Whereas the force of an ordinary solid shot is determined (other things being equal) by the distance it has travelled over,—or, in other words, by the force of its impact,—the force of a shell, regarding it merely as to its shell-function, is determined by the locality where it may happen to be at the time of bursting, and the power of its bursting charge. Cannon balls have often dropped on to a ship's deck, and wrought no injury whatever. They have often lodged in a ship's side, and their presence there has been rather more advantageous than would have been the hole resulting from their extraction. Performing the office of a plug, a solid shot has often kept out that flood of water, which, by rushing into the ship, would have sunk her. But contemplate a live shell dropped down on a ship's deck, or bedded in a ship's timbers. Contemplate that shell, under solemn covenant to burst at the expiration of a given short time, and bursting accordingly! The consequences are obvious. A few such explosions, accurately timed, would destroy the largest ship that ever swam on ocean.

For a season let us assume land fortresses to have no existence. Let it be imagined that the only functions of war ships are to be brought into operation against other war ships; then the conclusion seems
almost inevitable that shells discharged horizontally, as ordinary shot would be—the system, in point of fact, of Paixhans—must necessarily present advantages over solid shot, so varied and so numerous, that no unprejudiced judge could hesitate to accept them for naval armaments. Nevertheless, such recognition was not universally accorded. It is not universally accorded even now. Only the Americans have adopted the shell system for their navy exclusively: in other words, to the abandonment of solid shot altogether. Even the French still retain a complement of solid shot in their naval armaments, and ourselves still more. Wherefore this discrepancy of practice? is the question which may now be asked. Are there two rights and two wrongs on one and the same matter? If shells exclusively are best for the naval armament of the Americans, wherefore not for ourselves and the French? The explanation is simply this. Whilst the Americans never contemplate the possibility that ships shall operate otherwise than against ships, the French and ourselves hold in perspective a second view of a war ship’s functions—namely, the attack of fortresses.

Let us pause here to notice an admission made, tacitly or overtly, by France, England, and America:—namely, that the Paixhans system is not adapted in the highest degree to the attack of stone work.* Officers of the American navy with whom I have conversed,

* This remark does not apply to large rifled ordnance shells.
conceded the point at once. "We should never dream of attacking a first-class fortress in that way," they said. Other means would be taken.

Fortresses thus ideally abolished for the simplification of a position, shall be now assumed to exist. We will imagine the *dramatis machinae* involved, to be ships of war, and a fortress. We will assume that those on ship board propose the demolition of the fortress, or the capture of it, whilst those on land propose the demolition or capture of the ship. Both are armed with a certain complement of shell guns of course; but not yet the refinements of rifled artillery. The opposing forces are, at—say fifteen hundred yards distance; and the strife begins. Estimating the relative advantages involved, let us glance at them. The fortress is stationary, the ship can move: the estimate involves subtraction as well as addition. The fortress must stand still to receive all the broadsides of the ship; whereas the latter may move about, and thus disturb the aim of the fortress. Not every advantage here is on the side of the ship. Less probability is there of her being hit indeed, because of her motion: but that very motion interferes with the accuracy of her aim. The fortress is a larger mark:—granted. The ship would hardly fail to hit it, whilst the fortress would stand many chances of not hitting the ship. This, too, is granted:—but as to the probabilities of injury after being hit, the advantages are immeasurably on the side of the
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fortress. Distant fifteen hundred yards, or even a thousand yards, a ship might fire a broadside of China oranges at a first-class fortress with the probability of inflicting as much damage as by the firing of iron balls. No distance more considerable than three or four hundred yards will tell for good.* A ship, then, which intends to finish her work that way, will have to take up the distance of three or four hundred yards, and (as long as possible) keep it. It is quite worth while to reflect on this little fact just now when long-range rifle guns of small shell-capacity † are in the ascendant. Whether rifle gun or common gun, the projectile it hurls, must be either shot or shell. If shot, the question is not how far it will go, but how hard it will hit at any given distance. If shell, then superadded to its hitting or penetrating power, comes the even more important consideration of its power of explosion. How much gunpowder or other explosive material will it hold? The powder-holding capacity of the largest existing, I may even say the largest possible Paixhans shells, is quite insignificant viewed as to its ability to batter down a fortification

* At 400 yards' distance Armstrong's larger cannon was fired at the "Trusty," floating battery, from the "Mayflower." Contrary to what has been elsewhere asserted, Armstrong's missiles did not perforate the four-inch iron protecting plates; as will be more fully set forth hereafter.

† Armstrong's larger shells hold each considerably less than 1 lb. of powder.
at a range of fifteen hundred yards. Such shells might do great execution against the gunners of a battery *en barbette*, or even against an ordinary un-covered battery; but casemated batteries may be regarded as proof against Paixhans shells, that is to say, shells horizontally fired from unrifled guns. The next question is, whether the shells of rifled guns would be more effective. That depends on the size to which rifle ordnance may be developed and brought into practice. Armstrong's rifle gun being that by which greatest expectations are now raised, that arm may be accepted as our standard of investigation. Up to the present time that weapon has been turned but of two dimensions; the larger has a bore of $\frac{3}{4}$ inches, and a length of 10 feet 6 inches, the diameter of the smaller being only two inches and a half. The largest projectile weighs thirty-two pounds, the smaller about eighteen.

The larger Armstrong gun would hold a spherical iron shot having a weight of a little over four pounds. It is not intended to project that sort of missile. Its projectiles are cylindrico-hemispheroidal, belted with lead. Now, the quantity of gunpowder which the largest of Armstrong's shells can hold must be trifling. Conceding for the weapon long range, and accuracy of flight, points which no one doubts—conceding the terrible effects of such a weapon when employed by ship against ship, or by fortress against ship—still a projectile only weighing thirty-two pounds cannot hold
enough explosive material to effect much damage by mere explosive power on stone fortifications. Explosion after penetration would of course be more prejudicial; but no considerable degree of penetration could be accomplished against well-set stone at a less distance than 800 yards, even with a rifled bolt like Sir W. Armstrong’s; and at that distance the attacking ship, if vulnerable, would be a sure mark for not merely Paixhans shells, but red-hot shot. I would not be understood to depreciate the value of rifle cannon; but it seems that the existing calibre of the Armstrong gun is not competent to effect that which a breaching cannon will be expected to effect in times to come; and there seem fatal objections to making rifled cannons on Armstrong’s type much larger than those already manufactured. They are of wrought iron, a material to the fashioning of which into gun barrels there are narrow limits. Cast iron would not answer the manufacturer’s purpose. Wherefore it would seem that guns on Armstrong’s construction should not be capable of being made considerably larger than at present; and as constructed now, they are not large enough to give effect to the practice of shells horizontally fired against fortresses.* Russia need not fear that her

* Stress is laid on horizontal firing, because of a reason to be made evident hereafter. The question will be asked in the sequel, whether the most profitable way of attacking fortresses from seaward will not consist in rifle firing conducted at high
Cronstadt will be demolished by any sort of missile that can be shot from three-inch guns.

Whatever may be the perfection to which rifled ordnance are brought hereafter—and I for one expect great things of them—still, shells vertically fired,—in other words, mortar shells,—will assuredly play a very important part in the demolition of fortresses. It is a very different affair to fire a shell horizontally Paixhans fashion, whether from an ordinary Paixhans or a rifled piece of ordnance, and to fire a shell vertically from a mortar. In the former case, not only is the force of impact less as the distance is greater, but flying horizontally, or, more properly speaking, in a curve of small curvature, the explosion must occur at one precise instant of time in order to be effective. The difficulties in the way of graduating or timing such explosion need hardly be pointed out. Add to this the smaller dimensions of shells to be horizontally fired from Paixhans, or, indeed, such rifled cannons as are at present in use, and we shall presently learn how great are the advantages of mortar practice against fortifications. A bomb-shell setting out on its trajectory at an angle of about $45^\circ$, and falling on a locality, strikes angles—angles as near $45^\circ$ as may on experience be found to give maximum range for each particular rifled ordnance. But the idea here advanced could only be perfectly realised with rifled guns of large bore, eight or nine inches at least.
with a force of impact great in proportion to the range it has accomplished. The timing of its fuse is by no means so delicate a matter as the timing of a shell to be horizontally fired; and inasmuch as mortars can be made of larger dimensions than long guns, bomb-shells have a proportionately greater capacity than shells of the latter, except the long guns be rifled and charged with bolt-like shell, for holding a bursting charge of gunpowder.

Resuming now a consideration of the influences which the introduction of Paixhans' system has effected on armaments and arms, the first result of that adoption was, perhaps, the building of casemated batteries; the next result was seen in the impetus given to the creation of rifled cannon of large calibre, to the end of dealing with such casemates by horizontal firing. Next followed the idea of monster mortars, determined by the same cause; whilst, in presence of new means of destruction existing or threatened, it seemed desirable to apply the idea under a modified form of casemated forts, and protect by iron sheets the sides of floating batteries. As regards rifled cannon of small calibre (such, for example, as Armstrong's), notwithstanding the vaunted excellence of these arms as battering ordnance (which I believe is not their best characteristic), the chief motive cause of their existence was probably the vast strides made in the elaboration of rifled small arms. It was hoped a means
would be discovered of supplying to field pieces much of the power which had been taken from them by infantry long range rifles.

§ CHANGES OCCASIONED BY RIFLED SMALL ARMS.

Not less important than the changes referable to the introduction of the Paixhans system are others immediately dependent upon the general introduction of rifled small arms to the troops of civilised powers. So long as the smooth bore musket was the arm of the infantry soldier, 200 yards might be accepted as the extreme distance at which the musket ball would prove effective. But at the same distance grape and canister are still more effective, and by means of Shrapnell shells the "scatter shot" practice of artillery (as it may be termed, in contradistinction to practice with single and solid shot) is rendered effective to distances up to 1,000 yards, and, under certain circumstances, still further. So soon as the infantry were armed with picket-shooting rifles on the modern construction, the relation long subsisting between field artillery, and small arms, became disturbed at once. Small arms experienced a vast accession to their power, whilst the powers of cannon remained nearly the same; for notwithstanding minor improvements, no organic change had been wrought out in the construction and employment of artillery since the close of the French wars, until the movement commenced in favour of rifled
cannon; a movement which has since eventuated in the production of many kinds of that sort of ordnance, of various degrees of merit, and to be described farther on.

Nevertheless, the question of range has been greatly misunderstood, and the advantages of it have been greatly exaggerated. As soon as the fact was discovered that rifled small arms might be rendered effective at a distance of 1,000 yards, or even further, the public very complacently speculated on the issue of future land battles being decided at that long range. It seemed enough to learn that mere round shot would tell for little against skirmishers loosely thrown out; that Shrapnell shells were always uncertain, owing to their principle; that, when bursting as calculated, their scattered shot would produce little effect at distances beyond 800 yards; whilst every infantry soldier could kill his man (supposing the latter to be hit) at a still greater range—it seemed, I say, a necessity to the minds of some ardent people, after giving weight to these considerations, that the sphere of field artillery was almost annihilated. Practical men thought otherwise. For obvious reasons, they saw that the mere length of range of a small arm, even when co-existent with accuracy of flight, though an important element to be considered, was not the only element. That compound quality, so well designated by "pluck," is not to be contemned in armies, after all; and pluck
happens to be a far more general characteristic of a good infantry than ability to perform those phlegmatic calculations, and angle takings, which the accomplishment of any extreme range must necessarily imply. If a mortar were planted at the Horse Guards with the intention of destroying Buckingham Palace, it would be quite compatible with the intention desired to be fulfilled that the mortar shell should curve high aloft, and drop down upon the palace at last; but if St. James’s Park were thickly studded with the enemy’s troops, of whom it was desirable to kill as many as possible, one at all events, by small arm shots, then, other things being equal, the firing would prove effective in proportion as the trajectory curve described by them did not ascend above the level of the objects intended to be hit. Except for certain special services, a small-arm missile should not ascend above the head of a mounted trooper, in any part of its course.

It is needless, however, at this time to labour at a refutation of the once prevalent idea that the extreme ranges at which modern rifled small arms are capable of delivering their fire accurately, are practically advantageous. Last year the French rifled small arms were sighted for no longer distance than 600 metres. The sights are now being reduced to the standard of 400 metres; the ability to hit an object farther removed being more than compensated by the high trajectory necessary to accomplish the lengthened dis-
tance, and the trouble and calculation incidental on the employment of various sights.

The Minié arm of our own service (pattern 1850) was sighted for the extreme range of 900 yards, though its effective range, if desired, could be much farther extended. The present small arm of the British infantry service (Enfield pattern, 1853) is only sighted for the extreme range of 900 yards, though, like the Minié, capable of doing execution much farther. Still, 600, or even 400 yards, is a very long range by comparison with what un rifled muskets could accomplish. Doubtless those ranges* for other purposes, and longer ranges exceptionally, have gravely compromised the powers of artillery in the field, as those powers were in the time of un rifled muskets. The French appear to have been the first to take this matter seriously into deliberation, and deal with it practically. Slight reflection suffices to convince a reasoner on this matter, that the increased efficacy of small arms in the field could only be adequately met on the part of cannon, by increasing the shell power of the latter. The slaughter capable of being effected by mere solid cannon shot is a bagatelle, after all, by comparison

* The universal adoption of rifled small arms by civilised powers will not do away with the existence of special rifle corps. The latter will be set aside for special service as heretofore, and their firelocks will be sighted for longer ranges than those of the general infantry of the line.
with the slaughter resulting from good practice with grape shot, canister, and, more than all, shells. Grape shot and canister are of no great service beyond 300 yards; and, to utilise them fully, much closer quarters must be selected. But it seemed almost a matter of demonstration, that such close quarters could no longer be taken up, subsequent to the general introduction of modern rifle guns. An important revolution, then, in respect of the previously existing balance of power between small arms, and field guns, was effected. Formerly grape, and canister, were of longer effective range, and consequently of more avail than small-arm shot; but modern rifles once brought into play, the preponderance of destructive effect, under the best conditions which each arm could command, would seem to remain with the latter.

Obviously the best means of rendering field artillery effective against modern rifled small arms (assuming no organic change of artillery to take place—such as the rifled principle, for instance) was to develop the power of artillery to the highest degree possible in respect of their shell-throwing competence, and more especially Shrapnell shells. Now, though we English have long followed the custom of throwing Shrapnell shells out of every sort of gun larger than a musket in the service (except the mortar), continental nations had long adopted another course. Continental testimony was almost universally in accord as to the
conclusion, that nothing less than a calibre of about twelve pounds, spherical estimate, was large enough to give full effect to the principle of shell-firing, whether Shrapnell or common.

Of course, guns having a calibre of still more than twelve pounds (spherical estimate) would be still more efficient in respect of shell practice; but long guns of larger diameter would be almost unmanageable in the field. As for short guns (howitzers), they might indeed be used of much larger calibre; but the howitzer partakes so much of the nature of a mortar, so high a trajectory must be afforded in order to accomplish a long range, that howitzers seemed unadapted to give sufficient scope to the genius of shell practice for coping with the modern rifle.

Accordingly the French adopted a compromise which, viewing all circumstances, appeared in their estimation to be best. They adopted as much as possible the calibre of twelve for field guns. They constructed field ordnance, which were a sort of compromise between long guns and howitzers. Thus they were not encumbered with the weight of ordinary long twelve-pounder guns; and the modified ordnance could accomplish ranges at lower angles of elevation than a corresponding howitzer. It will be seen that the capabilities of such ordnance for the firing of solid shot were diminished, in order that fuller effect might be given to their practice with shells.
Whether the proper solution of the difficulty was accomplished by the French (still assuming no organic modification of ordnance to have taken place, such for example as the rifled principle) is a matter of doubt. The arguments for and against belong to military men. The civilian who should deal with this matter would only show his presumption. The question need not come under discussion here. Enough has been stated to prove in what direction the current of French military opinion had been flowing; namely, in favour of shells as the proper means of dealing with rifled small arms.

Notwithstanding the secrecy in which all relating to recent proceedings taking place in French arsenals has been clouded, there can be little doubt at this time that rifled cannon constitute the arcuum imperii. This deduction might have been arrived at from a judicious correlation of disjointed evidence. Firstly, it oozed out that the French were throwing aside twelve-pounder field guns, and adopting four-pounder guns in their place. Now, it is not difficult to perceive that a four-pounder gun, i.e., a gun the bore of which is competent to hold and project a four-pounder spherical iron shot, must, except a rifle gun, be totally inefficient, and contemptible in practice:—especially must it be contemptible viewed as to its shell-launching capabilities. But if a rifle gun the case is altered. Then it need not, and assuredly would not, throw spherical shot
or spherical shells. Such rifled ordnance would be adapted for the launching of elongated shot and shells, something like the Minie in form, or even more bolt like. Such a nominal four-pounder might thus be made to launch projectiles, not of four pounds merely, but perhaps of twelve, twenty, or even more pounds. Therefore the newly adopted French ordnance must necessarily be rifled ordnance.

Another deduction follows equally important. If rifled ordnance, they must necessarily have been proved compatible with Shrapnell shell practice. No system of land ordnance, however deadly and efficient in other respects, could afford to do without that. I once doubted whether the Shrapnell system were compatible with the rifled principle; but Armstrong's gun has made excellent Shrapnell practice here, and the same compatibility must have been demonstrated in France, otherwise the new four-pounder could not have been accepted for general field service. It will be found, I believe, that the French rifled field gun now accepted again is a nominal muzzle-loading four-pounder; two grooved; firing an iron shell of the shape appended. The adaptation of the shell to the rifle grooves is accomplished by a pewter band, spread out into wings on two sides of the shell.

Such, then, is a slight sketch of the general development which the resources of warfare have
undergone subsequent to the year 1815. They will be perceived, I think, to have owed their origin, and to have been forced onward, firstly by the adoption of Paixhans' system, secondly by the universal acceptance of the rifled musket for general infantry purposes.
CHAPTER III.

FORMS OF RIFLED ORDNANCE AT PRESENT EXISTING.

When the expression "rifled ordnance" is employed, it is necessary to specify, within moderate limits, the general magnitude of the ordnance.

Shouldered fire-arms grow into cannon by imperceptible gradations; and inasmuch as the manufacture of rifled small arms is attended with no difficulty whatever, it follows that the manufacture of certain small varieties of rifled ordnance can be accomplished without much difficulty out of the very same materials that shouldered fire-arms are made of; namely, forged or wrought iron. But beyond a certain limit of weight and dimensions, wrought iron cannot at present be forged with the perfection necessary to insure the stability of a gun. The thirteen-inch bore un rifled monster cannon, forged at a great expense and with the utmost care by the Mersey Iron Company, and presented to the Government, is a complete failure. Although it has never yet been fired with anything like a full charge of powder, the gun is cracked at the breech, and its touchhole rapidly burns too large for service. If such be the difficulties attendant upon the successful forging of an un rifled piece of ordnance, how much
more considerable would be the difficulties experienced in the manufacture of a rifled gun of similar dimensions!

When, therefore, a successful wrought-iron piece of ordnance is spoken of, I repeat it is necessary to consider well the size of it; and this more especially in the case of rifled ordnance; the strain encountered by which is so much greater than has to be resisted by an ordinary or unrifled gun.

The only successful description of wrought iron rifled ordnance that I am aware of is that of the inventor Armstrong (with the exception of that of Captain Symonds, R.A.). Two questions then arise in relation to this sort of gun. Does it admit of being made to any extent larger? and if not, does the calibre of this gun as at present established comport with all the uses to which cannon are applied?*

I am not doubting the triumph of Armstrong's gun as a field piece; I do not question its efficiency against ships; but is it powerful enough to deal effectually with a first-class fortress like Cronstadt or Gibraltar?

Now, it has already been pointed out (p. 315 et seq.)

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* Armstrong's cannon have hitherto been constructed of two dimensions only: the larger having a bore of 3½ inches, the smaller a bore of only 2½. In either case the pitch of rifling is one revolution in 12 feet. The weight of the larger gun is 18 cwt.; of the shell, 32 lb. The lighter shell weighs 18 lb.
that no matter what the range of a gun may be, the efficiency of its projectiles must be proportionate to the extent to which these projectiles embrace one or all of four conditions, namely, penetrating, battering down, burning, or blowing up.

§ DESCRIPTION OF ARMSTRONG’S RIFLED ORDNANCE.

Although this now celebrated weapon was not by a great many the first in the field, yet there can be no doubt that it is the rifle-ordnance marvel of the day. Precedence, therefore, shall be given to it. I will describe it first.

Already it has been mentioned that the diameter of the calibre of Armstrong’s large piece of ordnance is three and a quarter inches. It would therefore contain (about) a four-pound spherical solid ball of cast iron; and regarded in that sense it might be denominated a four-pounder gun. Assuredly, however, spherical projectiles will never be shot from rifled guns, large or small, by sensible people again. Elongated projectiles, more or less bolt-like in form, will take their place, and of this kind are the projectiles employed by Sir William Armstrong.

It need not be pointed out that the spherical shot estimate of a piece of ordnance furnishes no indication whatever concerning the absolute weight of the projectile it can launch. A three and a quarter-inch diameter iron ball weighs (about) four pounds; but a cylinder
of equal diameter and equal height would weigh one third more; and so on in proportion for large cylinders. Armstrong's cannon are provided with projectiles (if we call them bolts the expression will be correct enough) of two different weights. The lighter weigh about 18 lbs. avoirdupois, the heavier about 32 lbs.

As to the larger gun itself, the weight of it is 18 cwt. That it loads at the breech is so commonly known that, except for completeness, I need not have stated the fact.

The construction of the gun is partly of steel and partly of wrought iron; the materials being distributed in the following manner:—In the first place, the portion of the bore or chase nearest to the shot—that is to say, the central portion of it—consists of a steel tube, along which, from breech to muzzle, run forty rifled grooves, the pitch of their screw turn being once in twelve feet.

Outside the central steel tube comes a wrought iron barrel or fillet, wound spirally from one end of the steel tube to the other, overlapping as it goes, and welded at the overlap; a construction, as will be perceived, exactly similar to that of an ordinary small- arm twisted barrel. It only now remains to be stated, that outside this lapped fillet comes another, twisted in the opposite direction, and the description of the chase or barrel part of Armstrong's rifled cannon is complete.
We now arrive at the manner of loading it, to illustrate which I append a modified sectional diagram* of the gun placed horizontally, the upper aspect of it being next the eye.

We may profitably at this point diverge awhile to furnish an instance of the curious manner in which discoveries laid aside useless in one age come round and are turned to account in times hereafter.

Every person who has given only moderate attention to difficulties which hem in the manufacture of cannon, must be aware that the problem of accomplishing breech loading is found to be one of no easy solution. Yet the turning out of breech-loading cannon is no mere feat of to-day.

*This diagram is to be regarded in a functional sense, not as a copy to scale.
Breech-loading cannon were manufactured and employed in the reign of Henry VIII., as there is evidence to testify. In the Tower of London may still be seen certain relics obtained from the war-ship "Mary Rose," which foundered in the reign of Henry VIII. Breech-loading cannon are amongst those relics; and, what is more, the system of breech loading resembles very closely that now adopted by Sir William Armstrong.

I do not for a moment state this by way of depreciation. I know perfectly well that the only difficulty attendant on the adoption of a breech-loading system in modern artillery is referable to the strength of our modern powder; the amount of it necessary for yielding modern ranges; and, perhaps more than all, on the more accurate fitting of projectiles to calibres in modern times. Give an unlimited amount of windage; fire a four-pound ball from a six-pounder gun, for example—and many imperfect breech-loading expedients totally incompatible with modern necessities, would then present no difficulty.

Having thus guarded myself against any imputations of disparagement, I need not fear to state, without being misunderstood, that the breech-loading construction of Armstrong's gun is very similar to that of the ordnance recovered from the wreck of the "Mary Rose." I will proceed to describe it.
§ BREECH-LOADING CONTRIVANCE OF ARMSTRONG'S GUN.

Looking down upon the modified sectional drawing of the cannon represented by Fig. 2, the reader will perceive, almost midway between the trunnions and the breech-screw, a white parallelogram having the letter T marked on the right-hand upper corner of it. That parallelogram is a sort of trap door, capable of being lifted up out of the gun, and thus throwing open an entrance to the breech extremity of the gun. The trap door, when removed, presents the appearance shown by Fig. 3.

The trap-door, as I have called it, is more properly speaking a trap block, being perfectly solid with the exception of a perforation corresponding with the touchhole T, and proceeding thence by an angular bend to the centre of D.

Particular attention must now be solicited for a little appendage barely shown, on account of its trivial dimensions, in Figure 2. It is a flat ring or short cylinder of COPPER let into the posterior extremity of the bore, and constituting part of the chamber for the main charge of powder.*

It is this copper cylinder more than anything else which makes Armstrong's gun a perfect breech-loading

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* The flannel cartridge c is purposely shortened, in order that the copper ring may be more evident.
contrivance. If some eccentric person were to set himself the task of preventing the exit of wind from the nozzle of a pair of bellows by plugging the latter with an iron rod, he would find it no easy matter: rather one might say he could not stop the escape of air. Iron being rigid, the bar and the nozzle would not accommodate themselves to each other, little channels of exit would remain, and air under sufficient pressure would escape. But the bellows nozzle might be effectually "corked" without difficulty; and this illustrates at once the difficulties encountered by others, and by Armstrong overcome, in respect of the construction of perfect breech-loading guns. No iron joint, or plane of contact, or screw, or iron plug of whatever kind, is found in practice tightly fitting enough, to restrain completely the impatient flame of gunpowder pent up in a gun-barrel. After the engineer had wrought his best, and turned out a gun perfect to the eye—back nevertheless the gunpowder flame would rush, fouling every part it touched, depositing soot on every finely-adapted surface; rendering parts, however nicely fitted to each other before, no better than the roughest mechanism.

To Armstrong the happy idea occurred* of corking the tube of his bellows, not at the muzzle indeed, but

* I am informed, however, that the idea of preventing gunpowder-escape by an expanding piece of copper occurred to Messrs. Church and Goddard, who patented the principle, and will contest Sir W. Armstrong's claim to exclusive reward on behalf of it.
at the breech end. When I further state Sir William Armstrong's cork is a copper ring, then the main secret of all his success is out. Under the enormous pressure of (it may be) fifteen tons to the square inch, that copper ring expands, and effectually corks up, the breech end of his explosive tube.

By reference to Fig. 2, it will now furthermore be perceived that immediately behind the trap plug with which we commenced our description is a large screw, which, being thrown open, converts the whole length of the cannon into an open tube. That screw itself is perforated axially,* as will be seen on inspection, the use of the perforation being this, a solid bar can be thrust up through it, and in this way the projectile (ball one cannot call it) here annexed is forced up into its place.

Assuming the projectile to be thus impacted, a large cartridge powder charge, marked 0 in Fig. 2, follows next; and inasmuch as that cartridge does not admit of being pierced, as is usual in other cannon, because of the angular bend the touchhole communi-

* In the only published account of the Armstrong gun which has hitherto appeared, this central hollow running axially through the breech screw is not mentioned. On one occasion a breech screw of an Armstrong cannon unturned slightly, thus permitting the solid block which closes the aperture to blow out, and seriously endangering the life of General Peel, who happened to be near at the time; and on another occasion the copper bearing plug split up, and the gun burst.
cation makes before terminating finally in the centre of the copper-chambered disc, special means of ignition have to be devised. The trap-plug is slightly excavated anteriorly, for the purpose of holding a small cartridge, wherefore Armstrong's cannon may be said to have two gunpowder charges, this second or smaller charge being ignited by a friction tube.* These trap-plugs, it should be mentioned, are supplied in duplicate, one remaining in the limber, while the other is in the gun. Each piece is supplied with telescope sights fixed laterally, and moreover there is a Vernier arrangement for estimating the deviation specially due to rifle motion.

It only now remains to be stated in respect of the gun itself that liberal sponging with water is essential to its being employed; wherefore, if under any circumstances water cannot be obtained, Armstrong's gun cannot be used.

§ DESCRIPTION OF THE PROJECTILES USED.

I am cognisant of the exact interior construction of Armstrong's shell, but, for the present, I do not think it desirable to make known the particulars.

The lightest of projectiles, as I have already stated, weighs about eighteen pounds; the heaviest about thirty-

* For a description of friction tubes, see ante, p. 270.
two; but the construction of them, so as to render them capable of being discharged from a rifled barrel, is that which more especially concerns us now.

The projectiles of rifled ordnance devised and made efficient hitherto admit of the following division:

\[
\text{PROJECTILES OF RIFLED ORDNANCE} \begin{cases} 
\text{Without envelope} & \{ \text{Wrought iron} \ldots \text{Lancaster.} \\
\text{With envelope} & \{ \text{Cavalli} \\
\text{Cast iron} & \{ \text{Wahrendorff.} \\
\text{Armstrong.} & \end{cases} 
\]

I do not include Whitworth's rifled gun in the classification, its inefficiency being universally conceded. Several of his cannon have been fairly tried by the English Government. All burst. None of his iron guns lasted up to the tenth round. The average time occupied in loading was half-an-hour; and the projectile could not be got down at all without previously lubricating the bore of the gun with hot oil.*

The Armstrong projectile is provided with two bands of lead, represented by BB, Fig. 4.† The intention of these will be obvious to all who understand the principles on which a rifled barrel depends for its efficiency. Though solid shot admit of being used in connection with the Armstrong cannon, the

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* One of the Whitworth cannon burst at the third round, with a discharge of only six pounds of gunpowder.

† Sir William Armstrong first covered his projectiles wholly with lead. The envelope was found, however, subject to strip away in firing.
genius of it, or any other rifled ordnance, is more specially congenial to the principle of shell firing; and the efficiency of shells being so totally dependent upon the nature of fuse employed, a minute description of the Armstrong fuse will be desirable.

In my treatise on projectile weapons, so full a description was given of the Belgian (Borman’s) Shrapnell fuse, and also Captain Moorsom’s concussion fuse, that further account of them in this place is unnecessary. The reader who wishes to understand the construction of the Armstrong fuse will, however, find it necessary to comprehend them, inasmuch as the latter is nothing more than an ingenious combination of the two former.

Strictly speaking, each of Armstrong’s shells is provided with two fuses; one penetrating into the shell from the outside, as is usual with every other variety of fuse; and another wholly within the shell. The latter is absolutely a percussion, or, rather, concussion shell, whereas the external fuse is partly concussion, partly a timed composition fuse, in its nature.

Borman’s Shrapnell fuse is ignited by the flash of the gun on discharge; and means are provided for promoting the ignition at any given distance in a horizontal channel of composition. Armstrong, however, does not rely on igniting his fuse by the flash of discharge; but accomplishes that end by puncture of a patch of explosive composition, through the agency of
a little steel point driven against it at the very instant of discharge, and by the force of the exploded cartridge.

The method by which this is accomplished may be rendered comprehensible by the following illustration. Fancy a pistol barrel, in the extreme breech end of which is tightly impacted some of the same kind of detonating composition as is employed for charging ordinary percussion caps. If that charge be punctured by a point driven against it, the patch of consolidated fulminate will inevitably explode. Fancy now a steel pointed bar, point downward, in the barrel, but suspended some distance over the patch by means of a wire or slender bar, thrust quite through a transverse hole in the bar, and also through corresponding holes in the sides of the pistol barrel. Quite evident is it that, so long as the wire remains unbroken, the point cannot fall, and the fulminating patch cannot be exploded. If the pistol bar thus armed, be smartly struck with a hammer on its breech extremity, probably the wire will not only break, but the point will be driven hard against the fulminating composition. At any rate, the tremendous shock of gunpowder explosion is sure to accomplish what a mere hammer stroke would probably fail to effect. The patch of fulminate almost always explodes; when, by very obvious means, the flash of it ignites a horizontally impacted streak of composition; communicating, when burnt out, with the
contents of the shell within. By means of a cap, and circular index arrangement, the composition in question can be ignited at any desired point from its beginning, and thus the duration of it can be timed. Such is the principle of Armstrong's external fuse. Concerning his internal fuse, little need be said. In principle it is a repetition of the concussion part of the external fuse reversed; the point being arranged in such manner that the shock of discharge breaks the suspending wire indeed, and sets free the steel pointed bar; which, however, instead of approaching the fulminating patch, recedes from it, and only pricks it at the moment when the shell, impinging against its mark, jerks forward the steel pointed bar.

Armstrong's gun is extremely accurate, and its range is very great. A flight of 9,600 yards has been accomplished by it, and shot after shot may be depended on for striking a target of not more than two feet square at a distance of 1,000 yards; but it is a slow loading gun. An ordinary cannon of equal size can be charged twice to Armstrong's once.

From the description given, there can be no doubt of the great power of this weapon. Whether any rifled cannon, however perfected, will be able to perform all the offices commonly required of cannon, is still a moot point. I am disposed to think not; but Armstrong's gun will accomplish as much as any rifle gun of equal bore.
NEW RESOURCES OF WARFARE.

The public has been made aware of the effects of this ordnance at Shoeburyness, against an iron cased floating battery, and fired from the "Mayflower." Newspaper reports of that trial were exaggerated. When one of the Armstrong projectiles struck the centre of an iron plate, it merely indented the latter. When, however, one of them struck an angle or edge of juncture, the plate was loosened, and the shell perforated the side. Practice was carried on at the distance of only 400 yards.

§ THE WAHRENDORFF BREECH-LOADING RIFLE CANNON.

A specimen of this arm was displayed in the Crystal Palace Exhibition of 1851. The Wahrendorff gun is made of cast iron, and the specimen sent for our national inspection had a calibre of about 6·40 inches diameter. It may therefore be denominated a 32 pounder gun (spherical estimate).

The Wahrendorff cannon is 4-grooved; the projectiles, of cast iron, are used without envelope, as already indicated, and are fashioned with projections adapting them to the grooves. I believe the Wahrendorff rifled cannon may be said to be in use; but it can hardly be denominated successful. The accident to which it is especially subject is that of bursting, or rather breaking off transversely near the breech extremity, at the
part where the first shock of explosion is experienced. If we take into consideration the enormous initial strain to which a breech-loading rifled piece of ordnance must necessarily be subjected when the explosion first operates, and the brittleness inherent to cast iron, this transverse fracture of the gun will create no surprise. Wrought iron being a tougher material, a cannon made of this substance would not be likely to become the subject of injury of this kind. But, seemingly, a wrought iron cannon, equal in size to the rifled ordnance of Count Wahrendorff, cannot be manufactured, and it would be impossible, on account of the softness of bronze or gun-metal, to use that material for a rifled piece of ordnance, firing naked cast iron shot or shell.

The perfection of rifled ordnance is one demanding for success little else than increased strength of materials. To this end several propositions are under notice, and one of them is especially hopeful.

§ THE CAVALLI BREECH-LOADING RIFLED ORDNANCE.

Although I am in possession of drawings illustrative of the construction of both the Wahrendorff and the Cavalli ordnance, I do not think it necessary to delay the publication of this treatise for the purpose of furnishing them at this time.

Omitting, therefore, all description of the means by which Cavalli accomplishes the act of breech loading,
I will limit myself to an explanation of the method by which he endeavours to combine the rigidity of an iron gun with the tenacity of a bronze one. In external appearance the Cavalli gun something resembles the ordnance of Dahlgren, figured at p. 151 ante. Viewing the exterior of it, the observer would fancy himself looking at a gun of cast iron wholly. However, the gun consists of an envelope of cast iron, embracing a pyriform core of gun metal towards the breech; the portion indicated by horizontal markings in the subjoined sketch.

![Diagram of gun](image)

Fig. 5.

Whether the cast iron be melted round this core, or whether a cavity is excavated out of an iron casting, and bronze subsequently run in, I am unable to say. The finality, however, is evident. That portion of the bore wherein the shock of explosion takes place is of bronze; the chase or tube, through which the shot has subsequently to find its way, being as in the Wahren-dorff gun of cast iron.

Of course it is always difficult to procure reliable testimony concerning the success or failure of foreign
artillery models; but out of the accusations springing from *amour propre* of rival nations, truth may often be arrived at.

Officers of the service to which Cavalli belongs (Sardinia) are loud in their condemnation of the Swedish gun, because of its liability to transverse fracture; whilst Swedish officers, on their part, aver that the elaborate expedient of Cavalli does not conduce to results a whit more satisfactory. I believe the Cavalli gun to be less subject to fracture than its Swedish rival; but still to be in a high degree unsafe: as, indeed, all breech-loading rifled ordnance supplied with naked cast iron projectiles must, seemingly, remain of necessity: and here, once more, occasion is found to indicate, as a corollary of much that has gone before, that, according to all experience and all testimony bearing upon the question, the Armstrong gun must necessarily be constructed of a tough metal. Cast iron would be too brittle; and whether bronze would succeed remains yet to be seen.

§ Lancaster’s System of Rifled Ordnance.

Having described Mr. Lancaster’s system so fully elsewhere,* it is unnecessary to revert to it here, except for the purpose of stating that it should not be regarded in any sense as the rival of the Armstrong

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* *Ante*, p. 229.
weapon. Up to the limits of calibre at which a breech-loading gun of wrought iron can be rendered efficient, and produced under circumstances of economy compatible with the requirements of a military or naval service, a breech loader, doubtless is the best. But the conclusion forces itself irresistibly on my mind, that to the end of breaching and demolishing first-class fortresses, ordnance having a calibre so small as three-and-a-quarter inches will not be found large enough. Long range is a fascinating element of contemplation to the public. To assume the little speck, five or six miles out at sea, darting Armstrong bolts at Cronstadt or Gibraltar, is very attractive. But an important question remains.—What can those bolts accomplish when they get there? To effect demolition is the intent of their mission—and their means of demolition are limited after all. To burn, or batter down, or blow up, and the list of resources is exhausted. Now though it might be very easy for Sir William Armstrong to set fire to a town near the sea coast—Brighton, for example—it would puzzle him to burn the granite of Cronstadt or the casemated rock of Gibraltar. Whether the Armstrong guns would succeed in battering down a first-class fortress at long range*—say four or five miles—may be judged of after studying the effects of these artillery on the iron-cased floating

* Or, indeed, at any practicable range.
battery, distant only from the "Mayflower," whence the shots were fired, 400 yards. Finally, as to burning or blowing up. These are functions which, as I have already shown, must necessarily be proportionate to capacity for explosive or combustive matter. Want of capacity is, perhaps, the weakest point of the Armstrong shell.

Contemplating the past and present of rifled ordnance—viewing their progress up to the time being—and reflecting on the limits which hem in their further development (perhaps only for the moment)—it will be perceived that want of adequate strength in the material of rifled ordnance is the chief, if not the only, impediment to the further development of this truly formidable principle. Even though the range of Armstrong's cannon has proved so unprecedentedly long,* it is small by comparison with what might have been, had the ordnance been strong enough to withstand a powder charge correlative to that employed in a small arm rifle. For direct or horizontal firing, the fact cannot be too deeply impressed that the more direct a projectile can be launched the better. Armstrong's gun accomplished its extreme range of 9,600 yards by an elevation of 36 degrees,† thus giving a

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* The longest range accomplished by his $3\frac{1}{4}$-inch gun at an elevation of 36 degrees was 9,600 yards.

† The expression "horizontal firing" can hardly with propriety be applied to discharges conducted at an elevation of 36 degrees.
highly incurvated trajectory. If the same range could have been secured at a lower trajectory by means of a larger charge, by so much would the powers of the ordnance have been increased for horizontal firing.

What the artillerist wants is, a material strong enough to permit the combination of a full charge of gunpowder with the rifled principle in ordnance.

This consummation effected, there seems no reason wherefore the rifled principle applied to heavy ordnance may not be combined with the practice of vertical firing. Hitherto vertical firing has been restricted to mortars, if a few trifling instances be excepted; nevertheless, certain dismounted long guns, partially imbedded in the earth and fired at great elevations, have shown some indications of the results to be accomplished by that practice, supposing it ever to be rendered capable of general execution. At present the difficulties in the way of constructing a perfectly safe thirteen-inch long gun, to be used at large angles like a mortar,* would be insurmountable; but if a thirteen-

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* I need not remind the artillerist that, assuming the existence of a vacuum, the longest ranges would be accomplished at an angle of 45°; and that for all slowly-moving bodies the vacuum estimate is not much departed from. Inasmuch as bombs are projected at low velocities, the vacuum elevation of 45° is closely approached; but in proportion as the velocity of a projectile is raised, so does the angle of elevation favourable to longest range become less. Thus the longest range of modern
inch bomb charge (5 lbs. of powder) could be plunged down from the vertex of a parabola, so incurvated as the one resulting from a large rifled long gun fired at the elevation necessary to accomplish its longest theoretical range, the consequences would be terrific. The point, I believe, is conceded that it would be much easier to demolish a fortress by plunging shells down upon the crown of it, than by firing either shot, or shell, horizontally against the sides of it. Mortars at present can only accomplish this vertical firing; and the question is, whether mortar boats could live under the storm of shot, and shell, that would be launched horizontally against them, assuming these mortar boats not to be sheltered. Now the extreme range of a thirteen-inch sea-service mortar (the largest now in use) is only about 4,000 yards, whereas the extreme range of modern long ordnance is far greater; whence it would seem that mortar boats will be so far under a disadvantage when matched against land fortifications,

shouldered small arms is accomplished at about 33°. The longest range capable of being accomplished by mortars is so inconsiderable that, even if the strength of their material permitted, greater elevation than 45° could not always be given for the sake of imparting increased verticality to the plunge of a shell; inasmuch as such increase of elevation would necessarily diminish the ranges. But if large rifled ordnance can be made strong enough to resist vertical firing, then, so great is their range, it might be worth while to sacrifice a portion of this quality in order to impart greater verticality to the ascending and descending branches of the trajectory of its shell.
assuming the ability to construct rifled long ordnance strong enough to withstand the explosion of a full charge, and that under the trying conditions of absorbed recoil, and high angles. Supposing the ordnance in question to be eight or nine inch guns, the ranges these missiles could accomplish would be too great for speculating on, without exposing the speculator to ridicule, and the effects of these shells would be proportionate to the usual ruling conditions—penetration and explosive power. The circumstances must be continually held in view that, when vertical firing is in question, the force of impact, and the penetration resulting from it, are always proportionate to extent of range; whence the longer the range, by so much more powerful is the resulting effect; which is the direct converse of what happens when horizontal firing is in question.

IMPROVEMENTS EFFECTED ON THE WAR ROCKET SINCE 1858.

Whatever be the scheme adopted to launch projectiles in warfare, it must only be regarded as means to proposed ends. Either it is intended to impart direct force of impact to the projectile, or it is desired to convey a receptacle (a shell for instance) to a given point, whereat arrived the receptacle shall work out some scheme of demolition.

It has already been shown—demonstrated, I be-
lieve—that no projectile which does not embrace the proper function—no projectile, that is to say, which cannot be depended on for retaining one definite extremity foremost in flight, and striking the object aimed at on that extremity—will be calculated to give effect to any destructive material more elaborate in its nature than gunpowder.

Gunpowder I believe to be the very best composition for the discharge of projectiles. Most chemical compounds are too explosive; they shatter too much. A certain progressive function of combustion is absolutely necessary when combustion is required to generate gas for projectile purposes. But when the combustive agency is requisite for any other shell practice than Shrapnell, then the more instantaneous it is, by so much more advantageous will it be; on account of its increased shattering effect.

I am of opinion that sufficient consideration has not yet been given to the modification of gunpowder designed for various purposes. Philosophically, it should seem that the rapidity of combustion of gunpowder should be varied, not only for guns of every calibre, but for guns of every length; in proportion to the force to be overcome, whether of gravity or of friction. For projectile purposes, it would be injudicious to diminish the rapidity of the combustion of gunpowder by varying the per-centage of its components. Perfect combustion is a desideratum in all
cases when gunpowder is employed as a projectile agent; for in proportion as combustion is imperfect, fuliginous and other solid results of combustion are left behind. It follows, therefore, that the only means available for lessening the velocity of combustion of gunpowder to be employed as a projectile agent will consist in enlarging the size of its grains. Just in proportion as ordnance are increased in size, so that the weight of their projectiles is proportionately increased—also just as rifle projectiles, of equal weight, and equal area of surface contact, are more tightly impacted into the barrel; so, theoretically, should the grains of gunpowder be larger. Practically this deduction is recognised, as may be seen in the custom of charging artillery with larger grained gunpowder than small arms, and rifled guns with larger grained gunpowder than un rifled arms of equal calibre. A gentleman who has devoted much attention to the construction and application of rifled guns has, I am aware, published his conviction that rifle gunpowder, to be effective, should be endowed with increased rapidity of combustion. This opinion is so much at variance with theory and testimony and practice combined—that I am at a loss to understand how it could have been arrived at. Still more extraordinary is it when placed in correlation with the fact that this gentleman, in practice, contravenes his published opinion. He has proposed a special kind of gun-
powder for his rifled arms. To be accordant with the doctrine advanced, the grains of that powder should be smaller than of the powder ordinarily in use for similar purposes; whereas they are larger, and in proportion to their increased size are they more slow in burning.

Granting that the size of gunpowder grains should bear some direct ratio to the force (either weight or friction) of the projectile to be overcome, then it would seem to follow that monster guns of smooth bore, and projectiles tightly impacted into rifled ordnance, have scarcely had a fair trial yet. I should, for instance, have been well pleased to have seen Mr. Mallet's great mortar tried with gunpowder having grains at least as large as horse beans; and it remains yet to be seen whether the powers of large varieties of rifled ordnance would not be increased, and the employment of them more easily brought about, by adopting that sort of ammunition.

Armstrong's cannon, small though they be, and constructed of almost the strongest material known to gunmakers, are hardly strong enough to withstand the explosive force of existing ordnance gunpowder. Somehow or other, newspaper reports de re militari sometimes describe the performances of guns under trial too favourably by half. To expect a reporter to be critical as to minutiae is expecting too much: but when a gun bursts under trial, one would think a reporter,
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then and there present, would be aware of it. Still strange errors of vision occur at times. I never remember to have seen it stated in newspaper reports, for example, that one of Mr. Whitworth's cannon burst at the third round, and that no single specimen of his iron cannon lasted until the tenth round. Equally silent were all the journals as to the fact that two of Armstrong's cannon burst under trial. The breech screw of one was partly forced out, and the chamber of another was fractured. On one of these occasions the life of General Peel was put in serious jeopardy.

Reverting now to the proposition, that the combustible material of projection ought, in order to develop its full effect, to be graduated as regards its time of combustion—whilst (except for Shrapnell practice) the most rapidly combustible, and therefore the most violently explosive substance which can be employed, is the best—we are led to speculate on the question how many of the terribly explosive bodies known to chemists, and in comparison with which gunpowder is a bagatelle, can be rendered available, only, as it would seem, by means of hollow polar projectiles, such as rifled bolts and rockets.

War rockets have already been fully described in their several varieties. They may be regarded under the two aspects of impact givers, and shell carriers. The rockets employed in our service combine these
two properties to pretty nearly an equal extent. In the Austrian service, however, where war rockets are used in the field far more generally than is the custom here, it is the shell function which is chiefly counted upon. The Austrian field war-rockets are each weighted with a shell, enormous for the diameter of the rocket; to the head of each of which a shell is attached by slender tin-plate straps. These rockets are fired at high angles, and tubes are used for discharging them; but the rocket tubes are very different from ours. The shell being considerably greater than the dimensions of the tube, each rocket is plunged tail downward through the bore of the latter, leaving the shell outside, and resting on the upper tubular edge. Firing is accomplished as usual; and the rockets, after accomplishing an insignificant range (no more than three or four hundred yards), fall, shake off each its shell, the latter alive, of course, and ready to burst after a time previously calculated. Such have been the Austrian field rockets, but it is within my knowledge that the Austrian Government is at present in treaty with an English gentleman for the purchase and adoption of a new variety of rocket.

Since last year the construction of rifled war rockets has undergone great modification. At p. 178 a diagram of Hale's rifled rocket, under the form then extant, is given. At present the tangential holes are reduced to two in number; but the most impor-
tant point in respect to them is this:—instead of being posteriorly situated they are now placed centrally in the rocket, or, more strictly speaking, coincident with the plane of the rocket's centre of gravity. The modified Hale rockets are now ignited, not at the extremity, but at one of the mesial apertures, whence the fire communicates throughout the whole perforation of the rocket.

Judging from the statement already made, it may, perhaps, be supposed that the central bore or cavity is single, as in an ordinary rocket. This is not the case. The exact structure of one of Hale's new rockets may be rendered comprehensible by stating it to consist of a pair of rockets joined together, coincident with the same axial line, and merely separated by a diaphragm of iron, perforated by a touchhole. Each of these rockets, making up the compound rocket, has its own specific function. The anterior one is exclusively concerned in furnishing gas for supplying the two tangential holes; the posterior one is exclusively devoted to the evolution of the flame of propulsion. The use of the touchhole through the transverse diaphragm is to obviate the necessity of igniting the rocket in two places.

Some experiments have recently been performed for testing the efficiency of rockets taking their flight under the surface of water, being regulated as to depth by a float. It would seem that much may
reasonably be expected from the performance of rockets used in this way. Doubtless, in the event of another naval war, attempts will be made to breach an adverse ship under the water line. Subaqueous rockets may probably be used to this end; and subaqueous infernal machines, first devised by the Russians, will, there is reason to think, be raised to a degree of efficiency which those who merely judge of them from the amount of mischief they have caused hitherto, little imagine.

I am not aware whether experiments have been performed to test the penetration of rifled bolts when fired downwards against an object under water. Round shot are almost inefficient under these conditions. A 68-pound shot fired at a depression of 20 degrees scarcely penetrates two feet under water. There is reason to believe that elongated rifle bolts would prove more efficient when discharged at a subaqueous target. The contingency of a shell breaching a vessel under the water line, and then bursting, has not yet been deemed possible. With ordinary guns and spherical shot, the case is doubtless impossible. Whether such a result be impossible under the altered circumstances of an elongated bolt discharged from a rifled gun, remains yet to be seen.
§ IRON MAILED FLOATING BATTERIES.

Assuming it to be the fact that first-class land batteries do not admit of being effectually battered by any gun which now enters into the armament of ships at a distance more considerable than four or five hundred yards, whereas land batteries can demolish timber structures at an enormously greater range, the question naturally arises whether it be possible to render ships impregnable by means of resisting iron plates.

I believe the point is generally conceded that, if this scheme be put into execution, special marine structures must be prepared for the imposition of the mailed covering; that, for example, to treat a ship of the line or a frigate in this way would result in making her too heavy. I believe it is conceded that her sailing or steaming properties would be thus vastly impaired; that she would become top heavy and unmanageable; moreover, devoid of flotation qualities to the extent required. Hence the mail-clad principle, if successfully carried out, will have to be used in connection with special floating vessels.

What should be the type of such vessels? Ought they to preserve a lingering analogy with ships in general exterior and bearing, or does it seem more compatible with the functions they are expected to perform, that the ship type be departed from altogether? On these points experience gleaned within the last few years has furnished some testimony.
The floating batteries initiated by the French, and imitated by ourselves, have closely followed the model of ordinary ships. They have been more or less wall-sided: they have been built with portholes like those of ordinary ships, from which they chiefly differed as to shape in the possession of roof-like decks. It was anticipated that, by retaining this much of the ordinary marine model, a considerable degree of sailing and steaming velocity might be counted upon, and that, notwithstanding the heavy top weight of mailed plates, moderate stability might be secured.

The result has been otherwise. These iron-clad floating batteries have sailed and steamed so ill, that worse is not possible. They have rolled so terribly that to lay their ordnance accurately, and fire with precision, has been impossible. The expectation that they would be able to cope with the ordinary strife of wind, and wave, has been totally disappointed. Devised to effect many purposes, they have been efficient for none. Adoption of the ship model has conferred none of the advantages of ships: whilst, contemplating them as mere batteries (surfaces of bearing from which guns are to be fired under conditions of as much tranquillity from wave-perturbations as science can bring about) they are perhaps so execrable, that no change of form could possibly deteriorate them. Here, then, is a fair field for experimenters to work upon.

Much of the stability of an ordinary ship, or, in
other words, her power to resist successfully the rollings, pitchings, and other perturbations due to the influence of wind, and wave, depends upon her sails. Now, it is almost a necessity that iron-clad floating batteries shall be denuded of sails. Retaining the ship type, they must necessarily be unsteady; but geometry suggests other forms which would present even more stability, perhaps, than that of the best trimmed ship. Wherefore not adopt them?

"Because the adoption would be incompatible with rapid progression," it may be said. But, floating batteries cannot sail, or steam rapidly, even as they are; and moreover, they are very unsafe when there is the slightest stress of weather. A floating body of whatever shape, can be impelled through the waves somehow. Given a sufficient propulsive force, and capability of locomotion to a very limited degree, then we seem to have all that can reasonably be expected of a floating battery. Tortoise-like as they are by their mailed sides: tortoises of the deep they must seemingly be, in the matter of slow progression.

To provide a means of escape for one of these floating batteries by rapid locomotion seems no better than an abnegation of faith in the principle on which they are guarded; viz., to defy the shock of each kind of missile that can be launched against them by projectile ingenuity. To that end are they built; and, if they cannot do this they had better have remained unbuilt. Then, instead of
being the boast, and triumph of modern nautical science, they would be its laughing-stock and opprobrium. I remember once looking upon the "Crocodile" frigate, in company with a nautical friend. He told me she belonged to the class of "jackass frigates"—an expression so new to me that I craved an explanation. "A jackass frigate," replied my friend, "is one that can neither fight, nor run away." Wherefore it appears that iron mail is not indispensable to the construction of that peculiar sort of vessel; and that, though a floating battery may, and indeed should, be able to dispense with any provision for running away, yet, contrary to the wont, and genius of a jackass frigate, she should be able to fight.

Cavalli, of the Sardinian artillery, whose rifled ordnance has been already adverted to, proposes a sort of floating battery which must needs possess stability in the water at least; as the sectional representation of it appended will make apparent.
A fast sea boat this iron-mailed battery would assuredly not be: but she could be made to find her way through the water somehow; and she would stand no more chance of foundering in a gale than the buoys on Goodwin Sands. Moreover, as far as form is concerned, the curved outline of her upper works would present the most favourable conditions for warding off shot tangentially; and, inasmuch as the iron constituting these upper works is corrugated, a still further tangential protection is imparted. Supposing a floating battery of this sort, absolutely impervious to missiles of whatever kind, to be placed in conflict with the enemy, the chance of damage occasioned by shot and shell going through the portholes has to be considered. Whilst the means of horizontal* firing remain as they are at present, such a floating battery would be something more than a "speck in the horizon." She would have to take up her position at a less distance than 1,000 yards—I believe, at a considerably less distance. Her port-holes would afford a target of no contemptible size; even for ordinary cannon: but Armstrong's rifled ordnance can be depended upon to hit a target of two feet square; again, and again. Short work would be made with the battery. But Cavalli proposes to abolish portholes, in their ordinary sense, altogether. This he would effect by the use of

* If vertical firing be in question, the iron envelope is material thrown away.
rifled cannon, *breech-loading*. Owing to the adoption of the latter principle, the ordnance would just want a small round hole to peep out of—no more: and their recoil being prevented by suitable expedients, there would no longer be experienced, the annoyance of smoke, lingering between decks.*

§ ON THE APPLICATION OF CHEMICAL RESOURCES TO THE CHARGING OF SHELLS.

This is a matter concerning which a chemist is permitted to speculate with more freedom than on the old technicalities of projectile science.

In another place I have stated, in accordance with the convictions to which I cannot help arriving, that if it be allowable to make war at all, it is allowable to put forth any sort, or degree of force, which may be deemed most convenient, to the end of destroying the enemy.

If it were consistent with the notions of civilised warfare to kill one's adversaries at all events, then it would be incumbent on a civilised belligerent to put in execution the least disagreeable modes of killing;

* Query.—If it be possible, compatible with the strength of rifled ordnance, to prevent their recoil, would it not be more profitable to use them from floating structures against fortifications at mortar elevation at once? The idea of a "speck in the ocean" might then be realised, and ranges fabulously long might be accomplished, by rifled shells doing the duty of bombs.
but inasmuch as it is always optional for the enemy to yield, I cannot but think it is an inconsequential use of philanthropic logic which leads to the conclusion that any convenient mode of destruction is not to be adopted at the pleasure of a belligerent.

Governments are coming to see the matter in this light; and were it otherwise, the necessity of abating somewhat of their scruples would be forced on them by the less scrupulous, insurgent elements of continental population; who in any future barricade-comotion would avail themselves of chemical resources to the fullest possible extent.

Being now engaged with another on experiments with new forms of combustive, and explosive shells, I may probably at no long period make known the results of our investigations. Meantime, I would caution the reader against the foolish, and prejudicial notion, that there can be any radical, or necessary secret, in this matter. It may occur to any one inventor to make any one particular combination of parts, or to apply materials which have not been applied before to the charging of shells; but, after all, the sphere of his application is restricted to an extent which a person not conversant with this subject would not have imagined.

The organic peculiarities of no shell, no gun, no agent of destruction, can long remain secret in these days; and in England, the absurd secrecy with which
Armstrong's gun has been invested; the arresting of a sketcher; the housing of the gun under canvas; the restraints imposed on even military men lest they might view it; are matters calculated only to provoke a smile.

A member of the profession of physic may be excused for viewing with a certain amount of disfavour all nostrums or hidden scientific secrets. There is a great deal too much of pretence, and, I will say, misappropriation of ideas, in all that relates to new projectiles, and their construction. It is not allowable for any one to publish, or allow his name to be published, as the possessor of an exclusive secret, which he is conscious of having procured elsewhere. On this point I have some remonstrance to make. A gentleman, to whose labours in the elaboration of explosive projectiles I have more than once borne honourable testimony, has either permitted the following statement, or suffered from the publication of that statement unknown to him. I perceive it set forth that a gentleman is in the exclusive possession of the knowledge of what he calls his "liquid fire charge." Why, I was the person who first told him how to make that liquid fire;—nay, I gave him some, and the fact of my doing so ought to be impressed on his memory.

"By no means put it into the recesses of your pocket," I said: "Carry it in your hand: for, if a little oozes out, you will burst into flame inevitably." He went away, promising to attend to the advice. Never-
Nevertheless, hating to be conspicuous, I imagine, he put the bottle into his pocket (a skirt pocket, fortunately), and pursued his way. Some of the liquid fire presently oozed out; and the result was as I have said. The gallant gentleman's skirt was set on fire; and he was presently seen, meteor- or rather comet-like, rushing through the streets. If this circumstance does not bring to his memory the real state of the case, he must be very unimpressible. But I shall believe, until otherwise assured, that the gentleman alluded to has no cognisance of the statement in question.
SUMMARY AND CONCLUSION.

It may now be desirable to present a summary of the chief propositions endeavoured to be established in the course of the foregoing pages.

1. That all the organic changes wrought out on projectiles, and the means of launching them, subsequently to the peace of 1815—in like manner all the corresponding changes proposed, or adopted, for marine war service, and that on shore—are mainly traceable to, firstly, the adoption of Paixhans' incendiary or shell system; and secondly, to the general diffusion of rifled small arms.

2. That mere range of a projectile is a quality to which inordinate advantages have been attributed by the public. That even in the case of rifled small arms, utilisation of the longest possible correct range is not now thought desirable. That the quality of mere long range in the case of artillery, is only of value in so far as it is correlated with (a) force of impact, (b) power of combustion or explosion. That impact sufficient to tell against timber might be of no avail against first-class land fortifications. That no rifle ordnance of 3½-inch bore, whatever the range of it may be, can hold a shell
having a sufficient powder-capacity for demolishing such fortresses as Cronstadt, Gibraltar, or Cherbourg. It is conceded that a shell of small capacity may, at long ranges, set fire to houses, stores, &c.: but it is suggested that the limits imposed by strength of material would seem to prevent breech-loading rifled ordnance from being made larger to any considerable degree than at present.

3. It is advanced that, though horizontal firing has to be used as between ship and ship, and employed by land fortresses as against ships, yet, by vertical firing strong fortresses will have to be reduced from seaboard in future. It is suggested that the ordnance now employed for vertical firing (mortars), would yield in value to large rifled ordnance elevated to the angle of highest trajectory, if only large rifled ordnance could be made strong enough to withstand the universal strain incidental to this mode of firing. It is argued that by this method alone the fullest advantages of long range could be made available from seaboard; that vertical firing (always correct enough for dealing with a large and fixed object) is totally thrown away upon a vessel at long range; and, especially a vessel in motion. Attention is drawn to the presumed advantages incidental to the polarity of rifled shells when fired vertically; advantages incidental to their principle; and, which are not participated by any other shells. It is
conceded that horizontal broadside-firing can never be expected to vanquish a first-class fortress, if the garrison be not surprised; and, if they be supplied with artillery equal to that of the attacking broadside in power.
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