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Title: Gunnery in 1858: Being a Treatise on Rifles, Cannon, and Sporting Arms

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Release date: September 23, 2013 [EBook #43799]

Language: English

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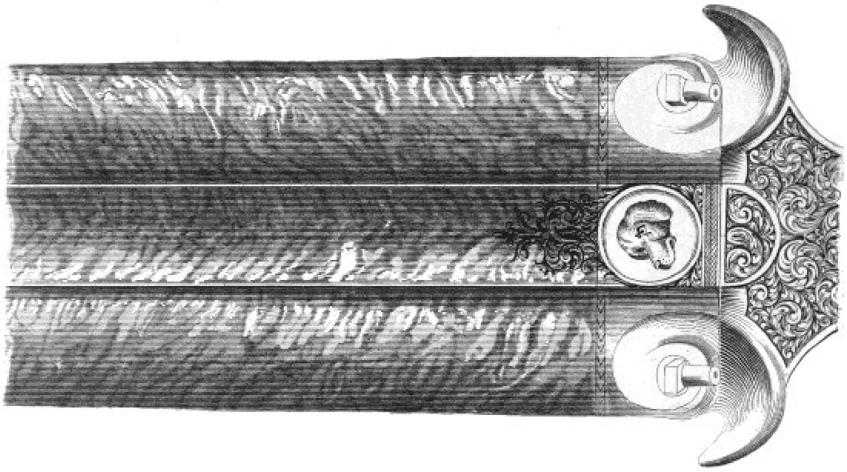
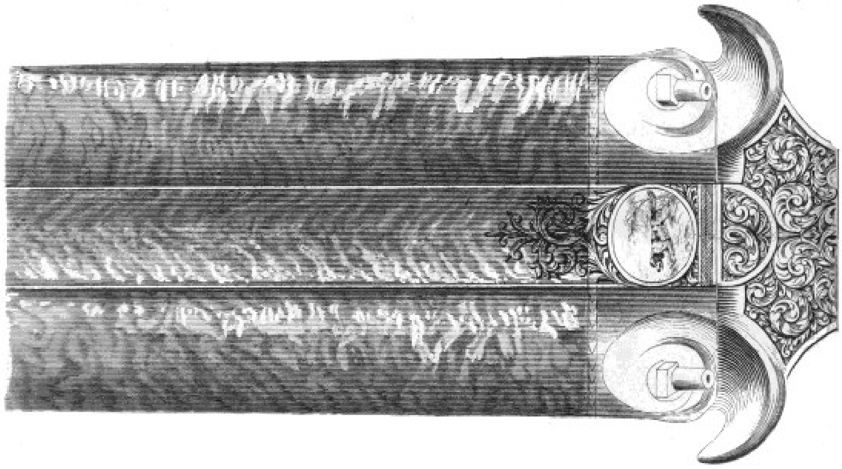
PLATE. 1.



ANGULARLY LAMINATED STEEL BARRELED GUN



LAMINATED STEEL BARRELED GUN

GUNNERY IN 1858:

BEING A TREATISE ON

RIFLES, CANNON, AND SPORTING ARMS;

EXPLAINING THE

PRINCIPLES OF THE SCIENCE OF GUNNERY,

AND DESCRIBING THE

NEWEST IMPROVEMENTS IN FIRE-ARMS.

BY WILLIAM GREENER, C.E.,
INVENTOR OF THE EXPANSIVE PRINCIPLE AS APPLIED IN THE MINIE AND ENFIELD RIFLES, AND AUTHOR OF "THE GUN," ETC. ETC.

WITH NUMEROUS ILLUSTRATIONS.

LONDON:
SMITH, ELDER AND CO., 56, CORNHILL.
1858.

PREFACE.

The urgent need for practical information on the important subject of Gunnery is evinced by the numerous patents taken out during the last few years, most of which have fallen still-born, through deficient practical science on the part of the inventors. My aim in producing this book has been to point out the errors into which many ingenious inventors have fallen, and to show how similar failures may be avoided in future, by indicating the only right road to improvement in Gunnery,—the strict observance of scientific principles in every old process and in all new inventions: for it is to the ignorance or neglect of the principles of the science that failures in Gunnery are due.

The necessity for progress in the science of Gunnery is now rendered more than ever imperative on our Government by the prodigious energy and activity of foreign Governments in providing armaments for land and sea service, the efficiency of which is ensured by adopting all the newest improvements in fire-arms. But the obstinate reluctance which all our previous Governments have shown to enter upon the, to them unwelcome, duty of investigating and experimenting on warlike inventions, necessitates strong “pressure from without;” for it may be truly said that all great improvements in Gunnery in England have been forced upon the authorities by absolute necessity, and it is still a question whether we shall profit by our recent experiences, or, as before, allow war to find us unprepared. We have, doubtless, armaments of gigantic proportions, and mammoth vessels of war, capable of discharging an ordinary ship’s cargo of shot and shell at a broadside; yet while millions have been thus expended, the *improvement of the Gun*, without which they would be mere masses of wood, and targets for more skilful opponents, has been neglected.

The GUN and its PROJECTILE will decide the victory in future fights. Indeed, we are even now waging war with our neighbours,—not on the battle-field or the ocean wave, but in the foundry; engineers being our generals, and founders our admirals. The present able ruler of France is actively at work, while we are but looking on: he is casting cannon the like of which have never been seen, while we are spending thousands in experimenting on cast-iron and foundries; and by the time our officials have discovered the best cast-iron for heavy guns, the French batteries on sea and land will be bristling with RIFLED STEEL CANNON of tremendous range and endless endurance.

Woe betide this country if at the commencement of a war we should find ourselves just where we are.

The Emperor Napoleon, as is well known, is well versed, theoretically and practically, in everything relating to Gunnery. Keenly alive to the minutest points of progress he receives, investigates, and immediately adopts all inventions of value; having the ability to perceive, the sagacity to appreciate, and the liberality to reward merit wherever it is shown.

Compare his system with ours, where men are placed in official positions, and entrusted with power, not because of their ability to fulfil the duties of their office, but for very inferior and often unworthy reasons; where talent and fitness are not considered, and consequently a long routine of forms is made to serve as “a buffer” to resist the troublesome pertinacity of inventors, who are apt to disturb the serenity of reluctant or indifferent officials. And when at last a trial is granted, the invention is either rejected or approved by incompetent or prejudiced judges. While this practice prevails, England must ever be behindhand in Gunnery; for improvements in cannon and projectiles cannot be carried out by private enterprise.

In thus strongly expressing my opinion of the way in which progress is balked, I am not merely echoing a cry, but speaking from my own knowledge and experience. I am actuated by no feeling of disappointment, for my invention of “the expansive bullet” has been at last adopted here, after it had been copied in France. My object is to induce public investigation and inquiry, and to ventilate this important subject; and I trust that my antecedents, and the fulfilment of my predictions in matters of Gunnery, will give weight to this deliberate and disinterested expression of opinion.

The great favour shown by lovers of shooting to my former efforts to disseminate a better understanding of the principles of Gunnery, has been an additional stimulus to the production of the present work; and I have taken especial care that my observations should tend to the improvement of sporting arms, and the increased safety of the sportsman.

Nor has the ingenious mechanic been overlooked, for perfection of gun-manufacture must ever go hand in hand with scientific principle; and the desire to promote their combination has prompted my endeavours to elucidate the subject.

Leaving to the reader to determine how far I have succeeded in my efforts, I merely wish to add that I make no pretension to literary style, but have aimed to produce a practical work for practical men. I have drawn upon my previous works for such portions of information as were needful to give completeness to this view of the science of Gunnery, its present state, and probable future.

WILLIAM GREENER.

Aston New Town,
September 3rd, 1858.

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SPORTING ARMS.

CHAPTER I.

ANCIENT ARMS.

From the earliest ages of the world, the jealousies and bickerings of mankind have been fruitful causes of war. Sometimes, perhaps, justified by political reasons; at others, it may be, arising solely from a desire, on the part of ambitious chiefs, to extend their territories by multiplying their conquests; while, in too many cases, the struggle for religious ascendancy has led to the most sanguinary and cruel battles.

War has been considered as a science from the most remote ages, and the ingenuity of the talented has successively been taxed to render it as perfect as possible. It is true—

> "Man's earliest arms were fingers, teeth, and nails,
> And stones and fragments from the branching woods;"

but these soon gave place to others, more calculated to decide unequal, and often protracted, conflicts.

Arms, in a general sense, include all kinds of weapons, both offensive and defensive; and amongst the earliest may be classed the bow and arrow, as it gave facilities to man to capture the wild animals for food, probably before their use was required for the purposes of war. The bow and the sling were the first means invented, and next only to the human arm for projecting bodies with an offensive aim: the great principle which, to the present day, reigns unrivalled, developing the ruling passion of man to injure, while remaining himself in comparative safety,—"self-preservation" being "the first law of nature."

To the bow and sling were soon added spears, swords, axes, and javelins, all of which appear to have been used by the Jews. David destroyed Goliath with a stone from the brook. The invention of the sling is attributed, by ancient writers, to the Phœnicians, or the inhabitants of the Balearic Islands. The great fame that these islanders obtained arose from their assiduity in its use; their children were not allowed to eat until they struck their food from the top of a pole with a stone from a sling. From the accounts left us (probably fabulous), it appears that the immense force with which a stone could be projected, can only be exceeded by modern gunnery. Even at that early age, leaden balls were in use as projectiles; though we cannot put much faith in Seneca's account of the velocity being so great as frequently to melt the lead. The use of the sling continued over a long period of time, even as late as the Huguenot war in 1572.

The bow is of equal, if not greater, antiquity. The first account we find of it is in Genesis, 21st chapter and 20th verse, where the Lawgiver, speaking of Ishmael, says, "And God was with the lad, and he grew and dwelt in the wilderness, and became an archer." The arms of the ancient Greeks and Persians were such as we have described, with the addition of chariots armed with scythes, in which the chiefs sometimes fought; though their main dependence was upon their heavy-armed infantry. Elephants were afterwards used as adjuncts in their military operations, but their use does not appear to have been very great or very permanent.

The Romans were armed much in the same manner as the Greeks, with a slight difference in the form of their weapons; and the arms of the early Saxons were similar; those of the Normans were only altered in their construction, except that to them appears to be awarded the invention of the *cross-bow*, an instrument which afterwards became of great repute in England and elsewhere. It has also been asserted, that the Normans were the first to introduce a species of field artillery, from which stones and darts were thrown, and arrows, headed with combustible matter, for firing towns and shipping.

The artillery-proper of the ancients, as the engines for projecting masses of stone and such like materials may be termed, reached to wonderful perfection; and the velocity with which missiles of every description could be thrown from them, attest the skill and ingenuity exercised in their construction: indeed it is quite evident they are only excelled by the *more portable*, and simply constructed, artillery of our own day.

The great artillerist of the Sicilians, Archimedes, seems to have made some of the most powerful engines; but he, considering any attention to mechanics as beneath the philosopher, has not left us an account of any one of them.

It is said of the cross-bow that a *quarrel* could be projected from them 200 yards, so that we may imagine the force with which one of these lumps of iron would strike even the strongest armour,—as the velocity, to range that distance, would not be far short of 900 or 1,000 feet per second; nearly equal to the effect of a ball from one of our old imperfectly constructed muskets.

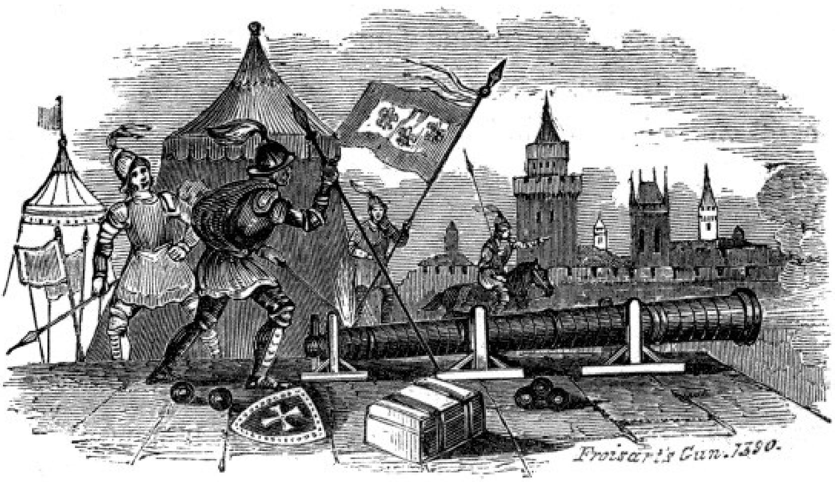
We are told incredible stories of the abilities of some of our bygone archers. Should it be true, as stated, that an arrow could be shot nearly 700 yards, we can easily conceive the immense velocity with which it must have left the bow; this range being quite equal, if not superior, to that of the late unimproved rifles. Though we must bear in mind, that the peculiar shape of the arrow fits it to cut the atmosphere with less resistance then the half sphere of a bullet; and hence one reason of its obtaining an extensive range. There is a story told of the famous Robin Hood, and Little John, "who could shoot an arrow a measured mile." We suppose the mile was the reverse of an Irish one, or they had the advantage of a precious stiff gale of wind. Historians sometimes "draw the long-bow" as well as archers. Many statements have descended to us of the power of the battering rams of old; but we have a much more ready method of blowing open gates by a single bag of gunpowder; and a 68 lb. shot has all the force that could be given even to that famous ram of Vespasian, "the length whereof was only fifty cubits, which came not up to the size of many of the Grecian rams, had a head as thick as ten men, and twenty-five horns, each of which was as thick as one man, and placed a cubit distance from the rest; the weight, as was customary, rested on the hinder part, and was no less than 1,500 talents; when it was removed, without being taken to pieces, 150 yoke of oxen, or 300 pairs of horses and mules, laboured in drawing it, and 1,500 men employed their utmost strength in forcing it against the walls."

With these remarks we shall proceed to introduce the invention of Gunnery.

Barbour, in his life of Bruce, informs us that guns were first employed by the English at the battle of Werewater, which was fought in 1327, about forty years after the death of Friar Bacon; and there is no doubt that four guns were used at the battle of Cressy, fought in 1346, when they were supposed to have been quite unknown to the French, and tended to obtain for British arms the victory. Froissart gives an excellent representation of a cannon and cannoneers, in 1390, a cut of which we give in the following page.

The use of guns in warfare is, therefore, comparatively of modern date, and the early specimens which are still extant, of which we have drawings and descriptions, must have been of very little service compared with those of the present day. The English musqueteer was formerly a most encumbered soldier. "He had, besides the unwieldy weapon itself, his coarse powder for loading in a flask, his fine powder for priming in a touch-box, his bullets in a leathern bag, with strings to draw to get at them, whilst in his hand were his musket-rest and his burning match; and when he had discharged his piece, he had to draw his sword in order to defend himself. Hence it became a question, and was so for a long time, whether the bow did not deserve a preference over the musket."[1]

[1] Grose's "Military Antiquities."



The mention of the *long-bow* is frequent in English history, and its use contributed, in no mean degree, to many important victories. Perhaps it might be that our forefathers were more skilful in the use of their weapons than their adversaries.

In our wars in France, in the reign of Edward III., thousands suffered by the English archery; and the brilliant success which attended them was, at that time, attributed to their "superior skill, combined with the valour of the Black Prince." So highly was this practice esteemed, that many statutes were enacted in successive reigns to encourage or enforce it.

Archery furnished matter for oratorical display, both in the senate and the pulpit; the palace and the cottage alike bore testimony to the great importance which was attached to the art; and it was at once the study and pastime of the whole nation. Thus, long after the introduction of fire-arms, the long-bow was held in great esteem; and it is no wonder that this favourite instrument should have been reluctantly relinquished, after obtaining such universal popularity, and becoming so intimately connected with many national and important events. It is now superseded by the gun, a more potent and destructive engine. The bow, so much valued, has vanished from our ranks by slow gradations, to make way for the musket; and the quivers of cloth-yard shafts have been supplanted by bristling bayonets. These things are now practically unknown as military weapons, though they contended for superiority with fire-arms during two centuries.

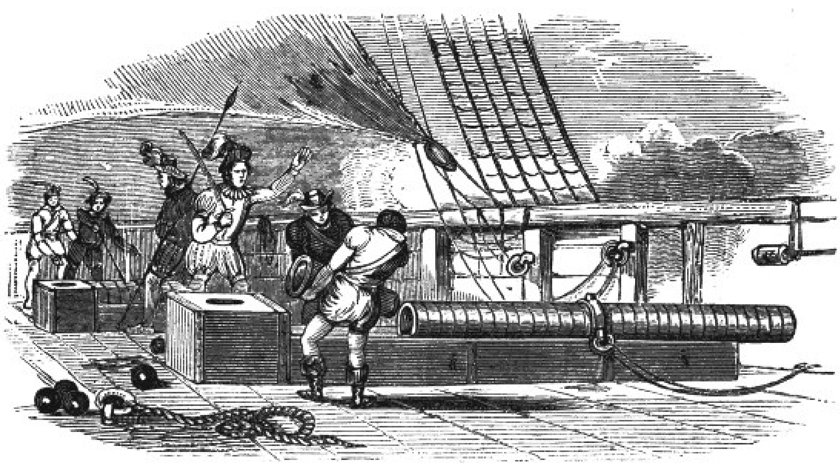
At this period, and for a long time previously, more attention was paid to the fabrication of defensive armour, than to the invention of weapons of an offensive character; hence the perfection that was attained in the manufacture of mail, of every variety, during the fourteenth and fifteenth centuries. The splendid manner in which some of the chivalrous knights of that age chose to have their armour constructed and ornamented sometimes proved fatal to themselves. Froissart relates that Raymond, nephew to Pope Clement, was taken prisoner, and put to death by his captors, in order that they might become possessed of his magnificent armour. Those gorgeous and costly fabrications were likewise doomed to give place to the advancing knowledge and skill of succeeding generations; being now only known as matters of history, and regarded as valuable curiosities. So late, however, as the latter part of the sixteenth century, armour formed part of the military equipment; and the French cavalry, called *carabins*, are described as having the cuirass sloped off the right shoulder, that they might the more readily couch their cheeks to take aim, while their bridle arms were protected by an elbow gauntlet.

The invention of portable fire-arms is awarded to the Italians by Sir Samuel Meyrick, and, in a memoir in the Archæologia of the Society of Antiquarians, he has named the year 1430 as the precise period of their introduction.

We have already stated that cannon, or heavy ordnance, was in use in the English army in 1327, more than a century before that time. It is not improbable, however, that the Italians were the originators of small fire-arms, for they had for many years been celebrated as skilful in the art of making armour—Milanese armour being considered the most valuable, and it is natural that their attention should be directed to the construction of offensive weapons of a different description.

The invention of the portable fire-arm, in its primitive state, was one of extreme simplicity; the gun consisting merely of a tube fixed to a straight stock of wood, about three feet in length, furnished with trunnions, cascable, and touch-hole: the latter was, in the first instance, at the top, like a large cannon, but was afterwards altered to the side where a small pan was placed to hold the priming, and lessen the liability of its being blown away by the wind. This contrivance was the first step to the gun-lock.

Before the adoption of the match-lock by the English, cannon, as I have before shown, had been in use, though they were of a clumsy description.



To the indefatigable exertions of Mr. Dean, we are indebted for the recovery of several brass and iron guns, belonging to the “Mary Rose,”—a vessel of war, wrecked in the reign of Henry VIII. of England, and Francis I. of France, in 1545: “while standing along the coast, during a distant firing from the French fleet, under Admiral Annebout, she was overpowered by the weight of her ordnance, and sunk, together with her commander and crew of 600 men.” One of these iron guns is in an excellent state of preservation, considering it to have been immersed above 300 years. The cut on next page will convey, together with the following description, a faint idea of its unwieldy and inefficient construction. It is composed of a tube of iron, whose joint or overlap is as its length; upon this is a succession of iron hoops, composed of iron three inches square, being in fact immense rings; these appear to have been driven on while red hot, and thus, by their contraction, forming a much stronger gun, when combined with the interior tube, than the generality of accounts given of ancient guns would lead us to expect. It will be perceived, that to describe it as “composed of iron bars hooped together,” is not correct. We may also mention, that if parties describing guns of this primitive manufacture will observe accurately, they will find that this is the general method by which they have been fabricated. They all appear to have been loaded by removing a breech part, or chamber, inserting the charge, replacing the chamber, and securing it by wedging it behind; as will be seen on a close inspection. No means of raising or depressing the muzzle appear available; the barrel or gun being sunk in a large block of timber, and secured there by bolts, as a musket barrel is secured in its stock; while a large piece of iron, or wood, was inserted perpendicularly into the deck to prevent the recoil. The advantage of "chambers" was perfectly understood even at this early period; they were apparently slightly conical, with a spherical bottom. It is no mean evidence of ancient skill, and knowledge of gunnery and mechanics combined, to state, that only a few years ago, a gunmaker of some celebrity, constructed a number of rifles and pistols to load at the breech, on the very same principle adopted in this gun 312 years ago. Strange, evidence from "the vasty deep" to show "there is nothing new under the sun."

During the sixteenth century, fire-arms of every description then in use underwent a variety of alterations and improvements; each change bringing with it a change of name, which would neither be profitable or interesting to enumerate here; our object being to trace out the advances which have been made in the manufacture of fire-arms since their general adoption as weapons of war, or auxiliaries to the sports of the field.

When first introduced into England, the hand-gun, as it was termed, had already received a slight improvement, in having a covering for the pan which contained the priming, and a sight on the breech, to assist in giving greater certainty to the aim; it remained thus until the trigger of the cross-bow suggested a contrivance to convey, with equal certainty and greater rapidity, the burning match to the pan.

The difficulty of using an instrument thus objectionably constructed, was in some degree obviated by the Germans; who, together with the Italians, were no doubt at this early period the principal manufacturers; they effected this, to a certain degree, by giving the stocks a crooked form, so that the breech could, with more ease, be brought to the level of the eye; this was, however, only an alteration of form, without involving any principle or leading feature of mechanical invention. Succeeding the match-lock, in the progress of improvement, came the "pyrites wheel-lock," an invention then looked upon as exceedingly curious and ingenious; this also is ascribed to the Italians, and one of the first occasions of its being used, is said to have been when Pope Leo X. and the Emperor Charles V. confederated against France. Whether the Italians are fairly entitled to the merit of this invention is, however, a matter of doubt, as it is well known that wheel-locks were for a long period manufactured in Germany.

The "*snaphaunce*" or fire-lock, is distinctly stated by Grose to be of Dutch origin,—hence the name. It was introduced into England in the reign of Charles II., though its general adoption is stated not to have taken place until the reign of William III., about 1692. Since that period, until the present, their use has been general in all the armies of Europe. How strange it seems that the Chinese and other Asiatics should have only the match-lock to the present day, while there can be no question that they used gunpowder some centuries before its introduction into our portion of the habitable globe!

The Syrians were formerly celebrated for their skill in the working of iron. Damascus gun-barrels were not to be obtained, at certain periods, at a price less than their weight in silver. The elaborate mixtures in their barrels, swords, and other weapons, entitle them justly to the honour of being the best of iron workers, as we shall hereafter have occasion to show; and the splendour displayed in their inlaying attests their taste and ability: but as mechanicians, formers of complex machinery, they never reached mediocrity. Turkey and Greece, as well as other countries which were renowned as having been, in days of yore, nurseries of the arts, but which have, in later times, degenerated into a condition little better than semi-barbarous, were remarkable for the great labour and pains which they bestowed upon the exterior ornaments of their firearms; but they never succeeded in improving the machinery of the lock in the slightest degree.

Although it was not until the latter part of the seventeenth, or the beginning of the eighteenth century, that gun manufactories were established in this kingdom, yet we have attained to a degree of perfection and excellence unequalled by any other nation in the world. Birmingham is the emporium of the world for guns, from the most inferior—the "*park paling*," so called, of the slave-trade, with which ships might yet be freighted at the cost of eight shillings and sixpence each—up to the elaborately-finished gun of the peer. Most of the alterations which have been made in gun-locks in England, have been with a view to simplify the machinery, and obtain the greatest quickness in firing: much complication has been discarded; a thorough conviction having seated itself in the minds of Englishmen, that to attain perfection, simplicity must be combined.

Many splendid emanations of genius are left to us, consisting of complex mechanism for gunnery. The most perfect we have ever seen, is a pistol made in Spain about the end of the seventeenth century. By moving a lever towards the butt-end, while the muzzle is depressed, the lock is primed, half-cocked, and the hammer shut down; return the lever, the powder is in the breech, and the ball before it. We have seen it fire twenty-six shots without a failure, and with one supply of ammunition. The magazine was in two tubes in the stock. The chance of blowing up was thought remote; but it eventually blew up. In short, it would be strictly advantageous to inventors in gunnery, to be sure that there has been no previous invention combining their principle as well as their arrangements.

The mine of complex inventions was exhausted during the last century; and the greatest benefactor to the science of gunnery will be he, who, blowing away the cobwebs of mystery, renders its principles as clear as the silvered glass. Nothing now remains of the beautiful machinery of the flint lock; the fancy cock and hammers have given place to a "simple" hammer, striking on a copper thimble, covering a steel pivot. What would the old lock-filers say to this, if they could return and see their handiwork consigned to the scrap-box as old iron?

To those curious in the progress of invention as it relates to gunnery, it would be highly interesting to visit the “Musée d’Artillerie” of Paris, and there to study the classified selections in the possession of the French Government. Among other specimens equally interesting, he will find revolving pistols, revolving rifles, and swords and revolving pistols combined in one; and these produced in the early part of the seventeenth century. The revolving pistol did not therefore originate with the present generation; and however universally we may use the “Colt,” “Adams,” or “Tranter,” neither can lay the slightest claim to originality. In that museum will be found four, five, and six charge chambers; and though in all there is certainly an absence of movement in the chamber, produced by the cocking of the lock, yet several present the appearance of having formerly had some mechanical adjunct for revolving the chamber: this, though well adapted to the present percussion system, must certainly have been troublesome to manage in the old flint lock; for when the first barrel was discharged, the priming of the other barrels would be lost during the revolution of the chamber.

A great improvement was, however, soon introduced; a hammer and pan were attached to each division of the chamber, and each being already primed, presented itself in rotation in the face of the flint. The gun or pistol was by these protuberances rendered clumsy and cumbersome, and thus fell, no doubt, into disuse; but every real mechanic must see on investigating the subject, that the principle was as perfect as that which is now in use. Mr. Colt had considerable difficulty in securing a patent for his revolver. The right of patent hinged on this simple question: did he, or did he not, first introduce a crank or lever for revolving the chambers during the cocking of the lock? After an expensive trial it was decided that he *did* introduce it; though doubts are still entertained whether there is not now extant a pistol having the same crank movement as that found in the “Colt” and other revolvers. At all events the invention of revolving pistols originated with our progenitors, more than 200 years ago, though their re-introduction is unquestionably due to Mr. Colt; and the “old broth warmed up” has no doubt proved more nutritious than the original concoction. In the Paris museum, a number of breech-loading guns are to be seen; I think more than sixty varieties. Many of them are highly ingenious, displaying great mechanical knowledge and working skill, and the whole, kept in splendid order, cannot fail to command attention.

Well had it been if the many hundred inventors in England and elsewhere had studied, and made themselves intimately acquainted with the productions there to be seen in such abundance. Monuments they are of mis-spent skill and labour; samples of the almost hopeless task of fabricating complicated machinery which shall resist the action of explosive gases at high pressure. An experiment extending over two hundred years, but unattended with success, notwithstanding all the skill and ingenuity brought to bear upon it, is, we think, sufficient to prove that breech-loading guns cannot be made sufficiently durable to yield any reasonable return for the extra expense and trouble attending their fabrication. Nevertheless, our “would-be mechanics hope against hope;” and to such we would, in conclusion, tender a word of advice. Before spending your money, make acquaintance (and an intimate one is necessary) with all that has been done before, and if in your own production you find principles which have been untouched by any previous invention, and untainted by any of the previous causes of failure, then patent your invention, and make a fortune—if you can.

Great mechanical skill, and even scientific principles, are to be found in some of the earliest productions after the invention of fire-arms; and thus is established the important fact, that want of experience was the chief drawback under which they laboured: one elaborate machine being unequal to their requirements was succeeded by another; and yet, with all these examples patent to us, we still fruitlessly fall back on exhausted principles.

A more intimate knowledge of what our predecessors have accomplished would be a great boon to our race. Foreign nations, but especially France, have provided for this by their museums; and we want here a museum of progression, an epitome of the mind of the present age, and which, continued to future generations, would leave to no man the fruitless toil of hauling in an endless rope.

CHAPTER II.

ON GUNPOWDER.

Gunpowder being the base on which the superstructure of this treatise is to be raised, the history, the use, and the nature of this explosive compound, are here placed in the foreground; as it is essential to the correct conception of the various matters hereafter to be explained, that the reader be first acquainted with the one grand principle in fire-arms, the propellant power of explosion.

Gunpowder, whether considered relatively to engines of war, or to those arms used with so much success in the sporting field, has, since its first *introduction*, been a source of much and frequent discussion. In regard to its origin, we shall not much enlarge, nor repeat the many suppositions and conjectures promulgated by the searchers after antiquarian evidence.

The inhabitants of India were unquestionably acquainted with its composition at an early date. Alexander is supposed to have avoided attacking the Oxydracea, a people dwelling between the Hyphasis and Ganges, from a report of their being possessed of supernatural means of defence: “For,” it is said, “they come not out to fight those who attack them, but those holy men, beloved by the gods, overthrow their enemies with tempests and thunderbolts shot from their walls;” and, when the Egyptian Hercules and Bacchus overran India, they attacked these people, “but were repulsed with storms of thunderbolts and lightning hurled from above.” This is, no doubt, evidence of the use of gunpowder; but as it is unprofitable to investigate this subject further, we shall merely confine ourselves to the European authorities.

Many ascribe the discovery of gunpowder to Roger Bacon, the monk, who was born at Ilchester, in Somersetshire, in the year 1214, and is said to have died in 1285. No doubt he was by far the most illustrious, the best informed, and the most philosophical of all the alchemists. In the 6th chapter of his Epistles of the Secrets of Arts, the following passage occurs—“For sounds like thunder, and flashes like lightning, may be made in the air, and they may be rendered even more horrible than those of nature herself. A small quantity of matter, properly manufactured, and not larger than the human thumb, may be made to produce a horrible noise; and this may be done many ways, by which a *city* or an *army* may be destroyed, as was the case when Gideon and his men broke their *pitchers* and exhibited their lamps, fire issuing out of them with great force and noise, destroying an infinite number of the army of the *Midianites*.” And in the 11th chapter of the same epistle occurs the following passage:—“Mix together saltpetre with *luru mone cap ubre*, and sulphur, and you will make thunder and lightning, if you know the method of mixing them.” Here all the ingredients of gunpowder are mentioned, except charcoal; which is, doubtless, concealed under the barbarous terms used; indeed, the *anagram* is easily converted into *carbonum pulvere*, with a little attention.

This discovery has also been attributed to Schwartz, a German monk, and the date of 1320 annexed to it; a date posterior to that which may be justly claimed for Friar Bacon; and as accident is stated to have been the means by which he discovered it, we have taken that incident as the subject of an illustration.

Mr. Hallam, referring to the authority of an Arabic author, infers that there is no question that the knowledge of gunpowder was introduced into Europe through the means of the Saracens, before the middle of the 13th century; and no doubt its use then was more for fireworks, than as an artillerist projectile force. There is good evidence, too, that the use of gunpowder was introduced into Spain by the Moors, at least as early as the year 1343. Now, as Roger Bacon is known to have been an Arabic scholar, it is not at all unlikely that he might have become acquainted with the mode of making the composition, and also with its most remarkable properties, by perusing some Arabian writer with whom we are at present unacquainted.

This invention, by which the personal barbarity of war has certainly been diminished, is, when considered as a means of human destruction, by far the most powerful that skill has ever devised, or accident presented; acquiring, as experience shows us, a more sanguinary dominion in every succeeding age, and subserving all the progressive resources of science and civilization for the extermination of mankind: which, says Mr. Hallam, "appals us at the future prospects of the species, and makes us feel, perhaps, more than in any other instance, a difficulty in reconciling the mysterious dispensation with the benevolent order of Providence."

The composition of gunpowder, as regards the proportions of the ingredients, has not undergone any material alteration; the chemical proportions of the ancients being nearly those of the present day.

Gunpowder is an explosive propellant compound, consisting of saltpetre or nitre, charcoal, and sulphur. The terms, *explosive* and *propellant*, are not here used as synonymous—they are not convertible; for a chemical mixture may possess the *explosive* power in a much higher degree than the *propellant*: fulminating gold, silver, and mercury, are dreadfully explosive; but they have not the same projectile force, nor can they be used as a substitute for it. Several experiments have been made with compounds of this nature, but the result is the reverse of what might be expected. Nothing can resist the exceeding intensity of the action of fulminating powder; a shot, when fired in this way, is not projected as by gunpowder, but is split into fragments by the velocity of its explosion, as we shall hereafter have occasion to show.

Nitre, or saltpetre, is strictly the essence of gunpowder. It is a triple compound of oxygen, nitrogen, and potassium. The chemical action of those elements on each other, and the play of affinities between them at a high temperature, occasion the immense effect produced by gunpowder on the application of fire or heat. By universal consent, sulphur is included in the mixture, but it is not absolutely necessary for the "propellant power;" for nitre and charcoal only will generate effects similar to the compound with sulphur. Gunpowder made without sulphur has, however, several bad qualities; it is not, on the whole, so powerful, nor so regular in its action; it is also porous and friable, possessing neither firmness nor solidity. It cannot bear the friction of carriage, and in transport crumbles into dust. The use of sulphur, therefore, appears to be not only to complete the mechanical combination of the other ingredients, but being a perfectly combustible substance, it increases the general effect, augments the propellant power, and is thought to render the powder less susceptible of injury from atmospheric influence.

"There is one good reason," says the Edinburgh Encyclopædia, "for the use of sulphur, although it does not contribute to the production of any elastic fluid. The carbonic acid which is generated would doubtless combine with the potash, if it were not for the presence of the sulphur, and thus so much elastic fluid would be lost. That this is the case we know to be true, from the fact that carbonate of potash is always formed when nitre is decomposed by charcoal alone, which I shall almost immediately show." This certainly would be the case, to a certain extent, with gunpowder without sulphur—some carbonate of potash would be formed.

The sulphur, we have no doubt, from experiments we have made on this subject, is, in part, engaged during the explosion of gunpowder in expelling the sixth proportion of oxygen from the potash, so as to combine with the potassium, to form a true sulphuret of that metal. This fact is easily ascertained, from the circumstance that no sulphuretted hydrogen can be detected, by the most delicate tests, coming from the residuum left after firing gunpowder, until moisture has gained access to it. The bad smell which arises sometime after the burning of gunpowder, is occasioned by the decomposition of the moisture which the sulphuret of potassium attracts from the atmosphere; giving rise, by this decomposition and liberation, to the fœtid foul gas, called sulphuretted hydrogen, and the production of potassa, or the oxide of potassium.

A commission of French chemists and artillerists was appointed by the Government, in the year 1794, to experiment upon the best proportions and constituents of gunpowder for the use of the French service. The following were the proportions of five different kinds prepared at the Essonne works:—

No.	Nitre.	Charcoal.	Sulphur.	——	
1	76·00	14·00	10·00	Powder of	Bâe.
2	76·00	12·00	12·00	„	Grenelle.
3	76·00	15·00	9·00	„	M. Morveau.
4	77·32	13·44	9·24	„	Ditto.
5	77·50	15·00	7·50	„	M. Keffault.

The first and third, after 200 discharges with the proof mortar, were declared the strongest, and the third proportions were adopted at the recommendation of the commissioners. Some few years elapsed, and the first, owing to its better keeping quality, was substituted, as it contained less charcoal, and a little more sulphur. The French Government having always been extremely impressed with the value of durability in gunpowder, they have since returned to their ancient proportions: 75 nitre, 12½ charcoal, 12½ sulphur. The charcoal, the absorbent of moisture, being further reduced, and the sulphur, the preserving ingredient, being increased in the same ratio.

"Mr. Napier tried a small quantity made of nitre and charcoal only, and was much surprised to find it project a shot as far as the best powder made in the usual manner. It is found that, in small charges, sulphur is advantageous; but, in charges of several ounces, the projecting force is as great without as with it. Therefore, under certain circumstances, sulphur may be dispensed with; but to make a good gunpowder, nitre and charcoal are indispensable."

Amongst the brilliant discoveries of modern chemistry may be classed the development of the fact, that a chemical combination, to constitute the same compound, always takes place in definite and unalterable ratios. To select one example out of a multitude: one atom of carbon combining with two atoms of oxygen produces the gas; because more would answer no useful end. So, with reference to the sulphur, if it enter into combination only with the potassium—the base of the nitre—the sulphur should be in that proportion to form the sulphuret of that metal; and in this case there would be no superfluity, for that would only add to the weight of the charge of powder, and diminish its absolute and effective energy. The view of the case which we have taken supposes only two combinations, viz. carbon with oxygen, and sulphur with potassium. Should there be a more diversified play of affinities, and the several elements of the powder enter into more complicated action, accurate analysis would conduct us through all difficulties, and point out what the proportions of the ingredients ought to be in order to sustain that action, and to produce a perfect ultimate result.

We thus perceive how analysis bears upon the case. We can see by such reasoning on the subject, that, theoretically, there can be but *one set of proportions calculated to produce the best and strongest gunpowder*, and that those proportions must depend upon the established and unerring laws of nature. The proportions, then, for gunpowder, by these considerations, will be those in which the carbon will just consume the oxygen of the nitre, and combine with the sulphur as much as will exactly saturate the potassium. This will be effected by an atom each of nitre and sulphur, and three atoms of carbon; or nitre 75·5, charcoal 18·8, and of sulphur 11·8.

In the present improved state of chemical science, when the nature of the bodies comprising gunpowder is so well known, as well as the compounds resulting from their action on each other, the proportions we have named may be taken as the best for practice.

The charcoal should, in particular, not be less than the nitre, as the smallest portion less than the whole atom would be the same as to leave out the whole atom, in which case there would be no carbonic oxide formed. If, for example, instead of the proportions of nitre 75·5, charcoal 16·2, sulphur 15, the carbon were 16, then there would be 4·2 of carbon left in the residuum, and no carbonic oxide would be formed, since bodies cannot unite but in definite proportions.

From these considerations we can perceive the reason why a small proportion of carbonic oxide is always formed during the decomposition of nitre by charcoal; for it will be evident, that as the nitric acid contains five atoms of oxygen, four of these must combine with two atoms of carbon to form two atoms of carbonic acid, while the *odd atom of oxygen* is compelled to take another atom to form carbonic oxide. But this is not the case in the combustion of gunpowder, as carbonic acid and nitrogen are the principal gases generated.

These proportions differ from any other formula yet prescribed; and, though different in a great degree from the proportions laid down by various writers on the subject, the reasons which are here given, as has been seen, are such as carry with them a conviction of their truth: for there cannot possibly be any benefit arising from a greater quantity of any of these materials than is absolutely necessary to form the composition in question; and if the smallest quantity be above what is requisite to consume the whole, that, however small it may be, is highly detrimental to the effective energy of the mass. What we may here call clean gunpowder, such as may be used with confidence for repeated discharges of fire-arms of any description, is of the greatest importance; therefore, it does not appear to us, that any given proportions are so likely to accomplish that object as those before specified.

TABLE OF COMPOSITION OF DIFFERENT GUNPOWDERS.

Mills.	Nitre.	Charcoal.	Sulphur.
Royal Waltham Abbey	75·00	15·00	10·00
France, National Mills	75·00	12·50	12·50
French Sporting	78·00	12·00	10·00
French Mining	65·00	15·00	20·00
U. S. of America	75·00	12·50	12·50
Prussia	75·00	13·50	11·50
Russia	73·78	13·59	12·63
Austria (Musket)	72·00	17·00	16·00
Spain	76·47	10·78	12·75
Sweden	76·00	15·00	9·00
Switzerland (Round Powder)	76·00	14·00	10·00
Chinese	75·00	14·40	9·90
Theoretical proportions as above	75·00	13·23	11·77

Gunpowder consists of a very intricate mixture of sulphur, carbon (charcoal), and nitrate of potash (nitre).

The proportions in which they exist are one equivalent of nitre, one of sulphur, and three of carbon. The great explosive power of gunpowder is due to the sudden development from its solid constituents of a large quantity of gases; these gases are nitrogen and carbonic acid.

At the ordinary temperature of the atmosphere these gases would occupy a space three hundred times greater than the bulk of the gunpowder used; but owing to the intense heat developed at the moment of explosion, the gases occupy at least 1,500 times the bulk of the original gunpowder. The mixture, consisting of one equivalent of nitre, one of sulphur, and three of carbon, would yield three equivalents of carbonic acid, one of nitrogen, and one of sulphuret of potassium. The change may be represented thus,—

$$S + C_3 + KONO_5 = 3\ CO_2 + N + KS.$$

The only solid residue, therefore, is the sulphuret of potassium, and this is the compound which produces the sulphurous odour on washing out a gun barrel; water is decomposed, sulphuretted hydrogen and potash being the result of the decomposition.

Now supposing the elements of gunpowder to exist in these proportions, it is essential, in order to secure their perfect combination, and thus to produce the largest possible volume of gas, that the elements should be in the most minute state of subdivision. Chemical action is a force exerted at insensible distances only, and chemical substances having the greatest affinity for each other will not combine, unless their elements are brought into immediate contact: thus oxygen and hydrogen may be mixed together in the exact proportions to form water; but no chemical combination will occur, simply because the ultimate particles of the two gases are not sufficiently near to each other for their chemical affinities to be brought into play; if, however, these gases are subjected to very strong pressure, so as to bring their particles into immediate contact, combination occurs, and the production of water is the result.

In order to insure the perfect combination of the elements of gunpowder the same conditions are necessary; that is to say, the ultimate particles of the nitre, charcoal, and sulphur, must be brought into the most direct contact, or the explosive power of the gunpowder will be comparatively trifling. If, for instance, the nitre, charcoal, and sulphur be pounded in a mortar, no explosion but a slow combustion will occur when the mixture is ignited; so that unless this intimate mixture of the elements is carefully attended to in the manufacture of gunpowder, it is easy to see that the article produced will be of comparatively little value.

It is evident then that if tons of the elements of gunpowder were stored in a warehouse which accidentally caught fire, no explosion would occur from the formation of gunpowder; though its ingredients would greatly increase the rapidity of combustion.

This remark is elicited by the recollection of a fearful explosion which took place at Gateshead in 1854.

It may be remembered that a warehouse caught fire from an adjoining mill, and the explosion was supposed to have been produced by the ignition of the elements of gunpowder stored in the warehouse in a crude state. The upper story of the building contained a large quantity of crude sulphur, and the basement story about the same quantity of nitre, whilst chemicals of various kinds were stored in other parts of the building; but according to the accounts published there was no large quantity of carbon in the warehouse; nevertheless, a terrific explosion took place, and after a lengthened investigation, the conclusion arrived at was this: the sulphur melting, mixed with the nitre, gunpowder was thus formed, and igniting, exploded, producing the terrible effects.

But gunpowder may be made without sulphur, whereas gunpowder without carbon is an impossibility; and though the elements of gunpowder had all been present, no explosion could have occurred, unless they had become mixed in the intimate manner already described.

It is true some of the chemical substances in the warehouse might have produced a fearful explosion: but a more plausible explanation is to be found in the fact, that gunpowder was at that time much more valuable abroad than at home; and it is quite possible that some kegs of gunpowder might have been stored away in this warehouse, until a convenient opportunity presented itself for their removal.

The foregoing remarks will serve to explain how it is that powder varies so much in strength and quickness of fire. If the elements are imperfectly incorporated, the powder can never be equal to that which is properly made; and the manufacturer, having ascertained the best proportions in which to mix the elements, had better improve his machinery for incorporating them, rather than his knowledge of the chemistry of gunpowder. These observations will also serve to explain the apparent anomaly, that the French, and some of our other continental brethren, are held to produce a much inferior sporting gunpowder to that which is manufactured in old England.

Gunpowder is now made by all the sporting gunpowder manufacturers from No. 1 to No. 5 grain; and it appears certain that a further increase in the size of the grain would be advantageous; for many years of patient and laborious experiment clearly show, that the old notion of gunpowder being blown out of an ordinary sized gun in an unburnt state, is one of the “purest of vulgar errors:” such a thing indeed cannot possibly happen unless the powder be bad, or the gun *imperfectly made*, or injudiciously charged.

I am satisfied that I am under rather than over estimate, when I assert that six drams of ordinary sporting gunpowder may be beneficially and completely exploded in a barrel of 14 bore, 2 feet 6 inches long, with a resisting projectile one ounce in weight above it. This, however, being more than a double charge for such a gun, cannot be pleasantly practised; and it is only asserted by way of argument.

Assuming, then, for argument's sake, that six drams of gunpowder are exactly consumed in passing from the breech to the muzzle of a gun 2 feet 6 inches long, and that the shot, therefore, acquires its greatest velocity as it leaves the muzzle, it follows that the ordinary charge of 2½ drams will be wholly consumed before it has traversed half the length of the barrel, and consequently the charge of shot must here acquire its greatest velocity. It is certain, then, that the shot must travel the latter half of the barrel at a diminished velocity, and its velocity must continue to diminish as it passes up the barrel; for two obvious reasons—1st, The column of air in front of the charge is more condensed, and thus offers a greater resistance to the exit of the charge; 2nd, The velocity is continually diminished by the increased friction of the charge against the barrel.

The perfection of projectile science is to make the projectile acquire its greatest velocity at the instant of leaving the muzzle; and if, by increasing the size of the grain of gunpowder, we can diminish the rapidity of its explosion—thus causing it to burn and generate fresh gas up to the muzzle of the gun—the projectile will then acquire its greatest velocity, and leave the gun to the best advantage: this is the important point which has hitherto been overlooked, not only in fowling-pieces, but in the expansive principle of rifles.

For artillery practice of every kind, whatever the weight of the projectile, gunpowder of a granulation suited to the weight of that projectile is essential, if we would produce the greatest possible effect by the least expenditure of means.

In artillery, at this most important time in war's history, no attention whatever is paid to this essential principle. A long 10-inch gun, a 68-pounder, and a short 6-pounder are all charged with powder of the same granulation; whilst by a more judicious use of gunpowder of suitable granulation, the range might be extended, just as it is in sporting arms, to nearly 20 per cent.

Artillerists seek to effect great range by doubling the weight of the gun, and projectile monsters meet us at all points, to become in every case "monster failures."

I fear that the most important points have been entirely lost sight of. Instead of ascertaining whether we have suited the projectile power to the 8-inch or 56-pounder, so as to get work from it which is now done by the 10-inch, we have, in our anxiety to get range, looked only to the form or material of the gun; vital principles being totally excluded. The construction of the gun being perfect, the question is, can the expellant force be brought to an equal state of perfection?

In order to obtain the best results from a gun, the gun itself must be perfect in construction, and the expellant force must be brought to bear in the best possible manner upon the projectile; and this is to be done by attending to the granulation of the powder, which must be suited to the length of the gun, to its bore, and to the weight of the projectile.

Common-sense, engineering skill, will demonstrate, that according to the weight of matter to be projected must be the nature of the expellant; *accumulative*—until it has overcome the inertia of that matter, *accelerative*—until it has communicated to it the highest state of velocity its power is capable of effecting. If, on the other hand, it is inferior to this, science has not extracted from it the full *horse-power* it contains; and we are uselessly expending force and destroying our engines by undue pressure being exerted on one part, and inferior pressure on another; whilst by a proper distribution of that force, durability of the cannon is insured, and from twenty-five to thirty per cent. more work may be obtained from an equal quantity of powder, provided its granulation be judiciously selected according to the area of the gun.

There is abundant proof that on this engineering question we have hitherto worked by the "rule of thumb;" prejudice having been a stumbling-block, which nothing but stern necessity will remove. The authorities have but just discovered this, although their attention was directed to it several years ago. In the year 1852, I produced before the Small Arms Committee, at Enfield, a portion of gunpowder suited to the expansive rifle; it was tried to a limited extent, and dismissed with the remark, "We don't think there is much in it." Experience, however, has demonstrated the truth of my observations, for, in all extreme range shooting with the expansive or "Greenerian"-principled rifles, not only is considerably greater *accuracy* obtained with it, but an *increase* of range equivalent to fifteen or twenty per cent.

Another advantage of using gunpowder of a suitable granulation is the absence of sharp recoil; and thus greater accuracy of range is obtained—accuracy of range and steadiness of weapon being inseparable.

Large-grain gunpowder is not only a more effectual expellant than the fine grain, but is much more safe to use, for by using it the risk of bursting the barrel is much lessened; as a very simple illustration will show. If we estimate the force generated by the usual charge of 2½ drachms (I confine the question to the 14-bore gun, for uniformity) to be 5,000 lbs., whether the powder be fine or coarse grain, it follows that the fine powder, igniting so rapidly, will exert all its force on the breech end of the gun; whereas the coarse powder, igniting less rapidly, distributes this force over the whole length of the barrel: hence the greater risk of a gun bursting with fine powder than with coarse. If we suppose the fine powder to be entirely ignited when it reaches half way up the barrel, then the force of 5,000 lbs. is exerted on the lower half of the barrel; but if the coarser grain is not entirely ignited until it reaches the muzzle, then the force of 5,000 lbs. will be distributed over the whole length of the gun.

But this is not all. The fine powder, igniting almost instantaneously, exerts its force in all directions at once, and the barrel may burst at the side before the charge has time to move; whereas the coarse powder, igniting as it does more slowly, first lifts the charge, and then the volume of gas behind it increasing as the powder becomes more thoroughly ignited, sweeps the charge out of the barrel with a velocity increasing towards the muzzle.

If time is not given for the charge to receive the full advantage of the expansive force of the generated air, the force is exerted, not upon the charge, but upon the barrel of the gun itself; and that time is necessary for the full development of this force, is proved by the fact that miners mix their gunpowder with sawdust, in order to diminish the rapidity of its explosion and thus get the advantage of its force in the distance: from the miners, then, let us learn how to obtain the greatest benefit from this force, and waste it not.

There can be no doubt of the importance of this principle; little progress has, however, been effected from want of scientific illustration; let it be defined like that of steam power, and its adoption will follow as a natural consequence.

For several years I have had gunpowder manufactured of various sizes, at the sight of which most sportsmen would express their astonishment.

One objection held by sportsmen to the large grained gunpowder is that it does not come up the nipple of the gun; now although I do not consider this at all important, still if the specific gravity of the gunpowder were increased by compressing 1½, 2, or 3 grains of gunpowder into the space of 1 grain, by means of hydraulic pressure, this objection would at once be obviated; whilst at the same time, the powder would be less liable to absorb moisture, or to become friable with age: either of which conditions is incompatible with good shooting.

The granulating of gunpowder, to be of the greatest benefit, should be on a uniform principle; the manipulation should be alike in all particulars, but especially in that part of the process which determines the specific gravity. The hydraulic pressure on the cake should be alike in all cases: in fact, the various sizes of grain might be produced from the same cake, and the desired object be thus obtained. But so long as the practice is followed of producing large grain from less condensed cake, the article produced will give unsatisfactory results; and the advantages which might be attained, as my experience denotes, and which would be of the greatest service, alike in sporting, rifle, and artillery powder, will be nullified.

Great improvements are yet to be made, especially in the powder used for artillery; whilst range, accuracy, and lessened recoils are points which may be determined with almost mathematical precision.

Great fame is in prospect for any one who can grasp and handle well this granulation principle; especially if he can define the sizes to be used for different varieties of guns. Artillerists who contend that a medium size grain, to suit all sizes of gun, is advantageous, might as well contend that cannon of a medium size would be preferable to so many different sizes, because, though we lose in range, accuracy, and recoil, it would be more convenient to have but one sized gun.

In making large grained gunpowder, the manufacturers defeat one of the main objects to be gained by granulation, from not subjecting it to the same amount of pressure which is necessary for the granulation of the very fine grain. In granulating very fine powder, it is necessary to subject the cake to such an amount of hydraulic pressure as shall give the mass a marble-like structure, or during the process of granulation, the whole of it crumbles into dust; but the coarser gunpowder may be granulated without subjecting it to this high degree of pressure, hence each grain is more porous and of lesser specific gravity: a difference which it is most important to avoid. It is clear, therefore, that according to the present mode of manufacturing gunpowder, the large and the fine grain are of very different kinds; the main difference being in their specific gravities. Gunpowder of less density burns with greater rapidity, because it is more open and porous; and if uniform density was observed, the diversity in the size of the grain need not be so great; whilst, at the same time, this anomaly might be avoided—that the same measure of fine and large-grained gunpowder contains a difference of the expansive element amounting to fifteen or twenty per cent. As gunpowder is now manufactured, it is highly necessary in all comparative trials to *weigh*, and not to *measure* the charge, or the results will be deceptive and worthless. The granulation question struggles with undeserved difficulty. Gunmakers, either not understanding the question, or constructing the chambers of their guns improperly, and not using suitable nipples, decry the adoption of large-grained gunpowder; but they forget the increased range obtained in the killing from their guns, and the *éclât* a long shot produces. In trials of guns at thirty or forty yards, the difference in the shooting with fine and large-grained gunpowder is not so apparent, and the maker exclaims, “Oh! the fine powder shoots stronger, and as close as the coarse.” I admit this to be the case, at short distances; but the great advantage of using the large grain is sufficiently evident when shooting at forty-five, fifty, and sixty yards, for then the fine grain entirely fails: simply from the oft-repeated fact, that the fine powder is more of a propulsive, while the large grain is an expellant force; so that according to the law of resistance in aëriform fluids, the one is sooner reduced to medium velocity than the other, which exerts its action more evenly. Powder of larger grain is thus more suitable for the larger sizes of shot, and would give an increased range in usual shooting, for the shot is kept better together, and is projected to greater distances. A common way of testing the quality of gunpowder is, to rub it between the hands, and observe the darkness of the stain; the darker the stain the more inferior the gunpowder is held to be. This test is, however, decidedly fallacious, because the gunpowder may be of low specific gravity, or it may have become friable from age and other causes.

Whales are shot with gunpowder proportioned to the weight of the harpoon required to kill them. Duck guns of the largest calibre are comparatively useless unless the gunpowder used is granulated according to the weight of the projectile; and the same law holds in regard to the most “mammoth” engine yet to be devised by the mind of man.

Gun-cotton has been before the world for some years, but, except as a curiosity, it has attracted little public attention; neither has it gained any reputation as a projectile force. It may be prepared by steeping cotton wool for a few minutes in a mixture of nitric and sulphuric acids, thoroughly washing, and then drying at a very gentle heat. It consists chemically of the essential elements of gunpowder: viz. carbon, nitrogen, and oxygen; but, in addition, it contains another highly elastic gas, hydrogen. The carbon in the fibres of the wool presents to the action of flame a most extended surface in a small space, and the result is an explosion approaching as nearly as possible to the instantaneous: in consequence of its rapid ignition it produces a violent kick; sufficient time is not given to put heavy bodies in motion, hence it cannot be usefully employed as a projectile agent. No one who values his limbs should trifle with it, for fearful accidents have resulted from its exposure to the heat of the sun, and other very simple causes.

There is an instrument used by some sportsmen, and strongly recommended by many gunmakers, for testing the strength of different kinds of gunpowder. It consists of a chamber closed by a spring, and fired like an ordinary pistol. When the powder explodes the spring is forced forward, and moves an index round a graduated circle; the more quickly the powder explodes the farther does it lift the spring; hence this is a measure of quickness of fire, but not of expellant force; and from the observations which have been made on gunpowder, it must be evident to any one who has paid the least attention to the subject, that this instrument is utterly useless.

An instrument to test the comparative strength of different kinds of gunpowder is yet a desideratum in projectile science; and we cannot doubt that such an instrument will be produced, when the importance of the granulation of gunpowder is more generally known and appreciated.

The charcoal formerly used was made in the common way, by pits, which must have been seen by almost every one. The method is now to *distil* the wood in cast-iron cylinders, extracting the pyroligneous acid, &c., by heating them red hot, and allowing all other volatile matter to evaporate, the charcoal only being retained in the cylinder or retorts; hence arises the name *cylinder gunpowder*. The best charcoal for sporting powders is the black dog wood; Government use willow and alder. Any charcoal does for common powders. Charcoal is ground in the same way as the nitre. Sulphur is purified simply by fusing, and when in that state, skimming off the impurities: it is cooled and pulverised in the same way as the other two ingredients. The three ingredients, after being carefully weighed in their due proportions, are sifted into a large trough, and well mixed together by the hands. They are then conveyed to the powder mill. This is a large circular trough, having a smooth iron bed, in which two millstones, secured to a horizontal axis, revolve, traversing each other, and making nine or ten revolutions in a minute. The powder is mixed with a small quantity of water put on the bed of the mill, and there kept subject to the pressure of the stones; and if we calculate the weight of the two millstones at six tons, it follows that in four or five hours’ incorporation on this bed, it subjects the ingredients to the action of full 10,000 tons. It is this long-continued grinding, compounding, and blending together of the mixture, that alone renders it useful and good. After this intimate mixing, it is conveyed away in the shape of mill-cake, and firmly pressed between plates of copper. Bramah’s press has been introduced of late years—we should say with a good deal of improvement to the powder, as will be shown hereafter—and by its means the mass is more compressed and in thinner cakes. It is then broken into small pieces with wooden mallets, and taken to the corning-house, where it is granulated, “by putting it into sieves, the bottoms of which are made of bullocks’ hides, prepared like parchment, and perforated with holes about two-tenths of an inch in diameter; from twenty to thirty of these sieves are secured to a large frame, moving on an *eccentric* axis, or crank, of six inches throw; two pieces of lignum vitæ, six inches in diameter, and two inches or more in thickness, are placed on the broken *press-cakes* in each sieve. The machinery being then put in rapid motion, the discs of lignum vitæ (called balls) pressing upon the powder, and striking against the sides of the sieves, force it through the apertures, in grains of various sizes, on to the floor, from whence it is removed, and again sifted through finer sieves of wire, to separate the dust and classify the grain. One man works two sieves at a time, by turning a handle and eccentric crank; the sieves being fixed to a frame, which is suspended over a bin by four ropes from the ceiling.”

The grains afterwards undergo a process of *glazing*, by friction against each other, in barrels containing nearly 200 lbs., making forty revolutions in a minute, and lasting several hours, according to the fancy of the purchaser. This part of the business we entirely disagree with, as injurious to the quick and *certain ignition*. Gunpowder is finally dried by an artificial temperature of 140° Fahrenheit, which is suffered gradually to decline. The last process is sifting it clear of dust, and then packing it in canisters or otherwise.

The utility of the process of granulation results from the impossibility of firing mealed powder sufficiently simultaneously to effect an explosion; and also from the fact that gunpowder, in a mass, does not explode. Fire a solid piece of mill-cake, and it does not flash off like unto granulated powder, but burns gradually, though with an extreme fury, until the whole is consumed. This arises from its density, the compression in the press; it also teaches us one fact, that to be of the greatest service, the time each grain should occupy in burning should be proportioned to the size of the gun for which it is required; since it is clear that the explosion of a heap of gunpowder is but the rapid combustion of all its parts. This action, as is well known, is so rapid, even in a large quantity of powder, that it appears to be a sudden and simultaneous burst of flame; though philosophically and actually it is not so.

Fine grain, when unconfined, explodes quicker than large, or is sooner burnt out, and consequently generates more force in the same period of time; but when it comes to large quantities, its very quickness is detrimental to its force, by condensing the air around the exterior of the mass of fluid which thus constrains its bound. In small quantities, the proportion of condensation is not so apparent, and hence the reason why greater velocities can be obtained with small arms than with cannon.

There exists a diversity of opinion in regard to the strength or projectile force of gunpowder. Dr. Ure remarks—"If we inquire how the maximum gaseous volume is to be produced from the chemical reaction of the elements of nitre on charcoal and sulphur, we shall find it to be by the generation of carbonic oxide and sulphurous acid, with the disengagement of nitrogen. This will lead us to the following proportions of these constituents:

				Hydrogen 1.	Per Cent.
1	prime	equivalent of	nitre	102	75·00
1	„	„	sulphur	16	11·77
3	„	„	charcoal	18	13·23
				136	100·00

"The nitre contains five primes of oxygen, of which three combining with the three of charcoal, will furnish three of carbonic oxide gas, while the remaining two will convert the one prime of sulphur into sulphurous acid gas. The single prime of nitrogen is therefore, in this view, disengaged alone.

"The gaseous volume, in this supposition, evolved from 136 grains of gunpowder, equivalent in bulk to 75½ grains of water, or to three-tenths of a cubic inch, will be, at the atmospheric temperature, as follows:—

	Grains.	Cubic Inches.
Carbonic oxide	42	141·6
Sulphurous acid	32	47·2
Nitrogen	14	47·4
		236·2

being an expansion of one volume into 787·3. But as the temperature of the gases, at the instant of their combustive formation, must be incandescent, this volume may be safely estimated at three times the above amount, or considerably upwards of 2,000 times the bulk of the explosive solid.

"It is obvious that the more sulphur, the more sulphurous acid will be generated, and the less forcibly explosive will be the gunpowder. This was confirmed by the experiments at Essonne, where the gunpowder that contained twelve of sulphur, twelve of charcoal, in 100 parts, did not throw the proof shell so far as that which contained only nine of sulphur and fifteen of charcoal. The conservative property is, however, of so much importance for humid climates and our remote colonies, that it justifies a slight sacrifice of strength.

"When in a state of explosion, the volume," Dr. Hutton calculates, "is at least increased eight times, and hence its immense power. The pressure exerted, if in a state of confinement, will depend on the dimensions of the vessel containing it; so that it would be no difficult undertaking to obtain any pressure above that of the atmosphere, up, we may fearlessly say, to the enormous amount of 4,000 lbs. per square inch."

The same quantity of gunpowder subjected to a variety of experimental tests, differs materially in its results; at the same time it is only by such a method that we can arrive at the relative strength or power which it possesses. Dr. Hutton, whose authority in all mathematical calculations is very high, and whose opinions and judgment in matters of this nature ought not to be unthinkingly controverted, states 2,000 feet per second (with cannon) as the highest velocity which any projectile had attained, at the time of his writing, which had gunpowder for its propellant power. A much greater velocity is now given in all guns fired at high elevations. "Monks'" gun attained a velocity of 2,400 feet in the first second of its flight, and this is now exceeded by rifled cannon.

This advantage does not arise, in our opinion, so much from the superior quality of the gunpowder, as from the improvements which have taken place in the manner of applying it. For instance, where experiments are conducted, as was the case with Dr. Hutton, with moving *eprouvettes*, a certain loss is sustained, in the same degree as the instrument is made to recoil from its original position; therefore, by restraining the recoil, an increase of momentum is given to the projectile, to the same extent as had been exerted upon the *eprouvette*, or cannon, in driving it several feet backward; and instead of dividing the force thus acquired between the shot and the gun, by having the latter firmly fixed and the recoil destroyed, the whole power is exerted upon the former, and its velocity accelerated in the same proportion.

Gunpowder, though astonishing in its effect, and tremendous in power, may nevertheless be controlled within a limited sphere, and bounds put upon its destructive energy. The following curious experiment, first tried at Woolwich on a small scale, has since been carried out to a great extent. Screw into each end of the breech part of a gun-barrel a well-fitted plug; drill a communication, and put in a nipple; having filled the barrel with powder, screw in the breech, and fire a cap on it, and the explosive fluid will escape by the small orifice like steam from a pipe. If the barrel be good, it may safely be held in the hand, merely using a towel to protect the hand from the heat the barrel absorbs. We have done it repeatedly with no inconvenience, and even carried this experiment much further; firing two ounces of the best powder in a barrel of good quality (though not in the hand) yet the barrel did not receive any violent motion by which it could be inferred that it might not be done with safety.

We have before observed, that, with very short guns, fine gunpowder produces the greatest result, inasmuch as there is no greater column of air in the barrel than the explosive fluid is equal to *displace*; or, in other words, the charge leaving the muzzle of the gun at the very moment when the explosive force is strongest, all the power is thus obtained of which it is capable; but if used in a longer barrel, and the fluid has obtained its greatest power when the charge has twelve inches of the barrel still to travel, the column of compressed air yet remaining in the muzzle of the barrel, exerts a resisting influence, in proportion to its density, upon the charge, and creates a dangerous and unpleasant recoil.

If a cartridge be placed in the centre of an open barrel eight feet in length, having a bullet abutting at each end large enough to fill the barrel, and a touch-hole is drilled as near the centre of the cartridge as possible, when it is fired, the balls will certainly be discharged from the barrel, but with a very small degree of force: in fact, merely driven out. With the same instrument, vary the experiment: place in it a cartridge charged with one ball, three feet from the muzzle, leaving a column of air five feet in length to act against the explosive force of the gunpowder, and the ball will be driven one hundred yards with considerable force. Again, let a third cartridge be introduced similar to the last, two feet from the muzzle, increasing the column of air to six feet; and the result, in distance and velocity, will nearly double what has been obtained by the last experiment; tending to prove that air thus forced back upon itself obtains a density, and consequent resisting influence, nearly equal to a well-screwed breech. In order to test this principle further, I put into the same tube a double charge of gunpowder, merely backed by a wadding, two feet from the muzzle, and then rammed down four balls as tight as possible into the short portion; in discharging it, the tube was burst immediately in rear of the charge.

In another experiment, I took a common musket barrel, having a plug of iron firmly fixed into the muzzle; the breech being unscrewed, and a ball introduced one-tenth of an inch less in diameter than the bore of the barrel, together with one drachm of gunpowder, I then fired the gunpowder, and the explosive matter escaped by the touch-hole. On examination, it was found that the ball was flattened to the extent of one-third of its sphere. The charge for the next experiment was increased to two drachms; when the ball in the discharge struck the muzzle very slightly, altering its shape in the least conceivable degree. The charge was next increased to three drachms, and the ball was extracted without any perceptible defect. In the fourth trial, another drachm was added, with which the effect was greater than the tube was able to resist; it was in consequence burst, about three inches from the muzzle.

From this I infer that, in the first trial, the velocity of the ball was not so great, but that the air escaped past it, by what is technically called the windage, allowing it to strike the plug at the end of the barrel with sufficient force to alter the shape of the lead in the manner described. The second trial gave an increased velocity; the opposing forces being so nearly balanced that the ball scarcely reached the end of the barrel, and was very little injured. In the third trial the velocity became so great, and the air was condensed to such an extent, that the ball struck upon a cushion-like surface so highly elastic that it was extracted without the least injury to its shape. The last charge was too powerful, inasmuch as the lateral pressure of compressed air rent the tube asunder.

The one great cause of this and other barrels bursting, arises from the velocity becoming too great, and thus driving back the air upon itself, until the mutual repulsion of the particles forms an almost impenetrable barrier, exerting a lateral pressure on the barrel, and resisting the passage of the elastic fluid. To make the explanation plain; supposing that the charge had condensed the air for the distance of three or four inches immediately preceding it, and then come to rest, the waves of vibration, travelling at the rate of 1,300 feet per second, would communicate to the remainder of the column the same pressure, and an equilibrium would take place. But this not being the case, and the air becoming still more highly compressed by the velocity not decreasing but increasing, the lateral pressure becomes greater than the fibres of the iron are able to withstand, and consequently the barrel is burst. Many accidents arise from this cause solely, and without any blame being attached to either the maker or user of the gun. While on this subject, we may remark that this is the more likely, inasmuch as the powder with which barrels are proved is not the strongest, and is also of a large grain; so that it is quite within the range of probability that a barrel may, and it does often, stand proof, and yet burst when it comes to be used with extremely fine-grained strong powder; as it is quite clear that a high velocity must create danger.

To pursue the subject still further: in order to procure conclusive evidence in support of this argument, I had a tube of iron manufactured, sufficiently good in quality to bear an enormous pressure; it was three feet in length, with a bore large enough to admit an ounce ball, and the sides of the arch were full a quarter of an inch in thickness. A piece of steel, one inch in length, was then turned of a size to fit the bore well, but not so tight as to prevent its free action: this I called a piston. From the centre of the tube to the muzzle, were drilled, on all sides, a number of small holes, a quarter of an inch distant from each other, in all amounting to sixty-eight; these were fitted with small pieces of steel needles, hardened, projecting into the interior of the tube a quarter of an inch, so that the piston, in its upward movement, should strike these pins, and thus enable me to judge how far it was driven by each experiment. Each end of the tube was then fitted with a breech, firmly screwed in; the upper one having a flat internal surface, the lower one, where ignition was to be communicated, being a conical or patent breech. This machine I termed an explosion metre; and it answered its purpose. With two drachms of the best canister gunpowder, the piston was propelled nineteen inches along the tube; breaking eight pins. The same quantity of the fine diamond grain reached only eighteen inches, or four pins. No. 3 grain, of both Laurence's and Pigou and Wilks' manufacture, reached twenty-four inches, or twenty-eight pins. A very superior powder, containing in one grain five of diamond, four of canister, and two of the above makers' No. 2, reached twenty-seven inches, and broke forty pins. In each of these experiments the greatest accuracy was observed, in preparing the metre as well as in weighing the charge.

These facts go far to prove that, in all uses of gunpowder, the grain should be of a size proportioned to the length and bore of the gun; for if we have not an accelerating force to overcome the increasing resistance of the compressed column of air in the barrel, there is great danger that the gun may be burst, and probably be productive of great mischief; whilst a judicious application of the extraordinary power thus placed at our disposal, may be alike conducive to our safety and our pleasure. A musket ball can be driven through an half-inch boiler plate; but this can only be accomplished by using as much powder as will generate a gradually, though rapidly, increasing power, until the ball has passed the limits of the tube.

Nitre is not the only salt which has been employed in the manufacture of gunpowder. Its quantity or proportion in the mixture has been lessened, and the deficiency supplied by another elementary combination; namely, by the chlorate of potassa.

The French succeeded in making powder of which potassa forms one of the component parts, and they say it ranges the projectile double the distance; but this is doubtful. The proportions of the mixture are nitrate of potash twenty-five parts, chlorate of potassa forty-five, sulphur fifteen, charcoal seven and a half, and lycopodium seven and a half parts. In the year 1809, a similar kind of powder was proposed to the English Government, by a person of the name of Parr; but its introduction was very properly opposed by Sir William Congreve, on account of the danger attending its use, and also from the fact that there was no piece of ordnance in the service able to withstand its effects. The proportions were, chlorate of potassa six parts, fine charcoal one part, sulphur one part. These ingredients to be *carefully* mixed together and granulated. The above mixture was laid aside, not only from the want of power to restrain its effects, but because it was useless, from the very extreme rapidity of its explosion: it forms the atmospheric air into a wall of adamant, by the condensation confining it to a comparatively small space; it becomes lightning—an electric fluid, which, from its very intensity, cannot displace any great mass of air.

Neither can any advantage arise from any greater velocity in projectile force, except we can obtain that by a graduated scale; for masses cannot, from a state of rest, be put in extreme motion instantaneously: philosophy teaches us, and experience makes it evident, that a portion of time must be occupied, however short that may be. All motion is gradual, and cannot be obtained otherwise; and hence the fact, that lightning conveyed into a tube filled with projectiles would not drive them out: it would not project them, but the blow would break them in pieces. So is it with this mixture; it is useless from its very rapidity of ignition. We have shown that even fine grain gunpowder is too quick, and that its quickness destroys its power; how much more so is the other: and what would it avail us, with these disadvantages.

A writer mentions what he conceives to be a curious fact: he says, "If a train of gunpowder be crossed at right angles by a train of fulminating mercury, laid on a sheet of paper on a table, and the gunpowder lighted by a red hot wire, the flame will run on until it meets the cross train of fulminating mercury, when the inflammation of the latter will be so instantaneous as to cut off the connection with the continuous train of gunpowder, leaving one half of the train unignited:" and again, "If the fulminating powder be lighted first, it will go straight on, and pass through the train of gunpowder so rapidly as not to inflame it at all." True; and the cause is quite apparent: the rapidity of combustion condenses the air so quickly, as to remove the grains of gunpowder liable to come in contact with the flame, and to form the condensed air into a line of demarcation: for heat cannot be taken up by the air quicker than the atmosphere will convey sound; and before the heat can evaporate the explosion is over, and is consequently noiseless.

In all mining operations: in the quarrying of stone, the destruction of sunken rocks, or in any other operations where it is desirable to detach large masses, the use of gunpowder is indispensable; not only because it decreases manual exertion but also because it can be used under circumstances and in situations unapproachable by other means. It becomes, therefore, a consideration for the miner what kind is best suited for the purpose; the finest grained powder is useless as is well known: it is also more expensive; but its principal defect arises from its quickness of combustion. Masses cannot be detached without first putting the whole in motion; and as this cannot be done in a very short time, it is necessary to prolong the explosion, so that the wave of vibration may have time to travel throughout the whole of the mass acted upon; and a repetition of these waves is necessary before any mass can move. Now, to obtain this, it is necessary that matter be so incorporated with the powder as to prolong that explosion; bituminous substances might be applied with effect, for their slow burning would keep the heat necessary to hold the permanent gases at their utmost stretch of expansion.

It is obvious, from the extremely high character English sporting gunpowder has obtained all over the world, that considerable improvement must have been effected by the private manufacturers, either in the purification or manipulation of ingredients; indeed the unwearied care bestowed on this point by several of our best makers is beyond all praise. To explain the various methods, or otherwise enlarge upon this point, would be injurious to individual skill and enterprise, and be the means of imparting knowledge to those who have not ability to invent, but who gather from the brains of others. The French set great value on the "Poudre de Chasse" of England. It is rather singular that we should excel those who pride themselves so much on their chemical knowledge; but, as before remarked, it is certain that the intimate incorporation of the ingredients is of more importance than the chemical proportions.

All military and naval gunpowder is not manufactured of the greatest strength that can be acquired "*at the Government mills*;" a sample is furnished to each contractor with each contract, and to this strength he is limited.

The fame of our English gunpowder makers is patent to all the world, and, where skill is equal, to name one rather than another would be invidious; though we must not lose sight of the facts herein established. "Granulation," properly understood, is an equivalent point to either chemical or mechanical knowledge and manipulation in gunpowder manufacture. Great anxiety to meet the wishes of the sporting world on this point, and to advance with the age, has been aroused; and specimens have been kindly furnished to me, not by one, but by all the following celebrated makers: Messrs. Pigou and Wilks, Curtis and Harvey, Lawrence and Son, John Hall and Son; and I have received also a very excellent specimen from the Scotch mills.

Gunpowder of five sizes of granulation, on the basis before alluded to: namely, No. 2, containing two quantities of No. 1, and No. 3, three, and so on in progression; but it is imperative that all the various sizes be produced from the same mill cake, or be otherwise of the same condensation or specific gravity, and in all experiments of comparison, equal weights are a "sine quâ non," otherwise the comparison will be futile; as measure is, for these very obvious reasons, inapplicable in comparative tests. When these points are carefully attained, increased power of killing, "decreased recoil," and much greater safety, will be the important benefits which the gunpowder manufacturers will confer on every one using a gun.

CHAPTER III.

ARTILLERY.

Arcualia, from "arcus, a bow," appears to have been the original name, and included all sorts of "missiles," as well as the engines by which they were propelled. The sling, still in common use by the Arabs on the banks of the upper Euphrates, being most probably the first kind of artillery, and the bow and arrow a succeeding stage of improvement.

Artillery, now in the general acceptance of the term, includes all and every description of gun, of greater power and dimensions than muskets and other shoulder guns.

Modern civilization, with its giant strides of improvement, has rejected the cumbrous and unsightly complication of springs, levers and wheels; and given to us, in their stead, the light and handsome six-pounder cannon; which is so easy of transit that it can accomplish the most complex and difficult movements, while the horses are at their fullest gallop. A single minute now suffices to stop when at the greatest speed, unlimber, load, fire a couple of rounds, and remount; the gun is speedily at a distance—while the eye can scarcely follow, or the mind imagine, the destruction that must follow when the "deep-tongued gun" is fired in attack.

I shall now proceed to notice the comparative effects of guns of various calibre and power, and attempt to convey to the reader a distinct idea of their respective defects and advantages. The artillery of England comprises an immense variety of weapons of war, suited for various purposes and situations, as experience has dictated, or necessity required. The present state of our artillery requires *an advance to the front*, to be in a line with the march of science, as regards the knowledge of gunpowder and projectiles; I may, therefore, be permitted to animadvert on what appears to me to need improvement.

The profession may think it presumptuous in me to offer a suggestion or give an opinion; for it too frequently happens that individuals, who have employed their whole time and study on one especial subject, think they alone can understand it, and consider any opposition to their opinions, or any doubt of the soundness of their conclusions, little short of a positive offence.

Having given considerable attention to the subject, I would now beg to offer some remarks on the Government arrangements of gunnery, which are not yet so perfect as they might be.

The authorities of the Ordnance Department are, I am sorry to state, too remiss in considering, and too unwilling to avail themselves of valuable improvements and discoveries; clinging too much to prejudice in favour of whatever has been heretofore in use. To such an extent is this habit carried, that many improvements become familiar to half the kingdom, aye, and are adopted by other countries, before our guides take advantage of them: for truly talent and ingenuity are but scantily patronized by them. My wish is to aid in sweeping away the cobwebs which still hang on the science of great gunnery; and to push the spur of conviction deep, that instead of Britain following, she may, in a time of peace, lead the way in improvements; so that whenever war returns, she may not be unprepared to wage it on equal terms.

I have in this chapter endeavoured to divest the subject of all extraneous matter, and impart as much information as will enable the reader to form an opinion for himself, and understand something of a science hitherto considered abstract, and which is, no doubt, abstruse. This I have sought to effect in plain language, avoiding, wherever it was possible, all technicalities.

The guns of the British nation may be divided into four classes—Park, or Field artillery, Siege guns, or battering train, garrison guns, and marine artillery. The numbers of different descriptions of rates, or weight of guns, vary in all the different classes of the service. There are light, medium, and heavy six-pounders; long and short twenty-four pounders; and two or more weights in all the varieties, even up to the ten-inch gun and thirteen-inch mortar. We have iron ordnance and brass, for long and short ranges, for small or great velocity. The rate, weight, length, charges, point blank, extreme range, &c., of iron guns, will be found in the annexed table, by which will be seen, at a glance, the various matters referred to.

Iron Ordnance.

Nature of Gun.	Weight.	Length.		Charge of Powder.		Point Blank Range.	Extreme at 5 deg.	Windage decreased.
Pounders.	cwts.	ft.	in.	lbs.	ozs.	yards.	yards.	
32	63	9	9	10	10½	380	1950	—
32	56	9	9	10	10½	380	1950	—
32	48	8	8	8	0	330	1740	—
32	40	7	7	6	0	340	1700	·06
32	32	6	6	5	0	330	1640	·11
32	25	6	6	4	0	225	1500	·11

32	25	5	5	4	0	225	1500	·11
24	50	9	9	8	0	360	1850	—
24	48	9	9	8	0	360	1850	—
24	40	7	7	8	0	340	1800	—
24	33	6	6	6	0	260	1560	—
18	42	9	9	6	0	360	1780	—
18	38	8	8	6	0	340	1730	—
12	34	9	9	4	0	360	1700	—
12	29	7	7	4	0	340	1650	—
9	26	7	7	3	0	330	1600	—
6	17	6	6	2	0	320	1520	—
Carronades								
68	36	5	5	5	10½	270	1420	—
42	22	4	4	3	8	240	1350	—
32	17	4	4	2	10½	235	1260	—
24	13	3	3	2	0	225	1150	—
18	10	3	3	1	8	220	1100	—
12	6	2	2	1	0	205	1000	—

Brass guns are invariably lighter, and considered less likely to burst. Gun metal, technically so called, is a compound of copper and tin, in the proportion of five, eight, and ten pounds of the latter to 100 pounds of the former. The peculiar property of the tin is to give hardness and solidity to the mass. The greater proportions are used principally for mortars, as they require a greater degree of hardness than other guns. A peculiar property attaches to the using of brass guns. If a considerable number of rounds be fired in rapid succession, the bore of the gun becomes to a certain extent elliptical. This peculiarity arises entirely from the extreme windage allowed by the present established rules of British gunnery; and is produced by the tendency of the shot, when propelled by the explosive force, to strike upwards from the breech, and then rebound downwards, and so on till it reaches the muzzle. Iron guns are not liable to this (although the same cause exists) from the unductile nature of the cast iron.

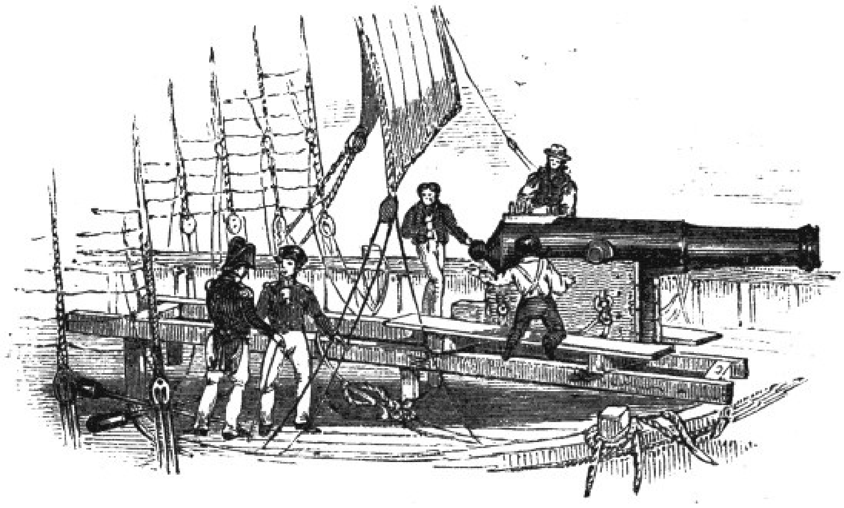
Brass guns are, after certain use, recast: this is done solid, with the cascable of the gun downwards, to give a greater density to the metal at the breech. The boring and turning are performed simultaneously by a very simple arrangement. At the siege of Badajos, the firing continued for 104 hours, and the number of rounds that each gun fired averaged 1,249; and at the siege of Sebastian, the quantity fired by each gun was about 350 rounds, in 15½ hours. These guns being of iron, none of them were rendered unserviceable; though three times the number of brass guns would not have been equal to such long and rapid firing. All brass guns are bouched with a bolt of copper at the vent, on the same principle as flint guns for sporting were formerly with gold or platina; copper withstanding the rapid escape of the flame better than the gun-metal. The charges, ranges, &c., are as follows:—

EXTREME AND POINT BLANK RANGE OF BRASS ORDNANCE, CHARGE, &C.

——	Charge.		Point Blank Range.	Extreme Range.	Elevation.	——
	lb.	oz.	yards.	yards.	deg.	
Medium 12-pounder	4	0	300	1,200	3	With round solid Shot.
Light 12-pounder	4	0	200	1,000	3	
9-pounder	3	0	300	1,200	3	
Long 6-pounder	2	0	300	1,200	3	
Light 6-pounder	2	0	200	1,000	3	
Heavy 3-pounder	1	0	200	1,000	3	
24-pounder howitzer	2	8	250	950	3½	With common Shells. When Shot is fired, they increase the elevation ½ a deg.
12-pounder howitzer	1	4	200	950	3¾	
Heavy 5½-inch howitzer	2	0	250	1,750	12	
Light 5½-inch howitzer	2	0	100	1,350	2	

The twelve, ten, and eight-inch guns, almost form a class of themselves, known as the “Paixhan Gun.” They are intended for throwing both hollow and solid shot. The larger are the description of ordnance with which we at present arm our steam frigates.

These are unquestionably part of the many doubtful descriptions of artillery which have been adopted of late years, with a view to *fracture* more than to secure a range of projectile. They are enormous machines, as will be seen on reference to their weights, as given in the following table; and their splintering powers are certainly very extensive indeed. But their range is contemptibly small, if we take into consideration their great weight. The effect of the explosion of the charge of one of these guns must be sensibly felt even by the strongest built steamer in the world. They are used with traversing beds. The gun carriage, when recoiling, in a backward direction, being driven up an inclined railway, with from 3° to 4° of elevation, from the cascable of the gun. This greatly tends to lessen the distance which the gun would be driven back, and facilitates the running out of the piece to the point of discharge. The woodcut gives a representation of the traversing beds; and the following table displays the ranges, &c., of this class of heavy artillery.



Range and Elevation, &c., of 12, 10, and 8-inch Guns, at Point Blank and Extreme, and 10 and 8-inch Howitzers.

Nature of Ordnance.	Length.		Weight.		Charge Powder.		Point Blank Range.	Extreme Range.	Eleva-tion.
	ft.	in.	cwt.	qr.	lbs.	ozs.	yards.	yards.	deg.
12-inch gun, with hollow shot, weight 112 lbs.	8	4	90	3	12	0	240	1,550	6
10-inch, with ditto, weight 86 lbs.	7	6	57	3	7	0	210	1,500	6
Ditto	8	4	62	1	8	0	250	1,400	5
Ditto	9	4	84	0	12	0	325	1,700	5
8-inch gun, with hollow shot, 48 lbs.	6	8½	50	0	7	0	210	1,300	5
8-inch ditto, solid shot, 68 lbs.	8	6	60	0	9	7	340	1,500	5
Ditto	9	0	65	0	10	0	300	3,250	15
Ditto, hollow shot	9	0	65	0	12	0	370	2,920	15
10-inch iron howitzers	5	0	40	0	7	0	2 deg. 600	2,078	12
8-inch ditto	4	0	21	0	4	0	3 deg. 730	1,725	12

[2] Length of time occupied in flight, 14 seconds, and 15¼ seconds.

Mortars are intended for three purposes; firstly, to bombard a town, or injure the defenders' artillery; secondly, to fire or overthrow the works, and to spread havoc and slaughter among the troops; thirdly, to break through the vaulted roofs of barracks and magazines which are not bomb-proof, or, in other terms, are not strong enough to resist the fire.

They consist, as will be seen, of five descriptions, but the 10-inch is considered, on the score of economy, as equal to all useful purposes. The French have, at various times, constructed mortars of enormously large dimensions, but certainly with no useful result. The monster mortar, used at the siege of Antwerp, fired only ten or twelve shots, and with comparatively little effect. It burst some time after, while under a course of experiment, with a considerably less charge than it had formerly withstood; thus affording one very conclusive and illustrative fact in the theory of vibrations in metals: for there can be no question but that the shell, from the smallness of the charge, was too long detained in the mortar; the waves of vibration caused by the explosive force moving so rapidly through the mass that the metal at last lost its cohesive nature from their very rapid succession.

It will be perceived, on reference to the adjoining tables, that ranges are obtained by the modifications of charges.

English Mortar Practice.[3]

13-Inch Iron. Weight, 16 cwts. Shell filled, 200 lbs.[4] Bursting powder, 6 lbs. 2 ozs. Blowing powder, 2 ozs.					10-Inch Iron. 16 cwts. 2 qrs. 92 lbs. 2 lbs. 10 ozs. 1½ ozs.					8-Inch Iron. 8 cwts. 1 qr. 46 lbs. 1 lb. 14 ozs. 1 oz.				
Ele-va-tion.	Charge.		Fuse.	Range.	Ele-va-tion.	Charge.		Fuse.	Range.	Ele-va-tion.	Charge.		Fuse.	Range.
deg.	lbs.	ozs.	inch.	yards.	deg.	lbs.	ozs.	inch.	yards.	deg.	lbs.	ozs.	inch.	yards.
45	2	1½	1·90	450	45	1	0½	1·90	450	15	0	14	0·80	500
	2	3	2·00	500		1	2	2·00	500		1	0	1·00	550

	2	4¾	2·10	550		1	3¼	2·10	550		1	2	1·10	600
	2	6	2·20	600		1	4¾	2·20	600	45	0	9½	1·90	450
	2	7¾	2·30	650		1	6	2·30	650		0	10¾	2·00	500
	2	9½	2·40	700		1	7½	2·40	700		0	12½	2·10	550
	2	11¾	2·45	750		1	9	2·45	750		0	13¾	2·20	600
	2	14	2·50	800		1	10	2·50	800		0	14½	2·30	650
	3	0½	2·55	850		1	11	2·55	850		0	15½	2·40	700
	3	3	2·60	900		1	12	2·60	900		1	0	2·45	750
	3	5½	2·65	950		1	13	2·65	950		1	0½	2·50	800
	3	8	2·70	1,000		1	14	2·70	1,000		1	1¼	2·55	850
	3	10	2·75	1,050		1	15¼	2·75	1,050		1	2	2·60	900
	3	12	2·80	1,100		2	0½	2·80	1,100		1	2¾	2·65	950
	3	14	2·85	1,150		2	1¾	2·85	1,150		1	3½	2·70	1,000
	4	0	2·90	1,200		2	3	2·90	1,200		1	4	2·75	1,050
	1	4¾	2·80	1,100										
	1	5¼	2·85	1,150										
	1	6	2·90	1,200										

5½-Inch Brass. Weight, 1 cwt. 1 qr. 10 lbs. Shell filled, 16 lbs.[5] Bursting powder, 10 ozs. Blowing powder, ½ oz.					4 2-5th-Inch Brass. 3 qrs. 19 lbs. 8 lbs. 5 ozs. ½ oz.				
Elevation.	Charge.		Fuse.	Range.	Elevation.	Charge.		Fuse.	Range.
deg.	ozs.	dr.	inch.	yards.	deg.	ozs.	dr.	inch.	yards.
15	6	0	0·73	350	15	4	8	0·80	450
	7	0	0·75	400		4	12	0·85	500
	7	8	0·80	450	25	4	0	1·10	540
	8	0	0·85	500	45	2	6	1·65	300
25	5	8	1·10	480		2	9	1·70	350
45	4	8		300		3	0	1·80	450
	4	12		350		2	12	1·75	400
	5	0	1·75	400		3	4	1·85	500
	5	4	1·80	450		3	8	1·90	550
	5	8	1·85	500		3	12	1·95	600
	5	12	1·90	550					
	6	0	1·95	600					

[3] Artillerist's Manual.

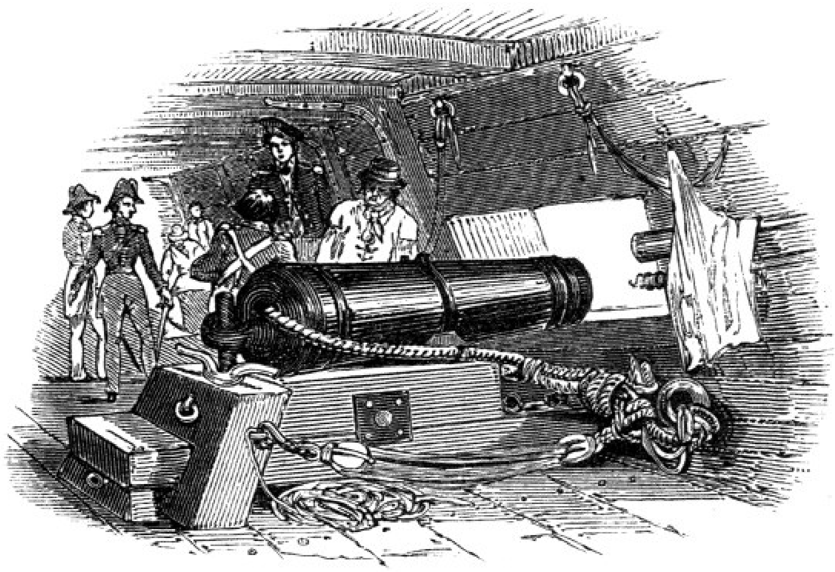
[4] Shells filled with sand, which will account for the weight.

[5] Shells filled with sand, which will account for the weight.

	13-Inch Land Service.	10-Inch Ditto.	8-Inch Ditto.
Greatest charge,	8 pounds powder.	4½ pounds.	1 pound.
Greatest range,	2,706 yards.	2,536 yards.	1,720 yards.

Weight of Land and Sea Service Mortar.

Inches.				cwts.	qrs.	lbs.		Inches.
13	Land service,		Weight,	36	2	0	Length,	36·563
10	do.		„	16	2	0	„	28·125
8	do.		„	8	2	14	„	22·500
5½	do.	brass,	„	1	1	15	„	15·104
4⅔	do.	do.	„	0	3	20	„	12·713
13	Sea service,		„	100	1	14	„	52·810
10	do.		„	52	0	0	„	45·620



Carronades are a short description of ordnance without trunnions, but fastened by a loop under the reinforce. Their construction is materially different from that of guns. They have a chamber like a mortar, a part scooped out inside the muzzle, forming a cup, and they have also a patch on the reinforce. The name arises from the Carron Foundry in Scotland, the first of them having been cast there in 1779. The construction is considerably lighter than that of guns of similar calibre. Their principal use is on board ship; but they are sometimes used in casemates, or retired flanks of fortresses.

The proportions of all guns to shot, will be found below; and in looking at this table, it will scarce be conceivable how such light guns can project such heavy shot.

Comparative Weights of Guns and Shot.

——	Weight of Guns.	Comparative Weight.
	cwts.	
12-inch Gun	90	1 to 112
10 do.	84	1 „ 82
8 do.	65	1 „ 107
8 do.	60	1 „ 96
8 do.	50	1 „ 82
32-pounder	64	1 „ 224
Do.	56	1 „ 196
Do.	48	1 „ 168
Do.	40	1 „ 140
Do.	32	1 „ 112
Do.	25	1 „ 84
24-pounder	50	1 „ 233
Do.	48	1 „ 219
Do.	42	1 „ 186
18-pounder	42	1 „ 261
Do.	37½	1 „ 233
12-pounder	34	1 „ 318
Do.	29	1 „ 270
Do.	21	1 „ 196
9-pounder	31	1 „ 285
Do.	26	1 „ 323
Do.	17	1 „ 211
6-pounder	23	1 „ 429
Do.	17	1 „ 327
68-pound Carronades	30	1 „ 59
42 do.	22¼	1 „ 58
32 do.	17	1 „ 62
32 do.	25	1 „ 96
24 do.	13	1 „ 55
18 do.	10	1 „ 56
12 do.	6	1 „ 56

The recoil, which in all the before-mentioned guns is very great, arises from the blow communicated to the iron in immediate contact with the explosive fluid. The granulatory system of the metal transmits to those grains, or crystals, immediately behind them, the blow or concussion they are subjected to, and these again to others, and so on, until the vibration has passed through the metal, from the interior of the breech to the exterior of the gun.

I am satisfied that in all small guns, from their slight substance, recoil is communicated a great deal quicker than in larger ones; hence arises the well-known fact that in shooting you receive a knock nearly simultaneous with the explosion. The greater and heavier the gun (even carry it up to General Miller’s gun of 84 cwt.) if the proportion which the shot bears to it be not too great, the less will be the velocity of recoil. But in carronades, as will be seen, the proportions are as high as 1 to 55, while in long guns, it is 1 to 429; a very considerable degree of difference.

Our ancestors had but a limited knowledge of the laws of projecting bodies by gunpowder. Their explosive power was not good; for there is clear proof, even since the time of Robins, that the purification of the ingredients has nearly doubled the explosive force. The mechanical construction and outer mould of their guns, were calculated to resist and limit the effects of recoil to a great extent.

Accumulation of metal in the rear of the breech-end of a gun is true science, and of so easy an attainment, that wonder arises in the mind why it has not been effected. The extent to which this principle is worked upon in our gunnery is very trifling; though recoil can by this simple arrangement be nearly destroyed, or so lessened as to add considerable percentage of range to the projectile. Add no considerable weight to the gun, but add it judiciously, behind the end of the chamber and vent, and immediately surrounding the breech. I have tried this to a great extent, on a small scale, “with fowling-piece barrels,” and find that the greatest advantage arises from an additional inch of metal to the extreme end of the barrel, as the recoil is thereby lessened; while, on the contrary, by reducing the exterior end of the breech, until it becomes of less thickness than the sides of the barrel, the recoil is doubled. Guns will some day be constructed as mortars are, with the axles, or trunnions, in rear of the tube and of the vent; for by this arrangement recoil would act less on the mass of metal forming the gun, and more on the base from which it is fired. We are quite aware that an arrangement of this nature could only be applied to certain descriptions of ordnance, and in certain situations; but on forts, or batteries commanding rivers and bays, and even in the bows of steam vessels, they may be placed with great advantage. But this objection may be started: “You could not use guns fitted in this manner horizontally, or nearly so.” Why not? The muzzle could be as easily raised or depressed as the breech, by mechanical means. I should much like to see the principle tried, and I hope to do so.

The following results of experiments prove, that if a true basis is not laid down, all the fabric raised upon it is but one of sand, which will crumble away from under us. Hutton says,—“Varying the weight of the gun, produced no change in the velocity of the ball. The guns were suspended in the same manner as the pendulous blocks, and additional weights were attached to the pieces, so as to restrain the recoil; but although the arcs of the recoil were thus shortened, yet the velocity of the ball was not altered by it. The recoil was then entirely prevented, but the initial velocity of the ball remained the same.” No doubt this was the result of his experiments by the pendulous suspension of the gun: but here he erred; for had he suspended a thousand tons to it, without incorporating it in the gun, the result would still have been the same. All the improvements effected, or yet to be accomplished, will be obtained by a concentration of metal.

An excess of weight in the fore part of a gun is very injurious, by inducing and lengthening the tremulous vibration created by the explosion. The only necessity for strength forward in a cannon, arises from the necessity of resisting the lateral pressure from the condensation of the column of air in the tube. The pressure of the explosive gases is, by the velocity obtained before reaching the fore part, of very little amount, from the short period it is exerted on the interior. Therefore weight, in the fore part of a gun, be it ever so great, will not prevent recoil if there is not a proportionate quantity behind. It will retard or lessen the distance to which the recoil will drive the gun and carriage, but the evil is then over.

If the slightest movement occurs in the gun, the shot is projected from an unsound base or foundation. It is precisely similar to a man who, in the act of throwing a stone, slips his foot backwards: the effect is at once apparent on the stone. If the trunnion of a gun breaks in the discharge, or a quoin flies out, the shot is materially affected; never ranging, under such circumstances, the accustomed distance, nor with its usual accuracy. Practice with mortars proves beyond dispute the necessity of a firm base for the gun, for with a much less charge they project a greater mass farther. A mortar discharged on land, exceeds in range the same description of gun on board of ship, or on the best-constructed platform. In truth, this is but another illustration of a law of nature: if you have not a solid fulcrum, it matters little what the power of your lever may be. Gunpowder is a powerful lever if exploded on a solid base; if not, its effects become limited in proportion. Unquestionably, much may yet be gained by an economical arrangement of our projectile force. Great and rapid as have been the acquisitions of knowledge in everything relating to gunnery in modern times, there still remains, I have no doubt, an unexplored mine of valuable treasure to be added to the science.

It would effect a great improvement in the mortars used by the navy, destroying the tremendous vibration and shake given to the ship, increasing their efficiency and aiding the projecting power, to place them on beds of the softest lead, not less than twelve inches in thickness. Though this suggestion is only theoretical, experience would soon determine the least degree of substance available. Advantage would arise, in the first place, from the non-conducting tendency of the lead; in the second, from its density, and, of course, incompressibility. The one protecting the ship, the other being the most solid bed for the mortar that can by possibility be obtained.

The weight of a hollow 13-inch shell is 190 lbs.; the bursting powder 6 lbs. 8 oz.; the weight, if cast solid, would be 290 lbs.: thus the action of so large a body on the atmosphere must be immense of itself. There seems to be much difficulty in projecting masses of great diameter, from this cause; and this should lead us to seek, as indeed it points to, another material for fabricating projectiles. As weight is less in substance, and, of course, less in space, much less resistance, in proportion, will exist in a bore of six inches than in one of twelve; and a greater projectile force will be generated with fewer countervailing disadvantages.

The first step in the vast improvements about to be effected in gunnery, has been successfully taken by Mr. Monk, of Woolwich arsenal, who has induced the authorities to allow a gun to be made from drawings and calculations of his own. The dimensions of the gun are as follows: length from cascable to muzzle, 11 feet; weight, 97 cwt. 3 qrs.; bore, 7⁷⁄₁₀ inches; weight of solid shot, 55 lbs.; shell, 42 lbs.; windage, 0·175; charge, 16 lbs. of powder; giving a range, at 32° of elevation, of 5,327 yards. *A compound shot*, (a shell filled with lead), was projected 5,720 yards, or *three miles and a quarter*, at a velocity, during the first second of time, of 2,400 feet per second, and occupying during the whole flight only 29½ seconds. The comparative weight of gun and shot is 1 to 220.

A course of experiments, extending over seventeen years, has firmly established this gun as the best ever yet constructed. Many attempts have been made to excel it, but all have failed. Guns have been made on drawings varying not more than three-tenths of an inch in their dimensions from those of his gun, and, with extreme *modesty*, the individuals have claimed a right to compete with Mr. Monk; and have even obtained competing trials, without any claim whatever to the discovery of the principle of it; coming into competition by no just claim or merit, but solely from the tendency to supersede any improvement emanating from a *civilian*. Eighteen, twenty-four, and thirty-two pounders are now, however, constructed on this model;—indeed the improvement is so great and so apparent, as to overcome every obstacle as yet thrown in its way.

With no wish to detract from the merit of Mr. Monk’s invention (upon which I congratulate him and the country) but, in justice to myself, I may remind some of my readers, that in “The Gun,” published early in 1835, I clearly laid down the principle in *projectile force*, on which this gun is constructed; and as he has since so successfully accomplished this great improvement, he must permit me to say, that the principle is the same which I have striven for, for many years.

Wilkinson says, “Guns cast on this principle, although several hundredweight lighter altogether, recoil less than those on the old plan, with equal charges of powder and ball, in consequence of the weight being *properly* distributed.” He adds, “One remarkable fact attended these experiments, namely, that by increasing the windage a little, the range was increased also, contrary to the received opinion; but this may be explained by the circumstance, that with very great velocities, and long guns, the column of air to be displaced before the ball quits the gun is considerable, and is condensed so rapidly, that it offers immense resistance to the passage of the bullet, if it fit the bore closely; but, by reducing the size of the ball, and thus increasing the windage, the air has more space to rush round it, and the ball escapes with greater facility.”

If the condensed air prevented the velocity being greater, it argues most clearly, that there was an insufficiency of explosive matter to keep up the velocity until the ball of less windage left the muzzle; and the result with the ball of greater windage establishes this assumption. For if the condensed air was allowed to pass the ball by the windage into the tube, it proves beyond doubt that there was a deficiency of matter there, or that the pressure without was greater than that within. How otherwise could such a result occur? It is a clearly established fact, that with the generality of ordnance, a full waste of one-fourth of explosive force, if not more, occurs by the *elastic fluid* escaping past the ball by the windage, instead of the reverse. Neither could the condensed air rush into the gun by the windage if there are any *permanent gases* generated; which Mr. Wilkinson himself says there are, to the extent of “250 times the bulk of the powder in grain.” These would offer a sufficient resistance to prevent the condensed air rushing in. I have found, by an experiment before described, that a ball driven against a column of air which has no escape, if the velocity be trifling, say 800 feet per second, the air will escape by the windage; but double this even, and it is so condensed as to form a cushion for the ball to strike against. Then how much less will the chance be of its escaping, if the velocity become two thousand four hundred feet per second. No, the cause is remote from that of Mr. Wilkinson’s supposition. There is a want of force—an accelerative propellant force—which should continue to the end of the tube, be that length ever so great; and on this point, for one, turns the whole future improvement of gunnery.

The result wished for can be obtained by a systematical arrangement of the granulation of powder. That a much greater velocity than is obtained in this gun—at present the greatest in any piece of ordnance in use, and possessing a longer range than has been obtained by any power in Europe—may and will be attained, I fearlessly assert. I have obtained a velocity with an ounce ball nearly doubling this; and though, as it will be argued, this may be too limited an experiment, yet let us not forget that great results most frequently spring from little causes. Large rivers owe their origin to small springs, and if the same principle by which we can penetrate a plate of iron half an inch thick with an ounce of lead, be fearlessly and judiciously carried through, we may (and no doubt we shall) live to see projectiles thrown 5¼ miles. That this will be difficult to accomplish I deny: no difficulty attends it, provided the principles before explained are duly carried out.

The great principle in a propellant force is so to arrange it that you do not obtain too great a velocity at the first move of the projectile; as no mass can be forced from a state of rest to a rapid state of motion, without communicating to the gun a corresponding motion, which will create a recoil: and the greater the motion, the greater the recoil. If the explosive matter merely expands for a brief period, and is burnt out before the shot has reached midway the length of the gun, the velocity there acquired will be reduced, by the condensed column of air in the other half of the barrel, to the velocity it possessed when only one fourth the length of the whole from the breech; consequently it would be advantageous to cut the gun in two at the middle, as a greater force would be then generated advantageously, than by the whole. But if you so arrange the granulation of your powder that it shall proceed into motion more gradually, a rapidly increasing force of elastic fluid will continue to be generated, until it reaches its greatest maximum of velocity (which it should do just as the ball leaves the muzzle) then you obtain with your means the greatest result possible.

We believe that the generality of gunpowder used by our Government is vastly inferior in strength to some made by private makers; yet it is not advisable to jump from one extreme to another. What is wanted is the proper blending of the qualities; an addition of a quantity of Harvey's quick powder to a charge, when it has driven the ball up three-fourths of the tube of a gun, and probably had acquired a velocity of 2,000 feet per second, might so aid it, that it would leave the muzzle with a velocity of 3,000.

You cannot put a locomotive train in motion at once: if it were attempted, you would break all the carriages; but if you gradually add your force, you gain in time the greatest possible velocity. I have drawn a parallel case: it is the same with gunpowder; only the velocities are widely different. Therefore, I may be pardoned, if I say gunnery is like steam, but in its infancy. Let us but clearly see and understand aright the principle—knowing that the greater momentum the less the action of the atmosphere—and if 3¼ miles can be obtained with a ball 60 lbs. weight, 5¼ may be easily accomplished by a ball of 120 lbs. Powder is made, and can be had, that will do this.

The use of compound-shot has of late years become quite common in experiments: why lead, with its alloys, has not been more extensively used as a projectile for large guns, has always appeared to me extraordinary. Its weight and density peculiarly fit it for this purpose, and its non-conducting principle is its greatest recommendation. How is it? In no instance, except as compound-shot, do we find any record of the use of leaden bullets on a large scale, save in Sir Howard Douglas's "Naval Gunnery," where, in a note, he says, "A very distinguished naval commander mentioned to me, that he knew a person who had served in an American privateer, which, being out of shot, and unable to procure a supply of iron balls, used leaden shot as substitutes. This person always mentioned with great surprise the superior effect of leaden balls." Well he might; for the reader need not be told that its greater specific gravity would add to its momentum, and a longer medium velocity be retained during its flight. But it possesses another recommendation, superior to all these, in warfare: that of communicating all its force, all its velocity, be they ever so great, to the body struck. Iron does not possess this quality; except to a certain extent, and that at low velocities. Hence the cause of its being found in naval warfare, that balls at low velocities damage and destroy ships' sides more than at higher velocities, even when passing quite through. Lead, in the act of striking hard substances, iron or stone for instance, is partially flattened, until the flat surface is nearly equal to the diameter of the sphere of the ball; thus parting with all the force it struck the object with, and in most instances falling motionless at the base of the object struck; while in the stone, the surrounding crystals or grains are, by their abrasion on each other, pounded into dust, in proportion to the size and force of the body of lead striking them: in many instances to many times the shot's bulk, and only flattening the lead, less or more, in proportion to the capability of the stone to resist. Iron striking stone retains its shape: the grains are driven back upon each other, and each offering its proportion of elasticity, the ball is enabled to rebound back; which it does in many instances to a considerable percentage of the whole distance it had been projected. The greater the velocity with which an iron ball is projected the greater the rebound back from a hard substance such as stone. Reversely, the greater the velocity of lead, the greater its effect on the object struck. Walls or fortifications struck by leaden balls at the same velocities (waiving the advantage to lead by its greater specific gravity) would be pounded into sand by less than two-thirds the same number of lead as of iron shot. Any unprejudiced person may soon satisfy himself of this, by trying it with a musket or fowling piece. A leaden ball will pound itself a hole many times its own bulk, while an iron ball will not make a hole half its size.

I have tried many experiments to ascertain the penetrating powers of iron and lead relatively, by striking various objects, from a boiler plate of half an inch thickness down to fir deals. The same size of lead will, under certain circumstances, punch a perfect hole in a plate of half-inch thickness, as I shall have occasion to show; while, under precisely the same arrangement, the iron ball would rebound back with very little diminution of force; and if the plate of iron be at a perfect right angle, the iron ball would nearly return into the muzzle, of the gun. In truth, I had a narrow escape seventeen years ago, from a bullet actually cutting the rim of my hat: so that it will be well, when experimenting in this way, to be sure that the person is well esconced, for fear of unpleasant results.

Lead, therefore, for destroying ships, as well as stone walls, is unquestionably highly advantageous; even if projected with the same velocities as at present adopted for iron. The additional weight would not decrease the destructive effects; it would augment them. I perfectly agree with the American *privateer*, that the wonderfully destructive power of leaden cannon balls will create surprise, whenever they shall come generally into use. Imagine the effect from a gun of the dimensions of a 10-inch bore. It is dreadful to contemplate.

The effect of lead will be easily understood when explained in the following way. If a 36 lb. shot have a velocity of 2,000 feet per second, the force is equal to the velocity multiplied by the weight, or 72,000 lbs. The whole of this force would strike a wall, and be left there, if communicated by soft lead; if by iron, at the same velocity, it would be minus the amount of force required to make it rebound to the great distance to which iron invariably returns. Though created by the elasticity of the iron itself, this must be deducted from the effect produced, and hence arises the great advantage the lead possesses. We are aware that iron driven with a slight velocity rebounds less; true, and less is its real effect; for under the very same circumstances would the great advantages of the lead predominate. It may be objected, that lead is too easily misshaped; "pure it is, but with alloys not so." At low velocities it might, but the greater velocities diminish that chance, as it is a well known fact that all dense incompressible bodies are least affected by an extremely sharp motion. All our arrangements in warlike preparations, at present, involve great weight of projectile for fracturing, not perforating. During the siege of Ciudad Rodrigo, 2,159 rounds, of twenty-four and eighteen pounders, were requisite to form the small breach of thirty feet wide, and 6,478 rounds for the larger of 100 feet. At Badajos there was expended, to form three breaches of 40, 90, and 150 feet respectively, the enormous amount of 31,861 rounds of the same sized iron shot. We may be pardoned if we presume to say, one-half the number of lead shot would have done more, and done it better.

If we bear in mind, that the whole round of experiments from which Hutton drew his deductions, were conducted with iron projectiles, the inconsistency of taking his data as the standard will be apparent. The dissimilitude of specific gravities being great, namely, 7,425 and 11,327—or one-third difference—it clearly shows, without any effort of the imagination, that the range must be in the same proportion, with the addition of greater momentum. For it will scarcely be denied, that a ball of gold or platina, from the same cause, will maintain a velocity longer, and consequently range further, than even lead. Hutton's theory only establishes the principle, that the lighter the body projected, the sooner it is acted upon by atmospheric resistance, and a medium velocity induced. We cannot attribute his preferring iron to arise from an opinion of its penetrating to greater depths; for a man of his extensive knowledge and research could scarcely be guilty of such an error. But even in our enlightened times we are told that elephants cannot be killed with any projectile but steel: leaden balls cannot do it. I should like to try, and receive the *tusks* in return.

The shrapnell shell (invented by General Shrapnell), or spherical case shot, introduced into the British service of late years, is probably the most destructive of any missile in use. It was intended to supersede—which it has done—canister and grape shot; effecting the same results at treble the range. The construction and principle are very simple, being merely a shell of an unusually light description; in fact, little more than a light cast-iron hollow ball, with a fuse hole. A certain quantity of leaden, or iron bullets is put into it, and the interstices around the ball shaken full of powder; a fuse of the length required is inserted, and explodes the shell during its flight: the peculiarity being, that the body of small balls retain their medium velocity and travel on, merely diverging, latterly, like an immense charge of bird shot. They are usually fired from howitzers, carronades, and other wide bored-guns, at or near horizontal ranges. A considerable delay occurred before they were successfully perfected. It was found that when the small balls did not pack perfectly tight, or were packed overtight, the case frequently exploded in the gun: occasioned, no doubt, by the friction creating a spark at the moment of the howitzer being fired, and thus exploding the shell before its time; but we believe such an occurrence rarely happens now, from other improvements since adopted.

The preceding pages appeared in my last work published in 1846. They are still so much in keeping with the state of gunnery at the present day, and so prophetic of what has, and is about to occur, that they will be regarded, I trust, as bearing the stamp of authority.

Progress, in its rapid advance, has made many English guns objects for the furnace or the museum; and many guns, which formerly ranked high as useful and important weapons, have become things of the past.

Monsters are now all the rage, with a range of three miles, and artillerists contemplate extending the range to double that distance; whilst the projectiles used are not "pounders," but approximating to tons. So much for improvement. In political economy we are told that improvement to be good must be gradual; but only effect some slight improvement in gunnery, make but one step in advance, and the desire for further improvement then ranges at will, and impossibilities are craved for and sought to be attained.

Twelve years ago the success of Mr. Monck (certainly the first modern improver of ordnance,) led to the unlimited production of undigested plans for changes in gunnery; but, unfortunately for the science, no progress was made on the one great improvement of Mr. Monck.

War found us ill prepared in the field, and out-weighted "afloat," so that almost as many men were killed by the bursting of mortars, and other ill-constructed guns, as by the fire of the enemy: so critical was our situation, indeed, that but for the general adoption in England's army of my great invention, the rifle on the expansive or "Greenerian" principle, and its skilful use by our brave soldiers, the war had gone against us. Our rifles were equal in range to our artillery, and this saved us; whilst the enemy, astonished at the effects produced by our bullets, and conscious of their inferiority both in the construction and use of small arms, abandoned the contest: but no doubt with a firm determination to profit by their dear-bought experience.

It is generally admitted that our artillery was never so effective as that of the enemy, and that more is due to the patient and enduring bravery of the British soldier than to our field-pieces and heavy ordnance. That England's artillery was at this time most disgracefully inefficient, it would be folly to deny. The larger guns were destroyed in an inconceivably short space of time. After five, ten, or fifteen rounds were fired the guns burst, killing the gunners in great numbers.

The readers of my works are already familiar with my opinions on this subject, and their value will now be enhanced by the fact that they have been proved to be the opinions of a "practical man." Success in the improvement of small arms is a sure encouragement to those anxious for the advancement of projectile science, and it is a coat of mail in which to fight against the prejudices and incompetency of official management.

Who, on reading my work of 1841, believed the prediction I therein made, that small arms would be produced which would render field guns useless? The fact is, however, firmly established, that the best rifles on my principle will out-range by several hundred yards the best "six-pounder" in her Majesty's service; and that, too, with a repetition of fire wonderfully quick and effective: as the Russians in the Crimea can testify, on more than one occasion.

To endeavour to point out that an improvement may be effected in artillery equal to that which has been effected in small arms, is the object of the following pages.

The author asks a dispassionate perusal and careful study of his work, in justice to himself and to the importance of the subject. Judging of future probabilities by what has already been accomplished, the reader will be prepared for what follows. That great and important changes must take place in artillery cannot be doubted, and should England refuse to avail herself of the improvements to be effected, other nations, and amongst them our late opponent, will be the first to seize and adopt them. In former works I have asked the indulgence of my military readers on account of my scanty military knowledge; but professional men appear to be equally in the dark with the uninitiated: indeed, the lamentable shortcomings of the English artillerists have placed them in the rank of mere "waiters upon providence" for the next step towards improvement. The present time is decidedly propitious; let improvements now be made, and we may surely hope that they will be appreciated by the public, if not by the Government authorities.

What is the best metal for cannon? is a question which has often been asked, and the answers have been very conflicting. Some have advocated mixtures of copper and tin; others have advocated cast iron, and more recently wrought iron; still more recently steel, and, lastly, cast steel, have had their advocates. Arguments as plentiful as summer flowers have been advanced in favour of each, and the argument has been carried on with a vast amount of prejudice and warmth, according to the degree of acquaintance with or attachment to the favourite metal of each individual. It is rare to meet with a mind free from bias, equally well acquainted with the merits of the several metals, and their application to the purposes intended. Still more rare is it to meet with a mind possessing all this metallurgic knowledge, and combining with it an intimate acquaintance with the principles of projectiles, as well as a scientific knowledge of the construction of the engine (the perfection of which consists in its having no points which are weak or unnecessarily strong); and yet it is by such a combination of knowledge and the application of these principles that we must be guided, if we would be successful in the accumulation of projectile power. In the present age we are really alive to the advantage of "playing at long bowls;" and the question now to be determined is, what is the greatest weight of shot and shell we can throw, and how many miles can we project it. The Americans were undoubtedly the first to discover the great advantage of this question with their lesser frigates; the late war has developed it still more; and it now remains to be ascertained how much further can we go. For on this important point the superior efficacy of artillery depends.

At St. Sebastian, in 1813, cast-iron guns threw tons of shot at a range of 1,500 yards; some particular guns firing as many as 3,000 rounds, and yet it is more than probable that had the same guns been used in the Crimea, they would have burst with one-fourth the number of rounds. Experience proves that it is not the great number of rounds fired which strains and destroys the gun, but the high elevation at which these guns are placed, in order to get range; this it is which shakes and disintegrates the crystalline structure of the metal, and thus extreme range is obtained at extreme cost. A gun which at 6° of elevation could stand without a strain 200 rounds, would be likely at an elevation of 30° to burst before 50 rounds were fired. The explanation of this is sufficiently simple. A gun fired at 6° recoils as the projectile is projected forward, in proportion to its relative weight and friction; but when brought up to an elevation above 30° the gun is entirely out of the horizontal, and cannot recoil as it does at an elevation of 6°: the force is now exerted downward, and the gun impinges on its support—*i. e.*, either upon its bed on the deck of the ship, or on the solid earth of the battery, which is comparatively immovable; thus the force which displaced the gun in the first instance is now exerted on the sides of the gun, and the projectile receiving additional force is projected further. But this increased range is obtained at the expense of the gun, which is rapidly destroyed: 50 rounds being sufficient to render it unfit for service. To obviate this rapid destruction of cannon, the metal has been changed from the molecular to the fibrous; that is from cast iron to wrought iron. One object of this chapter is to point out the difficulties which arise in determining what the best metal for cannon really is, and to show the advantages to be gained by attending to the proper construction of projectile engines, without attaching undue importance to the *material* of which they are made.

Before rejecting cast iron as useless for the construction of large guns, it would be well to assure ourselves that no better quality of metal can be produced than that which is at present manufactured. We must also satisfy ourselves that we have clearly understood the proper shape and form of cannon to resist concussions. These concussions, be it remembered, were more violent in the late than in any previous war; and it is an undoubted fact that we had many more fractures then than on any previous occasion: first, on account of the strain produced by the great elevation required to get increased range; and, secondly, on account of the imperfect shape of the gun. The average number of rounds fired from the 13-inch mortars which burst at the bombardment of Sweaborg was 120, and the fracture in all was peculiarly alike; being at right angles to the supports. Now, that this is due to the form of the gun cannot be doubted; and it will be shown more fully in a subsequent page.

But there is another cause to which I wish now to direct attention, viz., the jamming of the Lancaster shell, which takes place in the increasing spiral of the oval gun at the very point where the projectile acquires a proportional increase of velocity. The effect of this may be illustrated by running a locomotive at its maximum of speed over an increasing curve in the railroad, with the certainty of landing it in an adjoining ditch. The principle which determines the result is quite immutable: viz., that matter in rapid motion cannot be materially affected by any force inferior to the primary force: the tendency of the body being to go straight forward; whereas a slow train goes round a curve with the greatest ease. Two motions can easily be given to matter in a lower velocity; but not so easily when the velocity is much increased. Hence I fear that the inventor of the Lancaster gun must have had a misconception of the true laws of motion; for by increasing the degree of spiral at the muzzle, instead of at the breech of the gun, he has rendered nearly useless what would otherwise have proved a most formidable engine of war.

From these observations it may, I think, fairly be doubted whether the bursting of cannon is owing entirely to the inferior quality of the cast iron used in their formation; though there can, I think, be no doubt that English cast iron is not only much inferior to what it formerly was, but that it is also inferior to that which is now manufactured in Russia. Why it is so will be subsequently explained.

These defects in cast iron have naturally led to many attempts to substitute for it a more durable metal; and in most cases the metal selected has been wrought iron. Wrought iron has been used, not only in solid cannon, but in the original “hoop and stave:” “staves outside,” and “staves inside,” as in Mr. Mallet’s monster mortar. Forms of gun as numerous as can be conceived have been constructed, only to prove themselves in every case most complete failures. Our friends at the Mersey Works, Liverpool, will, no doubt, demur to this assertion; as “all creations of the mind appear most perfect to the father of the thought.”

Great credit is, however, due to the enterprise and energy displayed by the inventors, forgers, and finishers of this great gun; which has been the wonder of many minds in this age of wonders: and it is a highly important invention, as showing what we, as a people, are capable of producing by our mechanical and engineering skill. But here, in my estimation, the wonder ceases; for so sure as there is any truth in the Scotch proverb, “A silk purse cannot be made out of a sow’s lug,” so surely is it true that no man, however great his genius and working powers, can make a good cannon of wrought iron. When the hardness and ductility of silver can be imparted to and held by lead, then will it be possible to make wrought iron accomplish all the purposes required of a good cannon.

In vain may Mr. Horsfall urge that his gun has never been burst. Why? Simply because it has not yet been subjected to the same amount of pressure on the square inch; neither has it been tested at the same elevation as some other 10-inch guns, which, in proportion to their size have stood a more severe test. It is a fact, which may be clearly demonstrated, that if a 10-inch gun of 95 cwt. be fired at an elevation of 40° with 17 lbs. of gunpowder, then a gun of more than six times that weight would not be overloaded if its due proportion of powder were about 100 lbs. Has this gun been fired with one half of this? Until it has been satisfactorily proved to this extent, we feel sure that the authorities are justified in not considering Mr. Horsfall’s a successful achievement.

Whatever may be Mr. Horsfall’s impression with regard to the advantages of wrought iron for making cannon, I am satisfied, after a long and careful study of the results of all its varieties, from the most ordinary to the most perfect combination that has been manufactured—either for tenacity, tenuity, or resistance of lateral pressures—that it cannot answer in large guns.

This I think any one will admit, after considering the two following facts; which apply equally to all varieties and mixtures of wrought iron.

1. The strength of iron is at its maximum in the smallest mechanical structures.

2. The quality of the metal is improved as it is subjected to greater pressure and condensation.

The extent to which this improvement may be carried has never yet been ascertained; every fresh manipulation improves its quality. The tenacity of wrought iron is best displayed in a wire, drawn out until it is not thicker than a human hair. Large masses of wrought iron are weak and spongy in geometrical progression with the mass, and the crystalline or molecular form increases with the mass. If large forgings are carefully examined, crystals will be found whose facets would produce inches of surface; as was clearly demonstrated by the bursting of a 10-inch gun at Woolwich: made, if we mistake not, by Mr. Nasmyth.

Another very important cause which renders large masses of wrought iron unsound (and which was fatal in Mr. Nasmyth's gun) is the impossibility of condensing tons of wrought iron equally all through the mass. No one has yet been able to overcome this difficulty.

When the force of a blow, however great, is exerted on the surface of a mass of metal, its effect is neutralized within a few inches of the surface; condensation takes place in inverse ratio from the point of impact, and thus the effect is limited. The force which produces this condensation tends also to elongate the fibres of the metal. This elongation is greatest in the immediate vicinity of the force; the fibres in the interior of the mass are less elongated therefore than on the exterior; and the fibres in the interior of the mass being less ductile (from the cause already explained) than those on the exterior, the interior of the mass elongates, by disintegration of its fibres or crystals, and a porous open mass is thus produced, surrounded by a fibrous case. Instances of this are to be seen in broken engine-shafts and anchors; and, indeed, in all large masses of wrought iron, whether fractured by design or accident.

Another cause of this defect in large masses of wrought iron, is the long continued heat to which it is necessary to expose such large forgings. The iron expands as it is heated, but it does not expand equally all through the mass; and the result of this is that the interior becomes porous and spongy: an appearance which must have been observed by every one who has operated upon large masses.

The shaft of the *Leviathan* weighs 26 tons; but, instead of resisting twenty-six times the pressure of a shaft one ton in weight, it will, from the causes already mentioned, be found unequal to half that amount.

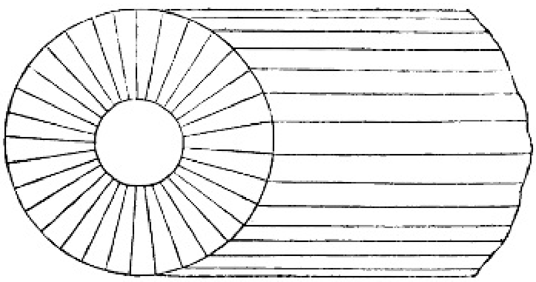
We have watched with much interest the forging of these immense shafts; and the difficulties attending the forging of this structure prove the accuracy of our reasoning on the strength of large masses of wrought iron. The weight of the shaft when finished is 26 tons, and the waste during the process of welding amounts to 74 or 75 tons.

The present shaft is the third which has been manufactured; the two first having proved notorious failures: thus 200 tons of iron have been wasted; which we think is sufficient proof either of the unfitness of the material, or of imperfection in the method of construction. Moreover, I fear that when the vessel encounters a rolling sea, the sudden check and strain produced by the total immersion of one paddle-wheel and the freedom of the other, will subject the present shaft to a strain which will affect its duration; and a vessel costing nearly a million of money may thus be left to reach her port with crippled powers of propulsion.

Where, it may be asked, is the skill in devising engines more powerful than the ingenuity of man can beneficially work out? This has indeed been done in the case of the *Leviathan*; a monster vessel has been built, but all the engineering skill expended upon it has as yet been insufficient to bring it to perfection.

The skill hitherto displayed in welding large forgings of wrought iron into shafts, or other large masses, has been of a very low order; much more may be done than has yet been accomplished, if men will only set about it in a scientific manner. The present mode of proceeding is to build a structure of iron much as a builder would raise a structure of bricks; large and small pieces being mixed together until the requisite mass is obtained.

Now, a much simpler method, and one which we have tried on several occasions, is first to construct several segments of iron of the requisite length, and of dimensions equivalent to the intended object; each segment being fitted to fill its place amongst a given number of other segments (whether twenty, forty, or fifty segments be required,) so as to form a complete cylinder; as the wood-cut will fully explain:—



In welding this structure, the heat is equally diffused all through the mass; and thus the great evil of unequal expansion and contraction is avoided. When the steam hammer is brought into play, its face is a "swage" of circular form, calculated to clasp a large portion of the upper part, whilst a corresponding space is formed in the anvil; and by gradually turning the shaft, the whole is forged into a perfect round. The peculiar advantage gained by this mode of proceeding, is not only the facility with which heat is diffused through the mass, but that each segment is made to act like a wedge on its neighbour; thus producing the most solid forging that has yet been attained. This is rendered still more perfect, both as regards strength and durability, from the fact that a hollow axle has been produced; the great advantages of which it would be out of place to dilate upon in this work.

We trust that these anticipated misfortunes may be avoided by the construction of a more perfect shaft; and that, not only for the sake of the shareholders, but for the credit of the engineer who devised this great vessel—deservedly one of the wonders of the world. A spare shaft would be profitable ballast, if of no more value to the *Leviathan*.

Rolled railway-carriage axles were constructed for me with perfect success on this principle nearly twenty years ago, at the Walker Iron Works, near Newcastle-on-Tyne. The idea has, however, been in a measure “shelved;” but necessity will bring it into use again.

The only engineer who has, by practical experience, satisfied himself that large masses of wrought iron are totally useless for making heavy ordnance is Mr. Nasmyth; whose monster cannon, which was to astonish the whole world, proved, when heated, to have so little cohesion that it would scarcely hold together whilst being lifted from the furnace to the anvil. And, to his credit be it said, Mr. Nasmyth, seeing that wrought iron would not answer the purpose, manfully gave up his hopeless task. Similar experience would probably make some of our present engineers wiser men.

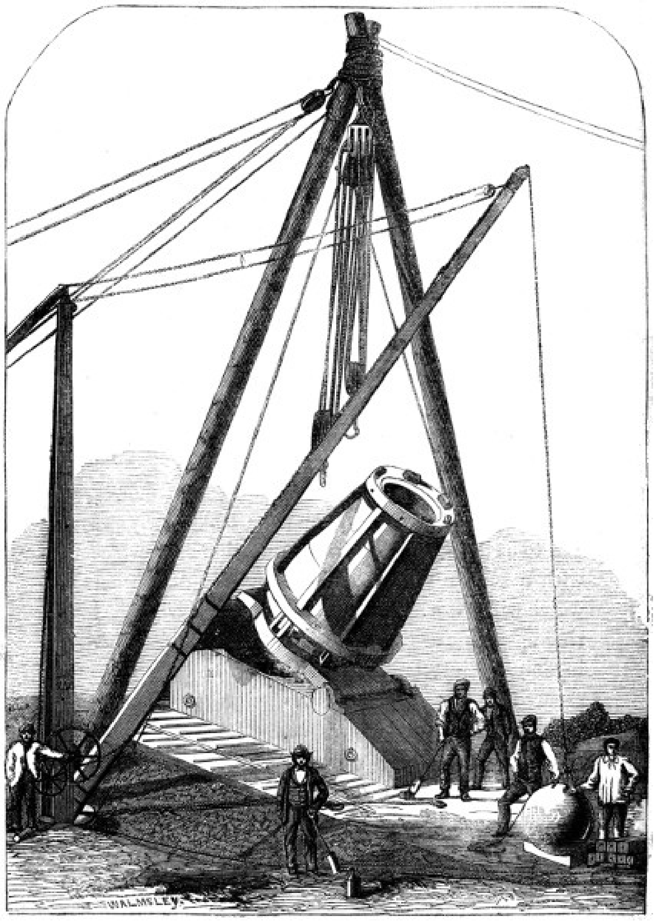
My experience in manufacturing the largest wrought iron guns which it is prudent to construct, sufficiently proves the truth of these assertions.

Harpoon gun-barrels, one inch and a half in the bore, having the metal at the breech end an inch and a quarter thick, will stand a proof which invariably bursts a thicker barrel; in fact, all experience tends to show that light wrought iron or steel barrels are stronger than unusually heavy ones. As all depends on the principle of condensing the fibres of the iron, *ceteris paribus*, the greater the condensation the greater the strength, and the less the condensation the greater the weakness.

That this argument applies principally to solid forged guns I am ready to admit; and that guns forged of hoops, rings, and bars, in smaller sections, are free from this objection, I am also ready to admit. These guns are, however, liable to objections equally fatal, both as regards their enduring and projective powers, as I shall presently show. Experience proves that brass guns are inferior, both in sharpness of shooting and in range, to cast-iron guns: this is undoubtedly attributable to the greater softness of brass than of cast iron; and for the same reason a wrought-iron gun, though made as sound as one of cast iron, would be inferior in these two important points. But when a wrought-iron gun is composed of many particles imperfectly secured (and no mechanical force is sufficient to secure perfect cohesion in large masses), the wrought becomes doubly inferior to the cast gun: a shot projected from such a gun starts from an unsound base; a large portion of the explosive force is absorbed by the variety of sections composing the gun, to the injury both of the accuracy and length of range of the projectile. The softer metals cannot be beneficially used in the construction of large guns, because they destroy the force of the expellant without making any equivalent return; and the softer the metal and the greater its substance, the more clearly is this important fact demonstrated. Thus, in experiments made with large cannon for increasing the weight of the gun beyond a certain proportion to that of the projectile, a gun of ten tons weight and ten inch bore would not exceed in range a gun of five tons, if the charge of powder were the same; on account of the indisputable fact that much more force of the expellant is destroyed, whilst more than double the force is absorbed for the recoil of the ten ton than of the five ton gun; and the loss from these two causes must materially affect the flight of the projectile, though fired at exactly the same elevation.

The great defect which experiment shows to exist in the hoop-and-stave wrought iron gun, and which renders the gun self-destroying, is separation at points between the trunnions and cascable of the gun. The force acting first upon the breech, it yields, and the force is then brought to bear upon the longitudinal portion of the gun behind the trunnions; the staves have thus to bear the first strain, and, after a few shots, become elongated. An opening of the hoops at their junction with each other (most frequently between the breech and trunnions) begins, after a very few shots, to be distinctly visible, and increases at every discharge, until further proceeding amounts to madness, or recklessness of human life.

That enormous engine, Mallet’s monster mortar, of which I give an engraving on page 100, clearly proves this to be the case. It will be observed to be constructed with a solid cast iron breech end, the dimensions of which will be seen by referring to the engraving. Abutting upon this are a succession of wrought iron hoops, ingeniously inserted into each other, and more firmly secured by six outside staves of great dimensions, which, at the muzzle ring, pass through openings in the muzzle ring, with heads like enormous rivets. The binding power is given by “quoin-like” wedges, driven through the opposite end of the stave, beneath the projection of the cast breech, giving power to tighten the longitudinal binders by a blow when required.



Mallet’s Mortar.

DIMENSIONS.

	Tons.	cwt.	qrs.	lbs.
Cast iron base with wrought iron breech shrunk into bore	21	19	0	2
Wood carriage complete, with wrought iron screw and spanner for elevating mortar	8	8	0	14
Bottom part of mortar to fit on top of the breech	7	5	3	23
Part of mortar (a ring) to fit on the top of the above	5	8	3	23
Do. do. do.	3	0	2	13
Muzzle ring	1	2	3	12
Wood ring	0	0	1	0
Wrought iron ring	0	4	3	4
Wrought iron conical ring to fix on top of muzzle ring	0	3	3	25
T-headed bolts, with gibs and keys for fixing mortar to base: may be called outer staves	1	16	2	0
Wood-wedges, &c., for elevating	0	13	3	22
Outer pin, with cross for turning mortar round	0	8	3	14
Total weight	50	13	2	21

Weight of shell unfilled, 26 cwt. 2 qrs.; diameter, 36 inches.

This is notorious as a monster failure, even with a charge of powder amounting to only one half what the projector fondly hoped would be perfectly harmless in its effects. This Brobdignagian toy has proved to be fearfully expensive, the cost having been estimated at eight thousand pounds. It has, I believe, been the largest and most expensive experiment indulged in by the noble “projector,”[6] and I sincerely hope it will be the last.

[6] Lord Palmerston.

The preceding pages will have done much to remove from an unbiassed mind any favourable impression of the advantages expected to result from the use of wrought-iron cannon. The knowledge of this subject, even among talented and scientific men, appears to be at a very low ebb, as is evinced by the multitude of failures that have taken place; not one success of any moment has as yet been attained, and not a discovery has been made worthy of being chronicled.

Having enlarged thus much on the qualities of a metal which it is certain can never supersede the use of cast-iron, even though it be freed from the defects found practically to exist in our present constructed iron artillery; and having also alluded to the fact that the *form* has much influence on the durability of cast-iron guns, I now proceed to the more important point of the qualities of cast-iron itself.

Little doubt exists that guns cast a hundred years ago were more durable than those of more recent formation; it is evident, therefore, that apart from mere form, some material depreciation must have taken place in the quality of the metal. The use of hot blast-furnaces, better fluxes, and improved chemical knowledge in the reduction of metallic ores, though highly profitable in a commercial point of view, doubling the products of our mines, and enriching their proprietors, has, unfortunately rendered English cast-iron perfectly unfit for the formation of cannon, if increased range and greater strain by high elevation are to be the order of the day.

The durability of Russian cast-iron is unquestionably greater than that manufactured in England. Some cause must exist for this; and the question arises, is the ore superior to ours, or does the superiority of Russian iron depend on their method of smelting? The latter is, we believe, the cause of the superiority of Russian iron; for experiments show that Russian ore, smelted in an English furnace, yields the same kind of cast-iron as is produced from the ore found in England. The inference, therefore, is plain, that the difference in the process of smelting makes all the difference in the quality of the iron.

Two thousand years ago the Romans, or their dependents, smelted iron in the county of Durham: vast accumulations of slag exist there at the present time; and thousands of tons have been beneficially re-smelted by two adjoining iron-works, and a percentage of iron obtained sufficient to prove that the Romans were little indebted to fluxes or hot blasts for the quality of iron they obtained. The Russians cannot boast of these adjuncts any more than the Romans: the old agents, wood and energy, are alone employed in the smelting of their ores; and in the absence of scientific aids, though they obtain a much smaller aggregate quantity of metal, yet it is undoubtedly of a much superior quality. With the Romans, also, the yield was meagre, but the quality was good; now, however, circumstances are reversed, quantity, not quality, being the order of the day.

The use of coals instead of wood in the process of smelting has introduced a mixture which is very prejudicial. Most of the coal, even from our very best mines, contains a large quantity of pyrites, or bisulphuret of iron, which, combining with the cast-iron, injures it to an incalculable extent.

These facts fully explain why our cast-iron guns are not so good now as formerly. Select the most suitable mine in the kingdom, erect a furnace on the most improved principles, employ wood fuel only, avoid fluxes and hot and cold blasts, and be content with the small amount of metal produced, and beyond all doubt the quality will be all that the most sanguine founder or artillerist could wish.

Thus the inferiority of our cast-iron guns has been accounted for, and a method suggested, which, if efficiently carried out, would effect the desired improvement.

We are indebted to Krupp for the first suggestion of, as well as the first attempt to introduce, a cast steel gun of greater durability and power than the best cast-iron gun which has yet been manufactured. Steel, possessing, as it does, hardness to any desired extent, ductility in an equal degree, tenacity unrivalled, and all the other requisites, is destined to take the place of all other metals in the construction of artillery. This metal waits only to be tested; and the greater the extent to which the trial is carried, the more confident we are that it will answer every purpose.

Krupp, like many other men with valuable ideas, has been peculiarly unfortunate in his attempts to carry them out. With a vast amount of knowledge of the science of metallurgy, he wants more knowledge in the not inferior science of projectiles; the most important point being to ascertain the form of gun calculated to be suitable for new metal, of the use of which, for cannon, the world possesses no antecedent knowledge.

The only failures Mr. Krupp has made (if they can, strictly speaking, be so called), have arisen from mal-construction, imperfect form, and unscientific combinations; defects which might be expected from a mere novice, though not from experienced artillerists or founders of artillery. The trial of the only steel gun sent by Mr. Krupp to this country, was conducted in the most absurd manner, and on wholly unscientific principles. I will endeavour to convey some idea of this most extraordinary of experiments. Whether Mr. Krupp was unacquainted with the durability of his metal, or was persuaded, against his will, to conduct the experiment as he did, I know not, but the following is what took place:—

In 1851 Mr. Krupp brought to Woolwich a specimen steel gun of ten-inch bore, weighing about four tons. He was induced (but why, I am at a loss to conceive,) to construct a cast-iron jacket, or outer gun, into which his steel gun was inserted up to the trunnions. The steel gun was separated from its cast-iron jacket by a space of half an inch in its whole length, except at each end, where the jacket was fitted to the gun with a moderate degree of tightness; thus the gun and jacket consisted of two tubes, one within the other, fastened only at their extremities, and that by a very slight force. The result, as might have been expected, was the bursting both of the gun and its case; but that the steel gun or its jacket would have stood the test, if subjected to it singly, cannot be doubted. The difference of expansion between the steel gun and its jacket would be quite enough to account for its bursting. Had the contact of the two been perfect throughout the whole length, but allowing half an inch all around for the expansion of the steel gun in that part which was subjected to the greatest pressure, the very act of restraining it in other parts so as to prevent equal expansion, would be perfectly certain to produce a fracture. Mr. Krupp's friends have complained loudly of unfair treatment, whether justly or not, no opinion need now be given; but it is much to be regretted that his experiment was not carried out on scientific principles. The introduction of cast steel guns will be the most essential improvement in artillery: and an extensive series of experiments, extending over many years, during which time I have manufactured gun-barrels of steel alone, ought to give my opinion some weight on this subject.

Laminated steel gun-barrels were well known in 1851; but the English bugbear, prejudice, raised a clamour against them, which was echoed by interest and ignorance, and thus their general adoption was for a long time prevented. However, in the short space of seven years, they have become universally adopted, with the most beneficial results; better shooting, less annoyance from recoil, less weight to carry, and greater safety to the sportsman, being the principal. And so it will be with steel cannon; as a short time will suffice to enable scientific investigation to remove all prejudices against them.

The external form of cannon is a question of vital importance, but one which is little understood by artillerists of the present day. Whilst it is a demonstrable fact that all excessive bulk of cast-iron causes weakness in proportion to the excess, no effectual steps have as yet been taken by the Government to ascertain what is the due proportion of metal which ought to exist in different parts of the gun. The American authority on naval gunnery, Captain Dhalgren, has paid considerable attention to this subject; and if the reports on the durability of American heavy ordnance can be relied on (and there is no reason why they should not) his investigations have been attended with much success.

Captain Dhalgren has extended the principle acted upon many years ago by Mr. Monck; his great improvement consisting in lessening the weight of iron in front of the trunnions, and adding to that of the breech. In cannon, as in fowling-pieces, weight in the fore part is useless; conducing neither to the safety of the gun, nor to the smartness of its shooting. For endurance, it is necessary that the expansion should be equal in every part of the gun; rigidity in one part increasing the strain on the immediately adjacent parts, which, if much reduced, are thus rendered liable to fracture. The breech has to endure the lengthened explosion produced by the burning of the gunpowder; and, as this continues until it has overcome the inertia of the projectile, it is necessary in all cases that the maximum of strength should be in the breech of the gun. When the projectile is once in motion the strength of the tube may be rapidly decreased; the only strain it has to bear is exerted whilst the projectile is passing over it; and this strain, in properly constructed guns, becomes of shorter and shorter duration as the projectile attains its highest velocity at the muzzle of the gun. The greatest strain a gun has to bear near the muzzle is that produced by the condensation of the column of air in front of the charge; and in almost every form of English ordnance the weight of metal here is greater than is necessary.

The Russian guns which have been brought to this country present the same superabundance of metal at the muzzle, whilst at the breech there appears to be a deficiency; and when we take into consideration the extraordinary reports of their endurance, we must ascribe it to some other cause than the proper distribution of metal. Their endurance is no doubt owing in part to the goodness of the metal, in part also to the form of the breech, to the uniformity of thickness in the sides of the arch, and, lastly, to the absence of those protuberances called “reinforce rings.” These rings might with propriety be termed “rings of destruction;” for wherever irregularities exist in the substance of the metal, there the waves of vibration are interrupted, and the weak point then becomes fractured. The science of spring-making in all its varieties demonstrates the truth of this statement. Leave on a coach-spring an abutment of metal like a “reinforce ring,” and a few motions will be sufficient to break it, however well the spring may be constructed in every other part. The rigidity of this protuberance, by interrupting the waves of vibration, causes additional vibration in the adjacent and more yielding part, and thus produces fracture. The same thing occurs in all ill-constructed artillery: where the vibrations are checked, there is always a danger of some weaker part giving way. But the laws which regulate the distribution of vibrations in metal substances are not yet understood by artillerists, or cannon would be differently constructed. Those unscientific protuberances called “trunnions,” which are to be seen in almost every description of gun, prove the accuracy of my assertions. These protuberances, if scientifically considered, would soon be discarded, since they tend not only to the rapid destruction of the cannon, but also exert a most injurious influence on the direction of the projectile. The most wonderful shooting ever heard of (and which has been before alluded to) is partly to be attributed to the absence of trunnions. Trunnions act as the fulcrum of a scale-beam; they allow the breech and muzzle of the gun to oscillate, but in an opposite direction to a scale beam. Rifled cannon can never be correctly constructed whilst any weight impinges on the gun in front of the first starting point of the projectile; they must have the fulcrum behind the point of discharge, and the more nearly in a direct line the better.

Rifled cannon will in some few years be perfectly constructed of cast steel; the projectile being made of gun metal, *i. e.*, ninety-five parts of copper to five parts of tin, or of lead and its alloys, and at a probable cost of ten times that of a cast-iron projectile of equal weight.

Rifled cannon must be elevated by raising the muzzle; no depression of the breech must occur as by the usual elevating screw; and the recoil must be received and borne by fastenings and axle in rear of the breech only. Trunnions and all impinging influences are incompatible with correctness of fire. The muzzle must be raised in a similar manner to the raising of a hand rifle, the recoil being thrown backwards, in as direct a line as possible with that of the shot.

It is only on account of the difficulty of experimenting with rifled cannon that they are at all behind rifled muskets in point of perfection. The ardent lover of science is appalled when an experiment costs hundreds of pounds. We have not a General Jacob everywhere who can afford to spend a thousand or two in experiments; but, nevertheless, the lover of science, could he experiment, might attain such extraordinary accuracy of range, as to blow up a smaller magazine than that of Kurrachee at four times the distance; and that, too, with a more certain effect, though with a projectile heavier than several of Jacob's rifles tied together. Correct direction is certain in proportion to the increase of weight; deflection being in the minimum with the heavier weight, from the well known law of momentum. That astute and energetic sovereign, the Emperor Napoleon, is pursuing experiments with rifled cannon; with what result there can be little doubt.

It must be by the use of rifled cannon that our artillery will regain the place it has lost. A short time will suffice to make the disparity between our artillery and small arms as great as when we were content with the six-pounder field gun and old "Brown Bess." Ranges will only be ruled by sight, and objects will be hit eventually with as much ease at 5,000 yards as they now are at 1,000. Steel, rifled cannon, and projectiles of gun-metal will assuredly bring about as complete a revolution in artillery as the Greenerian rifle and bullet have effected in small arms.

The form of gun best suited for all purposes has yet to be determined; and we have pointed out these defects in our artillery with the hope that some of the great practical philosophers of the present age may devote themselves to the study of this question. It is nearly allied to the science of bell-making, and a few more fractures of Big Ben will extend our knowledge of the subject, and produce a remedy which lies not very deep below the surface. The laws which should guide us in the construction of cast steel guns, so as to insure their durability, are very analogous to those which determine the durability of bells; for the laws which regulate disintegration of crystalline structures are very similar. Hitherto the rule of thumb has, unfortunately, been the only rule observed in measuring out the quantity of metal which shall surround that portion of a cannon which has to sustain the most violent concussion.

Professor Barlow many years ago proved, to the satisfaction of the Institution of Civil Engineers, that the metal in any cylinder decreases in utility in proportion to the square of its distance from the centre: that the outside of a gun of the form now used, in fact, is only one-ninth as useful as the inside; being three times as far from the centre. If we double the thickness, the outside, being five times as far from the centre as the inside, will be but one-twenty-fifth as useful; or in plain English, nearly useless. The reason of this is simple, and I will endeavour to explain it.

"A bar of cast iron one inch thick each way and 40 inches long will stretch about one-twentieth of an inch, if a weight of about four tons be suspended by it. When the weight is removed, the cast iron nearly recovers its previous form, and is uninjured; but if it be stretched more, by a greater weight, it is permanently injured.

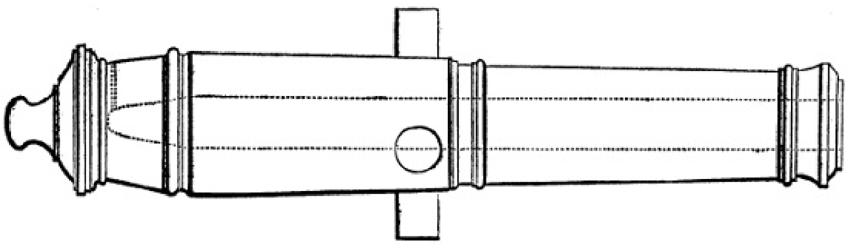
"A bar of the same thickness, but three times as long—120 inches—will stretch three times as much, or three-twentieths of an inch, with the same weight; or if only one-third the weight—one ton and a third—be suspended, it will stretch one-twentieth of an inch, the same as the shorter bar.

"If we suspend 16 tons by four bars, one inch thick and 40 inches long, they will each stretch one-twentieth of an inch only, and remain uninjured; but if we attempt to do so with two bars 40 inches long and two 120 inches long, then, when the whole have lengthened one-twentieth of an inch, the short ones are exerting a force of eight tons, but the long ones that of only two and two-thirds tons. The weight, therefore, will still further lengthen the bars, and permanently injure the short ones; perhaps break them first, and then the long ones.

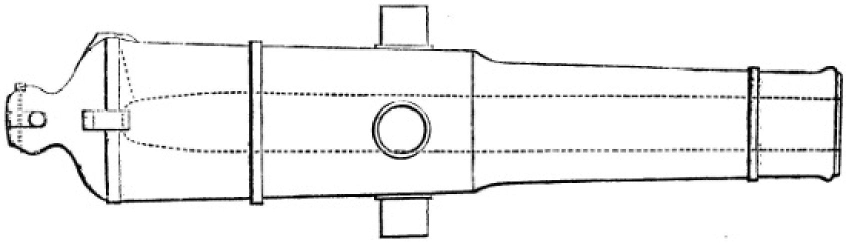
"This is the way a gun is burst. The inside is a series of bars of iron, say 40 inches long, in the form of a ring; the outside a series of rings, representing the bars three times as long."

Warfare, since the first introduction of gunnery into Europe, has been like one continued series of experiments for testing the efficacy of our guns. No description of gun we now possess can lay any claim to existence fifty years ago: the great majority of our guns now in use are of a much more recent date.

With one or two exceptions, no artillery has been constructed on any scientific theory; some alteration has been made, and if a gun of a certain form and dimensions gave a certain result, then an extension or emulation of that gun was tried; and if it succeeded a loud cry of exultation was raised, and the discovery was announced to the world as a great improvement.



Russian 56-pounder gun.



8-inch British gun.

Colonel Prejudice has invented a vastly improved description of gun; another guess is made, and so different forms of guns are multiplied. Can there be a more striking illustration of this than the one which took place during the late Crimean war? It was boasted that the whole human race might be exterminated by the new invention; but the “Lancaster gun” turned out to be most unscientific in its construction, and most eccentric in its action. Had such a thing as scientific knowledge in gunnery existed among the artillerists of the day, such a monstrosity would have been buried soon after its birth; instead of being allowed to squander large sums of money at every discharge, and then at last to become a “Whistling Jemmy” for our bluejackets to laugh at.

The form of cannon no doubt exercises a vital influence over their durability; bad form and imperfection of material combined, tended to produce the rapid destruction of our guns during the late important struggle.

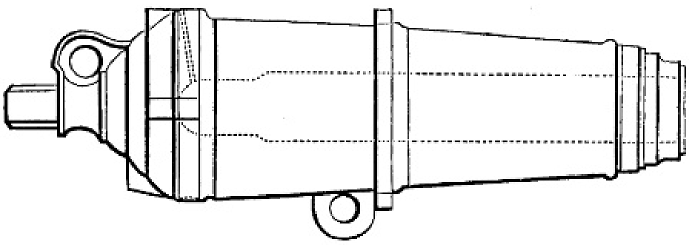
The gun which has been experimented with to the greatest extent, and which has withstood all trials successfully, is a Russian fifty-six-pounder; taken, I believe, at Bomarsund. In this gun there are two great peculiarities; the shape, as will be seen in the diagram, differs from all our own guns: it is a “chambered gun,” and the metal is taken away from the outside precisely as the contraction increases on the inside thus giving an equal thickness of metal in every part, of the arc (see page 114).

In contrast with this, we give a cut of our 8-inch gun, which most nearly resembles it as a chambered gun (see page 114).

The reader’s attention is especially directed to the dissimilarity in the distribution of the metal in the two guns. The want of uniform thickness of metal in our 8-inch gun must be sufficient to convince any one that, if the Russian gun be properly constructed, the principle of ours must be radically wrong. That such is the case, indeed, I cannot doubt, the Russian gun having undergone such a test as would have destroyed six of ours. The gun has since been made two inches larger in the bore, and even oval-bored, for firing shells, which should alone be enough to destroy it; and yet with all this the gun remains perfect.

The gun which most nearly resembles this is our English carronade; and that these guns have some important principle in their shape is proved by their great durability under all trials; and I believe that the tests to which the carronade has been subjected have been more severe than that of any other piece in the British service.

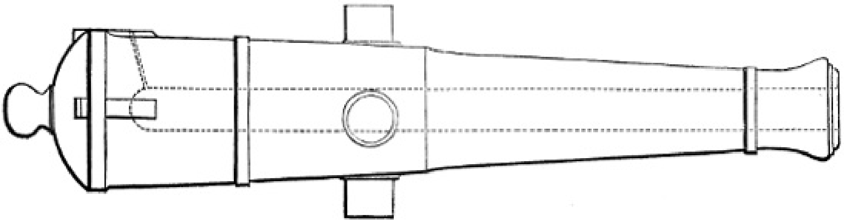
There have been many shrewd conjectures as to the cause of this durability; one of these was very pungent, viz., “the invention was not by one of the cloth.” An examination of the drawing of the 68-pounder carronade will enable the reader to perceive the great similarity between this and the Russian gun before spoken of (see page 114).



68-pound carronade.

The manufacture of these guns was originally in the hands of the inventors, and it is quite evident that they must have taken great pains with the form of the gun, and also have taken special care that the material of which it was constructed was of the very best quality.

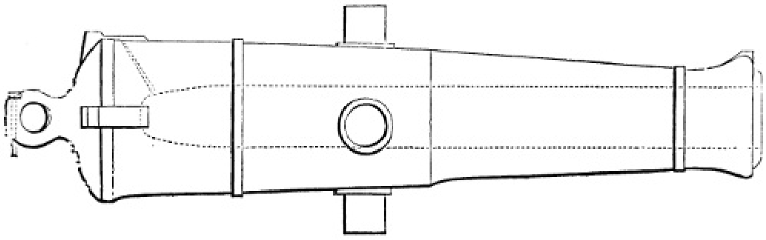
There is too much reason to doubt the proficiency of military men in the science of metallurgy; and the British system of depending solely on their knowledge for the last half century, has no doubt proved an obstacle to advancement in the science of gunnery.



Monck’s 56-pounder gun.

The gun which ranks next is Monck’s 56-pounder. Although not a chambered gun, it will be seen, from the diagram (see p. 117), to be an attempt (if not a perfectly successful one) to obtain uniformity of thickness in every part of the arc. The durability of these guns ranks as we have placed them.

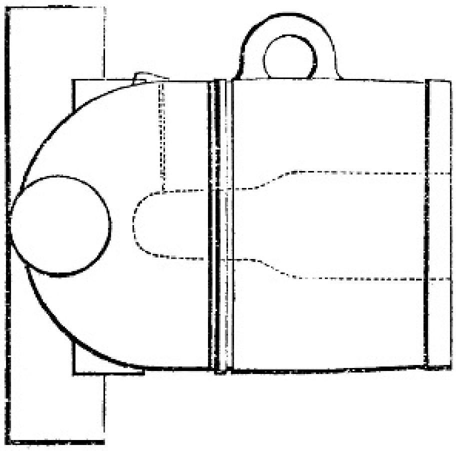
The next in rotation is the 8-inch or 68-pounder (see p. 114); which, although not the original sized gun that was rifled for the Lancaster shell, yet it was the one eventually used for that projectile up to the end of its very brief career.



10-inch or 86-pounder gun.

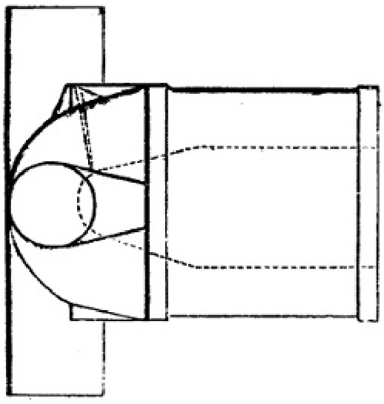
The 10-inch gun of 95 cwt., delineated at page 117, will be seen to be defective in its outlines when tested by the principles before laid down, and the fact of more 10-inch guns bursting at Sebastopol than any others (mortars only excepted), may be taken as exclusive evidence of its imperfection.

The bursting of mortars is quite notorious, especially the 13-inch mortars used for sea-service in the attack on Sweaborg. A slight examination of the engraving of one will be sufficient to convince any person that, if what has already been advanced on the form of guns can lay claim to being scientific, then this is of all guns the most unscientific that was ever manufactured. Its durability, too, like its shape, is of a very low order.



13-inch sea-service mortar.

The 13-inch land mortar depicted below is a much more serviceable production, because it contains much less metal.



13-inch land-service mortar.

Mortars will retain their place in spite of all improvements. Rifling is inapplicable to them. Their principal utility consists in obtaining a vertical fire; the shell being pitched to a great height, so as to fall into places that cannot be assailed by a horizontal fire.

The late Joseph Manton has the merit of being the first modern inventor of rifled cannon. His idea was, that if a motion on an axis parallel to the horizon could be given to cannon balls, they would range farther and with greater accuracy. As there exists great difficulty in causing the rifling in a gun to act upon an iron ball, he constructed a cup of wood, into which the ball was fitted, projections being made upon the wood to fit into the groves of the rifle; the spinning motion thus being communicated to the ball by its wooden adjunct. The result was twofold; for the expansions of the wood during the explosion, filled the tube of the gun tight, and effectually destroyed the windage. The government of the day did offer him a premium of one farthing each; but “Joe” over-reached himself, asking the sum of £30,000 down; this was refused, and the patent was allowed to expire without the Government taking any advantage of it, and experiments ceased to be made in this direction.

Rifled cannon have now, however, become a certainty. Mechanically speaking, they are as easily to be produced as hand rifles. The general application has, however, vast difficulties, which must be overcome before their use can become general. Small arm projectiles suitable for rifles must of necessity be made of ductile metal, and all the attempts previously made, whether with brass or iron guns, are alike useless. The mass in motion, even when of equal hardness with the gun (as in the case of cast iron guns and cast iron shot), invariably destroys that in a comparative state of rest; and the rifling is obliterated after a very few discharges. In a brass gun the destruction is certainly not so rapid, on account of the different nature of the metal; yet the destruction of the gun for all useful purposes is equally effectual. It is evident, then, that success cannot be obtained by using the present materials in rifled cannon; and the question inevitably arises, what better material can we use? Wrought iron shells have already been thoroughly tried in the Lancaster oval gun, with a well-known result.

Great hopes were at one time entertained, that something suitable would result from Mr. Bessemer’s discovery of the combustion of carbon, and that an iron of sufficient ductility, yet without the usual hardness, would be produced; but this, it appears, is still a myth.

Extent of range and accuracy of fire in gunnery will in future be of so much importance in war, that it is not extravagant to assert, that in contests between well-matched belligerents, the precious metals (if they gave any advantage to the user) would be unhesitatingly used in projectiles. But on the score of economy, science need not be impeded. Gun-metal projectiles and cast steel cannon would work as effectually together as lead and iron in small arms.

Some other mixtures less expensive might be produced (lead and copper in certain proportions are very ductile), and at the same time sufficiently strong to resist all tendency to squash; as the softer metals would inevitably do. The more ductile metals are limited in their utility, by the same law which limits the use of pure lead: that is, to given weight, height of column, or velocity. Great doubt exists whether a bullet made of gun metal, and of the same proportionate dimensions and form as an Enfield bullet, but fitted for a ten-inch gun, would not, if fired with the proportionate charge of powder (namely, seventeen pounds), be as completely squashed, or driven in upon itself, as the Enfield bullet if fired with the old Brown Bess charge of four drachms and a half.

Considerable time and experience will be required to ascertain the proportions of metallic mixture necessary to meet all contingencies; this, however, is a matter of detail, and must extend over so large an area, that it can be handled only by the government officials, with the necessary “sinews” of experiment. Nevertheless it must be undertaken; and the sooner it is done the better, for the prestige of that nation which would lead the van of improvement in gunnery, and increase its power of attack and defence beyond those of its rivals.

Rifled cannon is a generic term of endless application, presenting to the mind modifications of projectiles in endless variety, ranging from the “*light firebrand*” to the twice deadly rocket: not rockets of that eccentric and erratic character by which Congreve made an undying name; but real *bonâ fide* rifle rockets, which shall hit the dead-lights in the quarter-gallery of a frigate, carry away the halyards of your enemies’ ensign (making him drop his colours at the first shot) or dash the glass from the hand of the pilot. All such imaginary feats will yet be accomplished;

though the reader may smile at the idea. My experience with rockets goes to justify me in asserting that rockets discharged from a gun, under certain circumstances, can be as effectually controlled, and kept to a direct course, as a bullet fired from a rifle. The rocket, however, may be fired a much greater distance than we have ever been able to project a bullet; because, in addition to the force which projects it from the gun, its flight is maintained by the self sustaining agency in the body of the rocket. Rockets require a much smaller charge of powder to project them than that which is used for a bullet; a rocket started by its own force, expends, in acquiring even an approximation to its highest velocity, at least one-third of the force with which it is charged; but when projected by a small charge of gunpowder this force is saved, and the flight of the rocket is afterwards sustained by the force with which it is charged.

Firing rockets from cannon can only be practised under certain circumstances. The observations already made on the granulation of gunpowder will have prepared the reader for this announcement. When fired from a cannon under the old régime, the rocket was projected at high velocity, and the case of the rocket was destroyed by the very force which set it in motion. A rocket suitable for artillery should be cast of gun metal, with a frame of considerable strength. In form it should nearly approximate to an expansive bullet; but, instead of the limited length of one and three quarters diameter; it should approach to four diameters; two of which, at least, should be appropriated to the cylinder behind the head.

The head is charged with composition more densely driven than is customary in the ordinary rocket; the tubes in the cylinder are also charged with a composition equally dense. The outer frame of the rocket is cast with suitable projections to fit the grooves of the gun: the spiral of these grooves is considerable, being one turn in every three feet, in order to impart to the rocket an effectual spinning motion when in a low state of velocity. The rocket properly constructed is then placed in the rocket-gun, and fired in the usual way; but it is essential that the gunpowder used should be of a suitable quality: its combustion must be as slow as possible, a starting velocity of from 500 to 800 feet per second being sufficient to ensure the flight of the self-sustaining projectile to the end of its range. This principle may be extended from a light firebrand, as already stated, to that of a rocket charged in the head with the most deadly and destructive fulminate.

It may appear absurd to speak of fulminates being projected; since all experiments show that fulminates, even when adulterated, will not stand the concussion of a discharge, but invariably ignite in the gun, however carefully placed or packed in the shell which contains them: for this reason fulminates have never been successfully used. But if the fulminate is placed in the head of a rocket, this objection may be obviated. The gradual manner in which velocity is given to a rocket does not subject it to violent displacement during its flight; neither need the concussion in the gun be severe, owing to the nature of the gunpowder used, which in its gradual expansion is analogous to steam: thus the field for the application of fulminates is opened to an unlimited extent.

My own experience on this subject has been limited to its application for the saving of life from shipwreck, where the application of a line to the rocket limits its range and velocity; but sufficient is left in a rocket of an inch and a half diameter effectually to carry out a line of a quarter of an inch diameter to a distance of 600 or 800 yards: that is, more than double the distance obtained by either Manby’s apparatus or the rockets now in use; which, lamentable to state, are quite inadequate to the purposes for which they are intended.

Though the improvements in rifled cannon are at present only in their infancy, they have nevertheless attained to an extraordinary degree of perfection, verifying all our predictions to the letter.

A writer in the *Times* makes the following statements in favour of Mr. Whitworth’s improvements:—

“While some men of really inventive talent, and a great many charlatans, have been permitted to waste the public money in trying vainly to improve our artillery, it seems passing strange that it should not long ago have been discovered how impossible it was to hope for successful results in the direction in which they were working. It was clear that while increased range and precision of firing were wanted, it was nearly as important to bring the charges of ammunition and the weight of metal in guns into more manageable proportions to each other, and to the facilities for transit on active service. No sensible man can have witnessed the frightful damage done to the efficiency of our army in the Crimea by the exigencies of the siege-train during the winter of 1854-5 without being impressed with this conviction. The principle of the rifle offered an obvious suggestion for the proper means of working out the foregoing problem; but then for artillery, rifling by grooves would not do without the use of a pliant metal in the projectile, and the cost of lead rendered its application to that purpose impracticable. It was necessary, therefore, to alter the existing mode of rifling, and to modify the bore of the cannon, so that an iron projectile could be discharged from it, rotating on its own axis in the line of flight. This result once secured, it is obvious that a field-piece or gun of position would become a rifle on a large scale, and that the same immense increase of range and of penetration which had been realised by the smaller weapon as compared with Brown Bess, would be placed at the command of the artillery service. It is consolatory, after a series of failures worthy even of Brunel in launching the *Leviathan*, that the country has at last the well-grounded hope of an improvement by which our ordnance may be placed on a proper footing. In pursuing those careful experiments which he undertook for the Government, principally to improve the rifle, Mr. Whitworth, the eminent machinist, adopted a polygonal spiral bore of a uniform pitch, but more rapid than could be attained by grooves. This bore has enabled him to surpass immensely the range and penetration of the Enfield rifle; but even these advantages, important as they are, scarcely surpass those which it places within the reach of our artillery service. The strain of the projectile being distributed evenly over every side of the polygon, iron can be substituted for lead in the projectile, and this simple but beautiful mechanical appliance at once becomes available for cannon."

The powerful aid of the *Times* is "almost success;" though in this instance it has signally failed, the boasted accuracy there spoken of not having been yet obtained. This has no doubt arisen in part from the fact that Mr. Whitworth's great mechanical knowledge would not suffice to make him *au fait* at the compound science of gunnery. His "polygonal spiral bore of uniform pitch, more rapid than could be obtained by grooves," is after all only an experimental gun, not sufficiently developed as yet for practical utility. Still, the writer already alluded to has favoured us with the following remarks in the *Times*:

"Moreover, Mr. Whitworth has discovered in the course of his experiments, that according to the quickness of the turn in the polygon is the length of the projectile that may be fired; so that 24 lb. and 48 lb. shot have been sent to extraordinary ranges with half the usual charge of powder, from an ordinary 12-pounder howitzer. Here, then, is at once the solution of the whole question which has troubled the brains of so many inventors, real or pretended, for years. The artilleryman at one stride resumes the relative position to the soldier of the line which the Enfield rifle had so perilously deprived him of, and this mechanical country, after finding herself on the level of France, Russia, and other European States, is once more, as during the Peninsular campaigns, enabled to assert her natural superiority in the manufacture of cannon. We trust that no petty jealousies on the part of narrow-minded officials will be allowed to interfere with the course of Mr. Whitworth's experiments, and that the encouragement which he is now receiving from the Minister at War and the Commander-in-Chief will enable him, at no remote date, to realise for the benefit of the army and the nation that revolution in gunnery which the results already obtained by him promise."

Report says that 25,000*l.* is the amount of encouragement Mr. Whitworth has received from the Minister of War and the Commander-in-Chief; an adequate sum with which to conduct such an experiment, but not sufficient to insure success.

Of the success of Mr. Whitworth's polygonal projectile, on a large scale, none need speculate, for the principle is self-destructive.

Lancaster's oval shell, oscillated in its flight, took a flight so extraordinary, on account of the resistance of the atmosphere on the protuberances of the oval, that the principle may be regarded as fully established that enlarged projectiles must be smooth and free from projections that "saw the air," otherwise range and accuracy of fire will be sacrificed. The principle of Mr. Whitworth's polygonal bore is fully discussed in its proper place, and will here receive only a passing notice.

To Mr. W. G. Armstrong, of Newcastle-upon-Tyne, much more credit is due than can be claimed for Mr. Whitworth. Long before the paid efforts of Mr. Whitworth, Mr. Armstrong had made the subject of rifled cannon a special study, and the success of his investigations has been such as to couple his name with those of the earliest inventors of effectual rifled cannon. Mr. Armstrong may also lay claim to being an originator of wrought steel cannon; though here his name stands second as an inventor, for to Mr. Krupp is due the honour of first introducing cast steel cannon to the notice of our Government.

Mr. Armstrong tells his own tale so well in the columns of the *Times* that we cannot do better than quote it:—

"In the latter part of 1854, I submitted to the Duke of Newcastle, then Minister at War, a proposal for a gun which I anticipated would possess great superiority over the common forms of light artillery, and I undertook, with his Grace's authority, to construct a field-piece in conformity with the plan I had suggested. The gun was accordingly soon afterwards made, and has since, during a period of nearly two years, been the subject of numerous experiments, partly upon the ordnance firing-ground at Shoeburyness; but principally under my own direction in this neighbourhood.

"I have hitherto avoided publicity in reference to these experiments, but, as matured results of much interest and importance have now been arrived at, and as other names are already before the public in connection with gun experiments made during the same period, I feel that I may now, without impropriety, give some information on the subject.

"With a view to strength and durability, the gun is composed internally of steel and externally of wrought iron, applied in a twisted or spiral form, as in a musket or fowling-piece. The bore is nearly two inches in diameter, and is rifled. The projectile is a pointed cylinder 6½ inches long, and its weight is 5 lb. It is made of cast iron, coated with lead, and is fired from the gun with a charge of 10 ounces of powder; it contains a small cavity in the centre, and may be used either as a shot or a shell. When applied as a shell, the cavity is filled with powder, and a detonating fuse is inserted in front, so as to fire the powder in the centre on striking an object. When used as a shot, the powder is omitted, and an iron point, which favours penetration, is substituted for the fuse. The gun is constructed to load at the breech, the object being not only to obviate the disadvantages of sponging and loading from the front, but also to allow the projectile to be larger in diameter than would enter at the muzzle, and thus to insure its taking the impress of the grooves and completely filling the bore. The piece weighs 5 cwt., and is mounted upon a carriage which bears a general resemblance to that of an ordinary 6-pounder field gun, but which embraces a pivot frame and recoil slide. A screw is also applied, not only for elevating and depressing the gun, but also for moving it horizontally, by which means great delicacy of aim is effected. The recoil slide has an upward inclination, which enables the gun, after running back, to recover its position by gravity; and its use is to relieve the pivot-frame and adjusting screws from injurious concussion.

“I shall now give some particulars of the experiments recently made with this gun on the coast of Northumberland, near the village of Whitley, under the official inspection of Colonel Wilmot.

“Fourteen shots were in the first instance fired from a distance of 1,500 yards at a timber butt, 5 ft. wide 7½ ft. high. Six of these were expended in finding the elevation proper for the distance, but after that was determined every succeeding shot hit the object without previous graze. The final elevation of the gun was 4 deg. 26 min., and the mean lateral distance of the shot-marks from a vertical line through the centre of the butt was only 11½ in.

“Persons who are conversant with artillery practice will be able to appreciate the accuracy of this firing; but, for the information of those who are unacquainted with the subject, I may state that the ordinary 6-pounder field-piece, which in point of weight forms the nearest approach to the present gun, is perfectly useless at a distance of 1,500 yards, and is very uncertain even at 1,000 yards. It is only, therefore, with heavy artillery that a comparison can be drawn; and it will be sufficient to state that in tabulating the practice made with such ordnance the deflections are invariably recorded in yards, whereas with this rifled gun they can only be properly given in inches.

“With respect to penetration, the following particulars will be regarded as equally remarkable, considering the small weight of the shot and the length of the range. The butt was 3 ft. thick, and was composed of six layers of rock elm bolted together, so as to form a solid block. One shot passed entirely through; another struck near the edge and glanced; and the remaining six penetrated within a few inches of the opposite side.

“Shell firing was next tried at a distance of 1,500 yards; the gun being fired at the same elevation and with the same charge as in the previous practice at the butt.

“In this case two targets were erected, one behind the other, so as to appear as one object when viewed from the gun, and a space of 30 feet was left between them. The front target was intended to exhibit the perforations of the shell before bursting, and the back one to show the effect of the fragments resulting from explosion.

“After some preliminary experiments twenty-two shells were fired at the front target, and of these only one missed the object of aim. The following are the particulars:—Seventeen hit the first target direct, and burst behind it, the fragments penetrating the second one; three grazed and burst immediately in front of the first target, and perforated both with the pieces; one hit the bottom of the first target and exploded in the ground, and the remaining one missed entirely and burst on some rocks nearly on line beyond. A strong side wind was blowing at the time, and accounted for the deviation of this single shell.

“Four shells and three shots were then fired at an elevation of 6 degrees, from a distance of 2,000, or, more accurately, 1,964 yards. All these struck within the breadth of the target; but the elevation being scarcely sufficient, they all fell a little short, except one shell, which, ranging somewhat further than the others, hit the target and burst as usual.

“The results of this shell-firing were as follows:—The front target contained 51 holes, and the back one 164, while the ground between and adjacent to the targets exhibited about 70 perforations by fragments of shells, the greater portion of which were afterwards recovered by digging.

“With respect to ranges exceeding 2,000 yards, I may state that on previous occasions the gun had been tried up to 3,000 yards—a distance which was reached with an elevation of 11 deg., and the usual charge of 10 ounces of powder, or 1-8th the weight of the projectile. By augmenting the charge the range is increased, but the accuracy is impaired; and I therefore adhere to the 10-ounce charge, which gives ample penetration, as the experiments at the butt will testify. I may also observe that the ranges obtained with this charge bear a favourable comparison with those of the heaviest round-shot guns fired with a much larger proportion of powder.

“It is a curious fact, and one which greatly increases the efficiency of the shells, that owing to the bursting charge requiring a minute space of time to mature its ignition after the firing of the fuse by impact, the shell is enabled to travel four or five feet after striking an object before disruption takes place. Hence, therefore, it acts as a shot before it bursts as a shell. When it perforates a target the explosion may be seen to take place at a few feet beyond, and when it grazes it has time to rise, and may be observed to burst after clearing the ground. If, therefore, it were fired against a ship, it would first penetrate the side in its entirety, and then, bursting, traverse the deck in fragments; or if directed against troops, it would pierce the front line as a bullet, and operate like grape-shot beyond. The shells explode with equal certainty whether the first substance struck be hard or soft; and, in fact, they even burst on the surface of water, provided the elevation of the gun be not too great. The bursting charge is very small, but it suffices to break the shell into about 30 pieces, which pursue their forward course without too much dispersion.

"It is impossible to contemplate the results obtained with this gun without being impressed with the important part it is calculated to perform in warfare. Opposed to any ordinary field-piece, it would be like the Greener rifle against the old musket; and no gun could be worked at an embrasure if a fire of shells were directed against it by one of these rifled pieces placed within the distance of a mile. In naval operations, also, guns of this description, but of larger size, might apparently be applied with great effect—more especially as a system of breech loading, combined with a self-recovering recoil action, would be peculiarly advantageous in firing from portholes. Even light 5-pounders, sending their shells from great distances through the sides of a ship and sweeping the decks with fragments of lead and iron, would produce very destructive effects; and a small swift steamer carrying a few such guns might prove a very troublesome opponent to a large ship of war. But if the dimensions of the gun were increased so as to adapt it for shells of 20 lb. or 30 lb., still more terrible injury could be inflicted at greater distances; and the ponderous artillery now used at sea would be of little service when opposed to the accurate and long-range firing of such rifled shell-guns."

Since the publication of these remarks, rifled artillery of Mr. Armstrong's production has, we believe, been extensively tried. The results of these trials have been most extraordinary; and the principle is, we believe, identical with the expansive principle bearing my cognomen: an extension of the principle of the Greener and Enfield rifle, hereafter to be described. I have had the honour of being consulted both by English and foreign authorities, and I have assisted in constructing rifled artillery for several years; and the experience thus obtained justifies me in making known to the world some of my observations on this subject.

Rifled cannon with elongated projectiles, similar in shape and principle to the Greenerian bullet, give, with charges inferior to those of the old régime and calibre, more than double the range, with ten times greater accuracy.

Now, either of these points, if gained, would be most important improvements, and when combined would produce the most extraordinary results. But this is not all: a great diminution in the weight of the gun might also be effected; and these advantages may be still further extended when we have had time to increase our knowledge of the valuable materials with which we are only just now becoming acquainted.

The following table will show the advantages to be gained both in length and accuracy of range.

Before reverting to the table, it may be necessary to remind the reader that the great reduction in the weight of guns arises from the adoption of the elongated projectile. For example: the diameter of the *elongated* projectile for an "18-pounder" is much less than the diameter of the gun for the *spherical* 18-pounder; thus allowing the thickness of metal to be equal in both guns. The gun for the elongated projectile may be greatly reduced in weight without at all diminishing its strength, simply on account of the great diminution in the diameter of the arc.

There is another important fact, which Mr. Whitworth, with all his boasting, has carefully concealed: viz., that a much greater pressure is exerted upon the square inch in the lesser than in the larger diameter of bore; and to conceal this fact, whilst claiming merit for a bullet of 50-gauge exceeding in range one of 25-gauge, the charge of gunpowder being alike in both cases, appears very like deception. Any engineer will tell us that the pressure in the lesser is twice as great as in the larger bore; and this explains why greater velocity is given to the projectile.

With these explanations the reader will be better prepared to weigh carefully my observations. My task would, doubtless, have been rendered more easy, if a clear elucidation of the principles of the expansive bullet could have been given thus early in the work; but it is thought better to do this in its proper place. I will only add here, that although two bullets, one elongated, the other spherical, and of equal diameter, meet with the same amount of atmospheric resistance, yet the one containing twice as much matter as the other retains its medium velocity nearly double the distance. With these explanatory remarks I give the following table:—

——	Present Range of Guns.	Present Weight.	Reduced Weight when Rifled.	Range when Rifled.
6-pndr.	1,500 yds.	17	12 cwts.	3,000 yds.
9-pndr.	1,600 „	26	18 „	4,000 „
12-pndr.	1,700 „	34	22 „	4,500 „
18-pndr.	1,780 „	42	29 „	5,000 „
24-pndr.	1,850 „	50	34 „	5,500 „
32-pndr.	2,000 „	63	42 „	6,000 „
48-pndr.	2,500 „	70	45 „	6,500 „
56-pndr.	5,000 „	85	60 „	8,000 „
68-pndr. or 8-in.	4,500 „	85	60 „	8,000 „
86-pndr. or 10-in.	4,700 „	95	65 „	9,000 „

The reader must understand that all the guns given in this table were not rifled, and that they have not all been subjected to trial. The 6, 12, 18, 24, and 48-pounders have been tried, with the results given above; but the heavier guns have not as yet been tested: the ranges and weights given in the table have, however, been derived from the results yielded in the trial of the lesser guns, and may be safely relied on as scientific data; being, in truth, rather under than over the mark.

All experiments clearly establish one very important principle, long known to those acquainted with the science of projectiles, viz., “That the heavier the projectile, the less the deflection.” Thus it is quite possible that the longest ranges may ultimately be obtained without any perceptible deflection. And when we observe that the deflection of an ordinary 32-shot in a range of 2,000 yards, is 50 feet, and in 2,500 yards, 80 feet, whilst the elongated shot, at a much greater distance, is not deflected half as many inches, I think we may fairly say that our knowledge of gunnery is yet in its infancy. Fulminating powder may be used as an auxiliary in shells for various important purposes; such, for instance, as destroying an entire fleet; and it is clearly within the range of possibility that by its agency the largest ship may be destroyed by a single shot. The accuracy of rifled cannon renders it an easy task to strike a plank only one inch above the water line, and the penetration of an elongated gun-metal or lead-alloyed shell would enable us to reach the innermost parts of the magazine: for it is scarcely possible to produce even an iron casing which shall resist the power of such projectiles. It is possible, therefore, that we may see the noblest fleet destroyed in a few minutes by the agency of such projectiles.

I will endeavour to give an outline of the method by which this may be effected. A long rifled cannon, constructed for an elongated gun-metal shell; of from fifty-six to eighty-six pounds, and with an extreme range of from 6,000 to 7,000 yards, may be considered to be a suitable instrument. This shell should be charged in the head with a given quantity of the fulminate, such as would be most calculated to prevent the tendency to explode from the concussion produced by the discharge of the gun. It will be necessary to place the fulminate in thin layers between sheets of prepared caoutchouc, or some other preparation of India-rubber; having thus arranged the fulminate in the head of the shell and secured it there, the usual method of filling the remainder is resorted to, and the aperture is securely screwed up: fuses not being necessary in this arrangement.

The difficulty in using this shell is to prevent its explosion when the gun is discharged; and to obviate this all our engineering skill is required. Time and experience will show that, by a modification of the propelling agent, the shell may be started from a rifled cannon at a very low velocity; the velocity being increased like that of the rocket. This is to be done by modifying the arrangement of the gunpowder so as to ensure the shell acquiring its greatest velocity as it leaves the muzzle of the cannon. The result of this has been already shown. On the shell striking any object, such as the ship’s side, the metal of the shell is driven in upon itself, and an explosion of the fulminate follows as a natural consequence. Experiment has proved that shells exploding as they strike the ship’s sides, produce very little damage beyond making a hole in the ship the size of the shell. This, no doubt, arises from the short space of time occupied by the shell in passing through the side of the ship; all its force being exerted in the interior instead of on the sides of the vessel. All shells of the nature alluded to would, at certain distances, take such a line of flight as to ensure them dipping towards the centre of gravity, and thus exploding the magazines, however deep below the water-line; and when we consider the destructive effects of fulminates, we think it quite within the range of probability that they might produce all the effects we have spoken of.

There are many agents equally powerful to be introduced into destructive warfare; and with the advantages to be derived from improvements in rifled shells, which the ingenuity of the present race will certainly effect, he would be a rash man who would set any limits to the advancement of projectile science. The great difficulty in the use of fulminates will be surmounted if these suggestions can be carried out; and experiment is all that will then be necessary to establish the line of proceeding. To effect this is the province of the Government of the country; to wait for it to be perfected by individual skill and enterprise would be unjust to science, and injurious to the best interests of the nation. The needful expenditure can only be borne by the nation, and should be entered upon, in order to effect improvement in projectiles, with the view of maintaining our land and marine artillery at the highest point of efficiency.

There is one question of great importance to inventors, and to which I have paid much attention, namely, the obtaining a spiral motion in a projectile which has been fired from a smooth bored gun. All we have witnessed goes far to prove that the attainment of this is impossible, in consequence of a principle not hitherto investigated by inventors. If the course of a projectile is changed from the straight to the spiral, it can only be done at the expense of range; and that for the following reasons: first, the force which is necessary to induce this spiral movement must be exerted at the expense of the force which propels it forward; secondly, when this spiral movement is acquired, it is so much in excess of the direct movement, that after advancing a certain distance it falls to the ground. A very simple experiment will prove this. Take an ordinary tin tube, cut a bullet of an elongated form—cylindro-conical if wished—having grooves from the point backwards, with the degree of spiral necessary to effect the object in view. Let the bullet be made of cork or light wood, such as can be projected by a blast from the mouth, and the result will be that the projectile will go one-half the distance before the friction of the atmosphere produces a motion on its axis parallel to its line of flight; from this point it gradually loses its velocity in a forward direction, it spins until its force is expended, and then falls vertically to the ground. To find the sequel, try the same experiment without grooving, and the range, with the same force, will be found to be double. Some years ago I witnessed such a trial with a 32-pounder; and, to the astonishment of all present, the bullet rose above the horizontal line, and then fell to the ground, like the cork bullet of which we have already spoken.

The endeavour to produce breech-loading cannon is an effort to obtain uncalled-for and superfluous facility in gunnery; and if a perfect breech-loading cannon could possibly be produced, what would it avail? What superior property could it possess over the solid gun? It could not be safety; for when we consider the very limited number of explosions by which the very best guns are destroyed, it can scarcely be possible for a gun composed of many parts to endure the intense vibrations to which large cannon are subjected. The regular distribution of vibrations in the metal of the gun is the great point to be attended to in the construction of artillery; so that vibrations may not be incorrectly induced by malformation, or by an excess or deficiency of metal at any particular point; for where the waves of vibration are checked by an unequal distribution of metal, or other causes, there the weak point in a gun is always found, as all fractured guns clearly demonstrate. An intimate acquaintance with the metallurgy of cannon, enables me to give an almost unerring opinion as to the causes leading to the fracture. Most undoubtedly, vibration, if judiciously distributed, is the soul of endurance; but if injudiciously distributed is certain to result in the destruction of the cannon. In structures composed necessarily of many joints, obstruction to the waves of vibration must occur; the different parts do not expand and vibrate equally; a kind of revulsion is induced; part repels part, and destruction ensues as a natural consequence. Under no circumstances, therefore, can a breech-loader be as safe as a solid gun.

The facility with which breech-loaders can be charged is generally trumpeted forth to the world as an advantage of vital importance; but let us carefully examine this point and see if it has not been exaggerated—whether, in fact, a solid gun cannot be charged and discharged as rapidly as a breech-loader.

In the first place, all guns recoil; this necessitates the relaying of the gun after every discharge, in order to obtain accuracy of aim; and if facility of loading is to be obtained at the expense of aim, it can scarcely be called an advantage. Aim consumes more time than loading. A six-pounder may be loaded and fired six times in the first minute; but it would be impossible to do this and re-lay the gun after each shot. Where then is the advantage of firing six shots per minute if you cannot hit six objects? And if breech-loaders could be fired *sixty* times per minute, what would they avail if aim was wanting? The raising or depressing of the breech of a gun by means of the elevating screw; slewing to the right or left, spunging the gun, and ramming home the powder and shot, all consume time; hence we think that quickness of loading is worthless.

Breech-loading cannon cannot be constructed for bullets of larger diameter than that of the rifle bore, without a ductile bullet be used; for, as is usual in breech-loading small-arms, the bullet rifles itself as it is forced up the grooves. The projectiles for rifled cannon have hitherto been cast with corresponding grooves and lands to fit the internal form of the cannon. A compound shot, composed of iron, and covered externally with ductile metal, has been tried in a few instances; but, unfortunately, the difficulty of combining two metals so dissimilar as iron and lead has been found so great as invariably to end in a failure; therefore no prospect exists of bringing into play this, the best point existing in breech-loading arms.

Lastly, the tendency of all guns to absorb the heat, developed during explosion, puts a limit to all extreme rapidity of fire; even if this was not already limited by the more essential point of taking aim. At Sweaborg it was found necessary to allow an interval of five minutes between each discharge of a mortar, and yet the whole of them burst after an average of 120 shots. Time and ingenuity spent in planning and constructing breech-loading cannon will always end in disappointment and failure. Many are the plans extant, evincing great skill, perseverance, and everything needful in point of mechanical experience, but betraying a total ignorance of the metallurgic science and of practical results from the use of the engine. The study of these points will save money, time, and what is of more value, brain-work, which might be better employed. Striving to produce perfect breech-loading cannon is like striving to square the circle.

CHAPTER IV.

ON THE MANUFACTURE OF IRON FOR GUN BARRELS.

A considerable progress in improvement has taken place in manufacturing the higher quality of iron since my last publication. Not that I arrogate to myself any credit on that score, but it is evident that good frequently comes of flagellations, whether on the body or the mind. One part of human nature will ever fear the exposure of bad qualities, while another is emboldened to advance in improvement if the slightest chance exist of success or encouragement. Thus we often see men striving to produce one invention on the back of another, with wonderful perseverance, finding many blanks and rarely a prize; for truly in this competing age, the mind must be strong that can fight long. Bitter is the disappointment of the truly ingenious mind, to see the produce of his brains thrown as lumber into the *herring barrel*,—as the printer terms the receptacle for what he sets no value upon; while the valueless contrivances of the mean and sordid are preferred and rewarded, because they enable the manufacturer to produce cheaper, by foisting on the public a deceptive or a spurious article. All inventions for purposes of deception, are readily, aye, eagerly, patronised; for they return gold to the coffers sooner.

The improvement in the manufacture of gun-barrels depends on the quality of the iron entirely; for it would be a useless waste of time to endeavour to make a good barrel of inferior metal. Science and experience have worked a wonderful change in the mixture of the superior qualities of iron: we have had announcements of silver-steel barrels at *ten guineas a pair* in the rough, of Brescian steel barrels, carbonised iron, and I know not how many more descriptions or compounds of metals, to form the best material for high-priced barrels. We have now metal which, in the rod, cannot be sold for less than one shilling and twopence per pound: the iron for a pair of barrels thus costing sixteen shillings and fourpence. This is good; nay, more than good —'tis excellent. But there is a dark side of the picture, over which I would fain draw a veil: but I must not. Belgium, France, Holland, and Germany, are improving, are marching onward, and we, alas! are standing still. Competition and cheapness combined, are driving our gun trade into a labyrinth, out of which it will be long ere it finds the clue of exit. Our manufacture of inferior gunnery has certainly reached a depth of inferiority which never any other manufacture in the world reached, and I hope never will.

During the existence of the slave-trade, many thousand guns per year were made of what is, by the trade, technically termed "*park paling*," a material only fit for such purposes; and the cost of it was only *seven shillings and sixpence* each *spike*; but now we can furnish slave traders with ship-loads, if they choose, at only *six shillings and sixpence* each, and it is still supposed that one of these *imitation* guns is the blood-money for a fellow-creature. It would be a just and equitable law, if our legislature would pass it, "That every man should fire the guns he manufactures:" nothing would more surely tend to improve the quality of guns of a low grade.

A considerable increasing difficulty attends the obtaining of horse-nail stubs from the continent. In various continental markets from whence we draw our supply, the skill and ability of the gun-barrel makers have increased; and the preference for superior fire-arms which is gaining ground with many continental sportsmen, has taught foreigners the value of their old horse-nails; and hence their increased scarcity. The inferior iron of which we make horse-nails prevents entirely the use of our own; consequently it requires no foresight to predict that our manufacturers will soon resolve themselves into two descriptions—the very best and the very worst. The latter are already actively employed, and the others are advancing; as no doubt an increasing desire to obtain the most perfect gun pervades the thinking and affluent portion of the sporting world.

The manufacture of iron is a science truly worth the consideration of the philosopher, for it is fraught with the most important consequences, considered either as a material of commerce, or the means to an end. In advancing manufactures and the progress of improvement, it has had an effect on civilization unequalled by any known product, gold not excepted; for no substitute exists for iron, or ever did. No doubt the ancients had their bronze, of which they could form edge tools, even razors; but that was a very limited use of cutting tools: enough, perhaps, for war or subsistence, but not for the progress of the arts.

Of the first discovery and use of iron we have no record; though its value may be presumed from the fact, that Quintus Curtius mentions that "Alexander of Macedon, received a present from Porus, an Indian chief, of about 30 lbs. weight of steel." If this were a present fit for the conqueror of the world, its value, even at that early date, must have been great indeed.

For many centuries, up to the sixteenth, all iron was produced by the aid of wood charcoal; and with such contracted and limited means, it was found that not more than 50 per cent, of the metal contained in the ore was extracted; consequently at this day all the ancient deposits of *slag* are sought for and re-smelted, yielding a handsome return to the manufacturer. The adoption of coal coke was a matter of necessity, but it has been productive of extensive benefit in all manufactures of iron of medium quality. The opinions of many men of science lead to the belief that it has benefited the higher quality also; but I am quite satisfied of the reverse. The quantity formerly obtained in the yield was, as shown, only 50 per cent. of the quantity existing in the ore; but yet it was the purest metal: for it is unquestionable that the best is soonest fused.

The iron ore of Great Britain is, beyond a doubt, inferior to that of many parts of the world; as all attempts to produce good steel from it have been attended ultimately with disappointment. Mr. Mushet, in his excellent work on iron, says, “The successful exertions of individuals have increased the manufacture of cast and malleable iron beyond all precedent in this country; nor have we been without some enlightened individuals, who have laudably endeavoured to form a superior quality along with the extension of their manufactures. Success has so far crowned their praiseworthy exertions, aided by the operation of knowledge, in removing the prejudices of the artisan, that bar iron of our own manufacturing has been substituted, to a great extent, in place of that formerly used of the Swedish and Russian marks; but hitherto all attempts have failed to make bars of proper quality to form steel, in any degree comparable to that we daily manufacture in great quantities from foreign iron.

“Here we remain at an immense distance behind; and while our manufacture of iron goods exceeds the collective exertions of all Europe, we humbly feel our dependence upon two foreign markets for the supply of that steel-iron, without which the beauty, the utility, and extent of our hardware manufactures would be essentially injured and abridged.

“The policy of the foreign holders of this article communicates many undue advantages to the favoured few to whom the steel-iron is consigned in this country. The rapid progressive rise in value of this iron, for many years past, has already nearly doubled the price of steel to the workman, and given the trade in general a melancholy foretaste of the evils of dependence and *monopoly*.”

So it is with the scrap, requisite to form good iron for gun-barrels. I have had several pairs of barrels sent from Berlin and Vienna, to be fitted up in the English style, with a certain knowledge that they were wanted for patterns; and in justice let it be said, the material and figure in the barrel were most beautiful: being a variety of Damascus, or fancy pattern in the metal, *superior* to anything seen of this country’s manufacture. True, this is not an essential requisite, being more for appearance than utility; but the fact clearly shows the industry and will of the artisan. The iron, too, in clearness and density, we can scarcely surpass; therefore, if I regret that we are not advancing with our competitors, it proceeds from a clear conviction of the truth that we are slumbering upon our fancied superiority. A friend who had lately visited Liege, informed me that in one gun-maker’s shop alone, were employed fourteen of our best workmen; in fact, he brought with him a gun which attests the great improvement the Belgians have made of late years. I have had possession of three guns, bearing on the lock and barrels, “Joseph Manton, London;” “Joseph Egg, London;” and “John Manton and Son, London;” all of which were manufactured in Belgium; and so well is the imitation executed, that it would puzzle most amateurs to discover the fraud.

Recently a company, entitled “The Indian Iron and Steel Company,” has commenced importing and and manufacturing iron and steel from Hindostan ore, and native-made bar iron.[7] If they succeed in competing with Sweden and Russia, this iron will be a valuable acquisition to the British empire. They have already issued a quantity 35 per cent. cheaper then the latter, but quality is the end they should strive for. However, the business is in able hands, and I have no doubt but that this object will be kept prominently in view.

[7] The fine quality of the Indian steel is generally acknowledged. The iron is first obtained by smelting, in small quantities, the wootz-ore, or the magnetic oxide of iron, which it found combined with about 42 per cent. of quartz; the yield being, out of 100 parts of ore, only 15 parts of metal: but this is of the finest character.

The process by which the iron is converted into steel is as follows, and fully accounts for that peculiar quality for which the Indian steel is valued.

The iron is cut into pieces and packed closely in a crucible of clay, containing about 1 lb. only of the iron, mixed with a tenth part of dried wood cut small, the whole covered over with green leaves. The crucible is then stopped, by covering the mouth with tempered clay, so as to effectually exclude the air. After a time that is, as soon as the clay-plugs are sufficiently hard, from twenty to thirty of the crucibles are built up in an arched form placed in a small blast furnace, and kept covered with charcoal; thus being subjected to the heat of the furnace for two or three hours. The process is then complete.

As soon as the crucibles are cool, they are broken open and the cakes of steel are found rounded at the bottom.

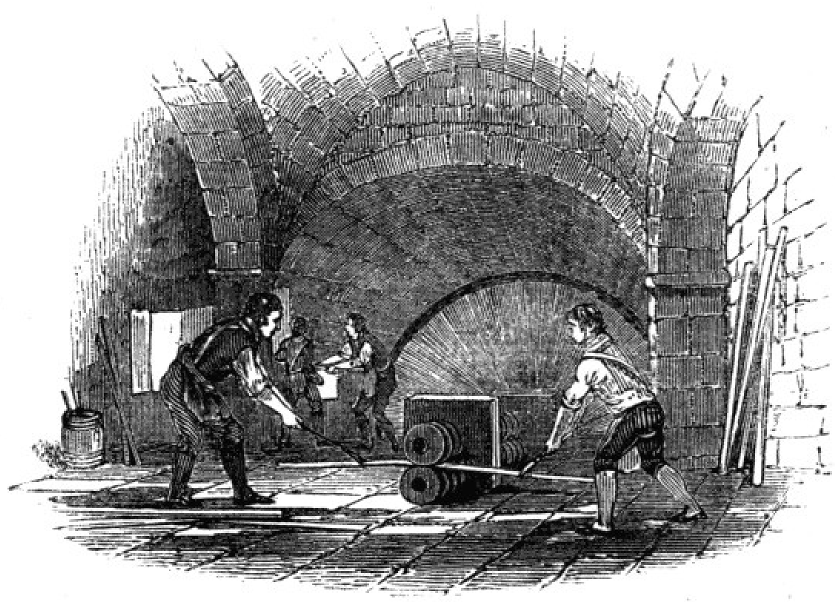
The top of the cakes should be found covered with striæ, radiating from a centre, and be free from holes or rough projections. If the cakes are honeycombed, the process has been imperfect and incomplete. When re-melted and tilted into rods, a very superior article has been the result.

The natives prepare the cakes for being drawn into bars, by annealing them for several hours in a small charcoal furnace, excited by bellows; the current of air being made to play upon the cakes while turned over before it, whereby a portion of the combined carbon is dissipated and the steel probably softened: without which operation the cakes would break in drawing them. They are drawn by a hammer of only a very few pounds weight, but the repeated hammering greatly tends to the production of a highly condensed and perfect article.

Foreseeing the difficulty that would eventually beset us in obtaining a sufficient supply of old horse nails from Germany and elsewhere, I directed my experiments to steel entirely, having formerly perceived that where the greatest quantity of steel existed in the mixture necessary to form material for their best gun barrels, there also existed the greatest tenuous strength. I had at that time a decided objection to all steel, as the following quotation from “The Gun” will show:—

“We recommend hammer-hardening in all mixtures containing iron. If you throw the iron aside, and confine your manufacture wholly to steel, it would be an evil, from this simple cause:—steel is of itself close enough in the grain; hammering it, therefore, in a cold state, only tends to make it more brittle. But the reverse is the case with iron: the more it is beaten the greater becomes its tenacity; and when mixed with steel in the way the stubs-composition is, it prevents the particles of steel from becoming too hard."

Mr. Adams, of Wednesbury, and the successors of Mr. Clive, of Birmingham, manufacture a considerable quantity both of silver steel and common twist steel for the trade; I make my own laminated steel: the difference in silver steel and common twist steel merely consists in the variety of tortuous twisting the former undergoes, while the latter is rolled out into rods of 6-16ths broad, with the fibres running perfectly longitudinal. The method of making or welding the pieces into a bloom, is in the following way. Having collected a sufficiency of mild steel scraps, such as cuttings of saws, waste from steel pen making, old coach springs, and the immense variety of pieces arising from the various manufactures of tools, they are cut into pieces of equal dimensions, polished in a revolving drum by their friction on each other, until quite bright, and then placed for fusion on the bed of an air furnace. The parts first fused are gathered on the end of a similarly fabricated rod, in a welding state, and these gather together by their adhesion, the remainder as they become sufficiently heated, until the bloom is complete. The steel is then removed from the furnace, and undergoes the effect of a three-ton forge hammer and the tilt, until it forms a large square bar; it is then re-heated, and thence conveyed to the rolling mill, where eventually it is reduced to the size of rod required. I generally have the metal required cut into short pieces of six inches long. A certain number are bundled together and welded, and then drawn down again in the rolling mill. This can be repeated any number of times—elongating the fibres and multiplying their number to an indefinite extent as may be required.



The great advantage derived in this instance from air-furnace welding is a chemical one; for while the small pieces of steel are fusing on the bed of the air furnace, the oxygen is extracting the carbon, and leaves the resulting metal mild steel, or iron of the densest description; while the succeeding hammering and rolling and re-welding, produce the mechanical arrangement of making the whole of an extremely fibrous description. The polishing secures a clean metal; indeed, so free from specks are the generality of barrels thus made, that it is scarcely possible to imagine clearer metal. When contrasted with the best of ordinary iron, by a powerful microscope, the closeness and density of grain are strongly apparent.

To such an extent has this been carried, that I can produce specimens of a considerably increased specific gravity. The barrels made of this metal, in general, beat all tried against them; with this great advantage, that the finer the polish in the interior the better they shoot, and continue longer free from lead. The only difficulty is in the working; as the boring, filing, &c., are more difficult. Moreover, greater care is required to see that they are not annealed,[8] when in the hands of the borer or filer; for in such case they would be considerably injured, though not to the same extent as barrels of a softer nature. I tested a great variety of bars by drawing them asunder longitudinally by the testing machine, and the average strength of a rod of 6-16ths broad by 5-16ths thick and 12 inches long, containing 1·40625 solid inches of iron, was equal to a tension of 11,200 lbs. This furnished a barrel having a thickness of metal in all parts of the arch equal, or 3-16ths of an inch thick, capable of bearing an internal pressure of 6,022 lbs. to the inch of the tube.

[8] Dr. Ure falls into an error in describing the process of barrel boring: he says "the barrel is first properly annealed, and allowed to cool gradually," &c. The barrel-maker that would take such a proceeding with a barrel of ours should never do so to another. The Doctor ought to have pointed out the evil tendency of this. We never saw it done, and we doubt much whether he did, though we have heard of the practice, which induces us to notice it, but the Doctor describes it as a *necessary* proceeding.

The generality of barrel makers spoil this metal by an attempt to obtain figure; for all extreme twistings in the rod depreciate the metal, by separating the fibres: to borrow a simile, they obtain only an over-twisted rope. This is not only disadvantageous but useless; for the extreme density of the metal renders the figure difficult to be shown distinctly, as acid acts upon it but slightly, and never so well as on metal fabricated from two differently constructed carbonised materials.

Many conjectures have been advanced, and an endless discussion created, to account for the watering or "*jowher*" in oriental sword-blades, and genuine Damascus gun-barrels. Anything approaching the truth is seldom met with; though I think the explanation is very simple. It must be well known that there is an immense variety of different qualities in both iron and steel: no uniformity of quality is found in two productions out of a hundred. The very ore, the coal, the presence of oxygen, the excess of it, all vary the quality of the material. An excess of carbon is more detrimental than a scarcity; for where carbon has once been, it leaves an indelible mark, and though extracted to as great an extent as practicable, it leaves a residue that possesses an affinity to absorb carbon again equal to the original quantity: thus, steel once made will never, by any process yet known, be reconverted back to iron of the same nature it was originally.

Mr. Mushet has given us the proportions of carbon *held in solution* by the various qualities of steel and iron, and the reader will find them in the note below.[9] It inevitably follows, as a principle, that the quantity of carbon contained in the metal—avoiding cast iron—will increase or decrease, and thus regulate the degree of hardness of the metals in question. A quantity of metals dissimilar in this particular, mixed together, and run into a vessel in a state of fusion, then, when cold, filed and polished, will show a variety according to the place they hold in the crystallised mass. Work and twist this material in all the tortuous ways and shapes it is capable of, and you only twist the fibres of the different bodies in the same way; and when they come to be acted upon by acid or oxidisation, they still retain their relative positions, forming the watering or figure, as was the intention of the tortuous twisting. All the beautiful arrangements in Damascus figures are obtained in this way. Metals containing more or less carbon will always produce this watering. To obtain a satisfactory proof, any person may case-harden a few pounds weight of stubs, and afterwards melt them in a crucible, and run them into a receiver; when these are worked down into the bar (or not, as he pleases), dress and apply a little sulphuric acid, and the peculiar situation the various stubs had taken in the fluid state, will be clearly discernible.

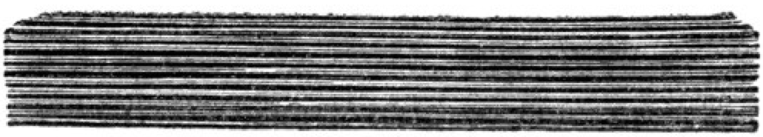
[9]

Iron, semi-steelified, is made with charcoal	1-150th	part.
Soft cast steel, capable of welding with ditto	1-120th	do.
Cast steel, for common purposes, with ditto	1-120th	do.
Cast steel, requiring more hardness, with charcoal	1-90th	do.
Steel, capable of standing a few blows, but quite unfit for drawing with ditto	1-150th	do.
First approach to a steely granulated fracture is from 1-50th to	1-40th	do.
White cast iron, with charcoal	1-25th	do.
Mottled cast iron, with ditto	1-20th	do.
Carbonated cast iron	1-15th	do.
And supercarbonated crude iron	1-12th	do.

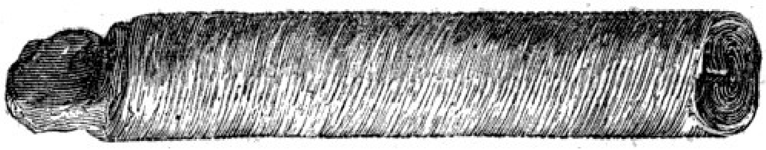
The original barrel-welders, the real Damascus iron-workers, were, like some of ours of the present day, not the most *conscientious* individuals, nor the most honourable. For, strange to say—but it is not more strange than true—on examination of most real Damascus barrels to be met with, we find the iron must have been so valuable as to induce the workmen *to plate* or *veneer* the superior mixture over a body of the commonest iron: all large barrels are thus made, rifles especially. I presume the moderns *borrowed* the invention; and it would be well if they made no more extensive use of it than on rifle barrels.

The modern method of making wire-twist and Damascus iron, being gradations from the same material, are here described under one head:—

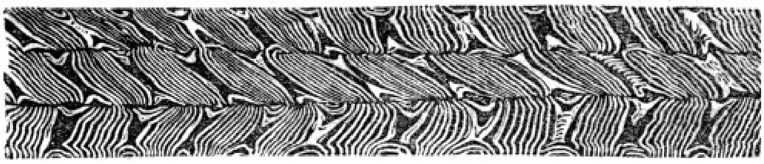
Alternate bars of iron and steel are placed on each other, in numbers of six each; they are then forged into one body or bar; after which, if for the making of wire-twist barrels, they are rolled down into rods of 3-8ths of an inch in breadth, varying in thickness according to the size of the barrel for which they are wanted: if for Damascus, invariably 3-8ths of an inch square. When about to be twisted into spirals for barrels, care must be taken that the edges of the steel and iron shall be outermost; so that when the barrel is finished and browned it shall have the appearance of being welded of pieces the size of wires, the whole length of the barrel. A portion of the rod, pickled in sulphuric acid, exhibits the following appearance, the bright parts being the steel, the other the iron.



When about to be converted into Damascus, the rod is heated the whole length, and the two square ends put into the heads (one of which is a fixture) of a kind of lathe, which is worked by a handle similar to a winch. It is then twisted like a rope (or, as Colonel Hawker says, wrung as wet clothes are) until it has from twelve to fourteen complete turns in the inch, when it presents this appearance.



By this severe twisting, the rod of six feet is shortened to three, doubled in thickness, and made perfectly round. Three of these rods are then placed together, with the inclinations of the twists running in opposite directions; they are then welded into one, and rolled down into a rod 11-16ths of an inch in breadth. Being pickled in acid, to eat away the iron, it exhibits the following appearance:—



This iron has long been held in great esteem. It looks pretty; but certainly does not possess either the strength or tenacity of wire-twist iron. It is well known that the strength of a rope may be destroyed by twisting it too much: so is it with this sort of iron. Iron is best when not twisted at all: I speak of the bar. It resembles wood, inasmuch as the strands or fibres run parallel, firmly adhere, and add strength to each other; if you twist those fibres you tear them asunder, and they no longer support each other. So it is with iron.

The objection made to the wire-twist is, that owing to the iron and steel being perfectly separate bodies running through the whole thickness of the barrel, there is a difficulty in welding them perfectly; and, of course there is danger of their breaking across, at any trifling imperfection or mis-weld. This objection is certainly well grounded, as many barrels break in the proving. I have seen a very strong barrel indeed broken across the knee without the slightest difficulty, while, to all appearance, it was perfectly sound. This is the reason why the manufacturers have ceased to make them, except for the American trade.

It may be said that the fibres in the Damascus, after being torn asunder, are welded anew. True; but could you ever glue the fibres of a piece of wood (twisted in the same way) together again, to make them as strong as before? No: cut several pieces of wood across the grain and glue them together, you would not expect them, though equal in substance with a piece in which the grains run lengthwise, to be of equal strength. In short, I hold a Damascus barrel to be little superior to a common barrel, in which the fibres run parallel to the bore.

All the varieties of figured barrels are but modifications of Damascus. The most endless variety possible may be attained; a figure with the carbonised material, showing only the ends or edges of the various laminæ, or portions of the face of that laminæ, may with equal facility be obtained, if the patience of the artist be in proportion. It would be a never-ending task, a subject for many volumes, to endeavour to describe a tithe of the varieties that might be, and have been made.

The Belgians are very expert at this sort of ornamental work. The very minute Damascus figure they frequently produce, is admirable, if beauty alone were the advantage sought in a gun barrel. They use thirty-two alternate bars of steel and iron, and roll them into a sheet of 3-16ths thick, and then slit them by a machine into square rods; these are twisted in the way just described, but to such an extreme as to resemble the threads of a very fine screw: six of them are welded into one, instead of three as with us. The figure is so extremely fine as to appear not to be larger than the finest needle. I have seen barrels made in Liege, superior in minute figure to any real Damascus barrel, or sword either. Our workmen here say the steel is better; which I am inclined to think is true: it is a branch of the gun manufacture they have long excelled in. The very best “Damascene” workers are to be found at La Chafontaine, a few miles from Liege, where they dwell in as beautiful a dell as fancy could wish, with a powerful hill-stream working their boring and grinding-mills, thus enabling them to send their barrels into Liege, ready for the filer. I have spent considerable time, and taken great trouble, to produce in Birmingham iron equally good; and I have succeeded: but, unfortunately, Englishmen are so extravagant in their ideas of value, as to render the constant manufacture of this iron here, a losing speculation. It can, however, be obtained from Belgium now, under the amended tariff, at ten per cent. on the value. It can be purchased there, ready for barrel making, at a franc per pound; and cheap it is at that price: two and a half francs would not purchase it here.

That Damascus iron is incompatible with goodness, I can and shall clearly prove. Experiment with the testing machine shows a rod of wire-twist 3-8ths square, containing 1·6875 solid inches, as equal to a tension of 11,200 lbs.; whereas a rod, when converted into Damascus of 11-16ths of an inch in breadth, by 4-16ths in thickness, containing 2·625 solid inches, was only equal to 8,960 lbs.; thus showing a clear loss of full thirty-five per cent. And when welded into barrels of the dimensions described, the relative internal strength of each is 5,019½ lbs., and 3,292 lbs. *to the inch of tube*. This constitutes a great difference. But unfortunately that is not all.

In the preceding chapter I noted the fact, that all sorts of iron lose a portion of their strength by being heated or softened; but I found that Damascus suffered more than any other sort of iron, excepting the common kinds. For instance, the bar of wire-twist would, in the state it came from the rolling mill, bear 11,200 lbs., but, after softening, it would only bear 10,180 lbs., being a diminution of 10 per cent. A bar of Damascus suspending a weight of 8,940 lbs., the measure of its strength, when annealed, was 7,840 lbs., being a falling off of 12½ per cent. Thus, I trust I have clearly shown, that whatever other quality Damascus possesses, strength is not one of its properties. It must not, however, be supposed that the above weight indicates its greatest strength; on the contrary, its strength can be increased full 22½ per cent. by cold hammering. Still, however, it will only hold its relative position to other kinds of iron with respect to strength, since they are all capable of having their strength increased by the same process.

Damascus barrels have fallen much into disuse, being rarely seen except as pistol barrels,[10] which, together with a great quantity of *counterfeits*, are made for the South and North American trades, in the shape of double and single guns of a flashy appearance—all invariably *veneered* or *plated* with ribbons of this ornamental iron. I shall now dismiss this subject; after remarking, that certainly a very handsome barrel may be made after this principle, if too much twisting be avoided. It has been seen that the rods are twisted until there is fourteen turns in the inch of length: an excess productive of the detrimental effect mentioned; while, had there been but two turns, a large proportion of strength, if not all, would have been retained. One turn only, under the same circumstances, would very likely be highly beneficial; indeed I have found it to be so: one twist binds the interior strands, as the outer does the interior in a rope, and thus adds strength. This shows that there is a medium in all things.

[10] The London makers are again using them extensively; which is certainly no proof of their judgment.

The use of old horse-shoe nails is of a date nearly coeval with the use of small fire-arms. These nails are made from rod iron of the best description; and the hammering cold, or tempering the nail, so benefits and condenses the iron as to improve it greatly. The method in use until a late period, was to fill and force into an iron hoop, of six or seven inches diameter, as many stubs as it would contain, to weld the whole, and draw them down to a bar of such dimensions as might be required. Modern improvement, however, has shown the advantage of cleansing the stubs perfectly by a revolving drum, and then fusing and gathering them into a *bloom* on the bed of an air-furnace. Thus a body of from 40 to 50 lbs. of melting iron can be obtained at one heat; a matter of economy and necessity, where large quantities are required, besides possessing the superior advantage of having the whole mass equally heated: this cannot be done by the old hoop method, as the surface must be frequently burnt before the interior is at all in a welding state.

Experience taught the late Mr. Adams and his brother George—who still manufacture some of the best gun iron in the world—that the stub iron alone was insufficient; for even then (forty years ago) the absurdity of imagining that no barrels were or could be good without being soft, was understood and acted upon by them. They introduced at first one-fourth of steel to three of stubs; this having been found highly advantageous, the prejudices of the gun-makers were gradually overcome, or left in abeyance from ignorance of the introduction. It is a fact, that as late as 1842, when I issued my former work, men who had been all their lives *gun-makers* (by courtesy) actually refused to believe that any steel at all entered into the composition of the best barrels; and several whom I know perfectly well, ordered the factors with whom they dealt “to be sure to send them no barrels with steel in, as they did not wish their customers’ hands to be blown off.”

Charcoal iron has, up to this day, been the only stub twist barrels they (and we believe two-thirds of the provincial makers also) have ever been served with. Reason with these men, and they will snappishly tell you, “We pay the best price, and we ought to have the best: we don’t see that our neighbours have any better.” On one occasion of my calling upon one of the first provincial gun-makers in the kingdom, the subject of barrels was adverted to—“An excellent work that of yours, I dare say; but, sir, you have done a deal of harm: it is wrong to let gentlemen know too much; they give you far too much trouble: they get too knowing.” These, and such like observations, are the only thanks I ever received from the generality of the gun trade. There are, however, some enlightened men who, understanding the subject, have appreciated my motives; but by far the greater proportion have done the reverse, asserting “that I had told them nothing but what they knew before.”

The mixture of a portion of steel with the stubs having clearly shown an improvement, an increased proportion has been adopted by various makers: we have had as high as three-fourths of steel to one of iron. Where proper attention is paid to the clipping of the steel to pieces, corresponding with the stubs, and properly mixing the whole, welding and forging by the heavy hammer, reducing by a tilt and rolling down to the smallest description of rod, a most excellent, tenacious, and dense body of iron is thus obtained; while, by cutting into lengths of six inches, bundling a number together, and re-welding them into a bar, an increased density and tenacity is gained, by an increase in quantity, and an elongation of the fibrous system. Any description of barrel, of this iron, if made with a moderate degree of care and attention, is considerably stronger than any explosive fluid ever yet compounded could burst, under any circumstances bordering on *fair experiment*.

The great advantage derived from welding on the bed of an air-furnace, arises from an absence of the minute portions of charcoal, of either wood or coal, as the case may be. Millions of these very minute portions are imbedded in the midst of the metal in every part. They are enclosed in cells originally of their own dimensions, but are drawn out with the fibres to an indefinite extent, forming a system of tubes that may be compared to the capillary system in trees, and making the iron of a spungy, compressible nature. It is the absence of these particles of charcoal that gives part of the superiority to steel as now made for gun-barrels; and the existence of a portion of them causes the inferiority of all other kinds of iron. In a chemical analysis of iron, a large portion of crude coal-charcoal or wood-charcoal is found, according as either has been used during the manufacture. This is not of course given as so much carbon in the result, though the injury is equally detrimental as an excess of carbon is to the goodness of the metal; for it renders the whole porous, and liable to attract moisture and induce oxidation. It must be kept prominently in view, and clearly comprehended, that the denser the body of metal, the less the liability to oxidise, or in other words *rust*; and here is the one great preservative principle in good iron: "it is the fibre of dense cocoa-wood, compared with that of willow or saugh." In all situations and for all purposes, where iron is liable to sudden changes of either heat or cold, wet or dry, the very best of iron should be obtained; as it will be less affected by the changes of temperature, and amply repay by its durability the extra cost in the first instance.

The very extensive round of experiments to which I have submitted mixtures of this nature, clearly establishes all the conclusions I have formed on these points. The strength of the mixture, three parts steel to one of stubs, gives a resistance in the rod of 6-16ths broad by 5-16ths thick, and 12 inches long, containing 1·40625 solid inches, equal to 10,295 lbs. before separating; thus being equal, in a barrel of the dimensions before mentioned, to an internal pressure of 5,555 lbs. to the inch of tube. The proportions mentioned in my previous work are 25 lbs. of stubs to 15 lbs. of steel; the strength of this mixture in the rod is equal to a tension of 8,960 lbs., and the barrel is capable of restraining a pressure internally of 4,818 lbs., making full 15 per cent. dissimilarity in favour of the larger proportion of steel: indeed, all experience points to the great advantage, that steel, properly worked, possesses over iron alone. Great good can be effected by condensing iron by hammer-hardening; greater than I have shown steel to be capable of receiving additionally: as, already having it naturally, there is no necessity for using artificial means to obtain it. Nor is steel so liable to depreciation in the hands of an inexperienced artisan; as the degree of expansion is not more, in the large proportion of steel mixture, than a loss of strength equal to 4½ per cent, by heating and cooling gradually. The loss in the mixture containing less steel is 7½ per cent. The specific gravity of the two is in proportion.

The frequent welding and re-rolling of iron is of the most beneficial tendency, the elongation of the fibres being highly advantageous; for, a fibrous piece of iron may be compared to a wire rope, the more strands the greater tenacity; and the smaller the strands, even up to a proximity of fineness to the human hair, the greater the weight they will bear in tension. One large wire which, when single, will suspend 500 lbs., will, when drawn down to six small ones, suspend 600 lbs.; and so on to the greatest extreme. Another great advantage received by the repeated reworking of iron, is obtaining an increased density; for when this is secured to a certain extent, you have closed in proportion the pores of the metal; and in this state it is not liable to that degree of expansion or contraction, or that fluctuation in strength, which arises from softening the iron. Nor can you gain, save to a limited extent, any improvement by hammering,—hammer-hardening, for instance,—simply because it is already improved to the utmost extent we are at present acquainted with.

How wonderfully beneficial to mankind is this beautiful arrangement of the metallic fibrous system! Without it what could we do? our manufactures would be confined to simple castings, or crystallizations, possessed merely of strength in proportion to the cohesive nature of the metal. Where would be all the wonderful springs whose fineness vies with the silken fibre? Of what could they be constructed? All-powerful gold would not suffice, nor silver; though each, in its place, possesses wonderful properties. Gold and silver may both be spread in the thinnest conceivable coat over space incredible; on the gilded cup, or, still thinner by electric agency, on the plated epergne. But iron alone is to the arts, the "*summum bonum*" for which there is no substitute: it is the "*sine quâ non*" of practical mechanics.

Improvements in the manufacture of a very superior iron may, we believe, be placed to the credit of the gunmaking profession exclusively; no other body or class of men having ever yet deemed it worth their trouble to endeavour to obtain anything of a better description *than bar iron, suitable to make steel from*. Mr. Mushet, from whose work I have already quoted, has evidently been more intimately acquainted with the routine of iron manufacturing than any other person I ever met with or read of: he understands the question perfectly; yet he seems to care for nothing further *than a suitable steel iron*.

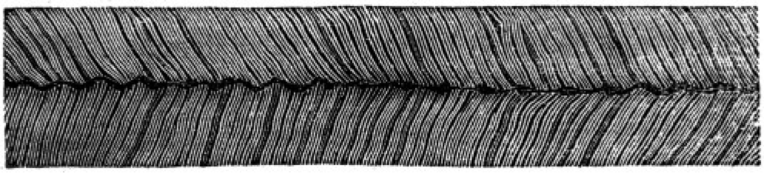
How many and how fearful have been the explosions by all-powerful steam since the period of its introduction. How many weeping widows, and how many fatherless children have had to mourn its effects! Yet what has human ingenuity done, what have the wonderful energies of the present race of scientific men accomplished to stay this annual slaughter? Comparatively little beyond discovery of mysterious causes where none exist. It reminds me of my first lesson in coursing—"If you want to find a hare, young man," said the keeper, "look at your feet: you will not find her at a distance." So it is with the state of knowledge on steam boiler explosions; if you want to find the cause, look "at your feet:" do not endeavour to envelope in mystery, what you may find in simple and natural causes.

I may here observe that I have been professionally engaged to inspect the effects, with a hope of finding the cause, of thirty-four cases of explosion, where the sacrifice of human life was above an average of two each, or nearly one hundred, and I never yet have found one single case which could not be clearly demonstrated to have been caused either solely by neglect of the superintendent, or from sheer ignorance on the part of the engineer constructing the arrangement of boilers. For every accident may *sweepingly be said* to be occasioned by a want of space for the escape of the steam: a too small valve, in the first instance, and in the second, a villanous construction of what is called iron boiler plate—a concentration of the veriest rubbish, under the name of wrought iron, ever gathered together. For this reason, I have drawn the reader's attention aside for a few moments.

The improvement of boiler-iron may detain us slightly, if by the delay any good can be accomplished. For an inconsiderable increase of outlay, a boiler might be rendered doubly safe to what it is at present, by simply using moderate caution in the selection of scrap iron, a perfect cleansing of that scrap, and by fusing the bloom on the bed of an air furnace. The great advantage would be that you would get a stronger, a much denser, and consequently a much better, metal: nor is this all the advantage; you might use a very much thinner plate, which would yet be equally strong; and science will tell you that steam would be more easily generated, as heat is more rapidly conducted.

There is a very handsome description of barrel-iron made, generally termed "Stub-Damascus." The method of preparing it, is of late considerably altered. A quantity of old files are hardened, by being; heated red-hot and immersed in water, then broken in pieces with a hammer, and afterwards pounded in a mortar until the pieces do not exceed in size a corn of number five shot. A proportion of 15 lbs. of these to 25 lbs. of stubs, is fused together on the bed of an air-furnace, beaten down, and rolled into rods. The rod of 3-8ths of an inch square, is twisted like a rope, precisely in the same way as the Damascus. The effect of this winding, is to give a beautiful mottle to the barrel; which will be found depicted in plate No. 3.

Another mixture, represented in plate No. 2, was first made by Mr. Wiswould, of Birmingham. It is a compound, so far as I have been able to ascertain, of three parts of steel to two of iron, intimately blended and intermixed, and twisted as just described. It is a most beautifully clean and dense iron; but the extreme twisting is to it, as to all, highly injurious and prejudicial. The twisting is similar to the Damascus; only that two twisted rods are welded together instead of three, and with the twist of the strands running in opposite angles, as depicted in the wood-cut below.



The degree of strength is similar to that of the stub, and other Damascus; it being quite certain, that, be the composition what it may, this rending of the cohesive attachment by twisting, will eventually equalise the strength of the whole.

The use and introduction of what is called "charcoal-iron," is one of the shams reared and supported by the hotbed of competition and deception combined: a wish to foist on the purchaser a counterfeit for the real metal. I would not give shop-room to the best barrels ever made from such a compound. I hate a scoundrel and a hypocrite; this iron exemplifies the qualities of both.

This worthless compound consists principally of cuttings of sheet iron; of which there is an endless supply in the neighbourhood of Birmingham, from punchings and from one inferior metal and another. After properly cleaning, a quantity is put into a charcoal furnace and melted, cast into a pig, then forged down to a bar, and rolled into rods corresponding with the size of stub twist, which it is intended to represent. The action of the charcoal communicates to it a portion of carbon, which, when stained in a certain way, gives an appearance much resembling that beautiful metal just mentioned (stub-Damascus); but if every means imagined by the inventive faculty of man were employed upon it, it could not be made into really good iron. An iron which is technically termed "weak," can never be made a strong bodied iron, or an "iron suitable to make steel," to repeat a former quotation. The original iron from which these scraps generally come, is required to be "weak" iron, for the facility with which it can be rolled into plates; a strong fibrous iron is not necessary.

Its greatest strength appears to be as follows: 7-16ths of an inch broad, and 5-16ths thick, solid contents 1·40635 inches, will bear a weight of 10,080 pounds; so that if my calculations are correct, it will bear only a pressure of 4,526 pounds in the tube. The loss of strength by heating or softening, being full 10 per cent.

This converted iron, however, will not endure the test of browning by smoke, or, more properly, flame; as the oxygen invariably destroys the appearance of steel in twelve hours after its application. By the old method of staining, it would be as impossible for any man, who was not a judge, to point out the real from the counterfeit, as to discern a copy executed by a clever artist from an original painting by one of the old masters.

But deception is ever fertile in expedients, and an ingenious invention was soon found out to imitate the advantage possessed by the "*smoke brown*," which they obtain by first browning or staining the barrels very dark. A weak solution of muriatic acid, or spirits of salt, is applied very lightly with a sponge, and the colour is extracted from those portions of the iron left more prominent, by the excessive *pickling* they are subjected to before staining; they are then immediately dried, scalded with hot water, and the stain is complete; it is a most ingenious imitation.

I have already stated that this iron is very much used in consequence of its cheapness; its cost being only fourpence per pound, while stub twist costs fivepence. It is also easily worked, being considerably softer than any of the above-described kinds of iron.

It may be asked, why so much inferior iron is used, when the difference in the price between the good and the bad is only a penny per pound? The reason is this:—If a barrel filer receive an order for a pair of barrels, he (having probably deceived his customer before, or, at any rate, knowing that he can deceive him without running any risk of detection) sends to the welder sufficient charcoal-iron to forge these barrels. Should the quantity amount to ten pounds, he, of course, saves tenpence. The welder receives two shillings less for welding this description of iron, than for welding stub-twist; so that here is already a saving of 2*s.* 10*d.* At the boring-mill, and the grinding-mill, the charge is also proportionate: the wages of the journeymen are less; so that by imposing on his customer one pair of barrels manufactured of this sort of iron instead of the real stub-twist, he pockets a clear gain of above 9*s.*; and should he manufacture one hundred pair of such barrels in the year, it would make at the end no small item in the year’s account of profit.

Thus it is with all description of barrels. The charge for making, by each workman, in the various stages of the manufacture, is according to the quality of each pair of barrels. The saving, then, to the man who makes one hundred pairs of barrels in the year, though it be but a farthing in the pound of iron, amounts to a considerable sum. This fraudulent gain of more than 5*s.* on a pair of pretended stub barrels, is what is called in Birmingham, “doing the natives,” and is a reward for ingenious knavery.

When orders are given by what are called general factors, who very kindly supply their country friends at a moderate commission of 40 to 50 per cent., these gentry take care to lap up the cream; for we know from facts that the barrel filer has sometimes scarcely five per cent. for his trouble of overlooking. One consequence naturally results from this, that every species of deception will be resorted to, in order to indemnify workpeople for their labour and trouble. At the present time, I have no doubt that there are hundreds of guns made in Birmingham, the barrels of which, in some instances, never enter the proof house: as eightpence per barrel, the cost of proof, is a great temptation! Besides, a great number of barrels declared “wasters”—such as repeatedly bulged in the proof, are full of flaws, have holes in the sides, or some other fault sufficient to condemn them in the eyes of a moderately conscientious barrel-maker—are bought by men who live by this species of fraud; and are repaired with great neatness, by putting in pieces artfully, beating down swellings or bulges. Then the proof-mark “of doubtful identity;” and, last of all,—mark!—they fit them up, and send them to the engraver to have the name of some living or defunct London gun-maker of respectability engraved upon them, and palm them off upon some dealer as a good article.

I commend to the reader the advice of “Edward Davies,” a gentleman who wrote in 1619; who says “He that loves the safetie of his own person, and delighteth in the goodness and beautie of a piece, let him always make choice of one that is double breeched; and if possible, a Mylan piece, for they be of tough and perfect temper, light, square, and bigge of breech, and very strong where the powder doth lie, and where the violent force of the fire doth consist, and notwithstanding thinne at the end. Our English pieces approach very neare unto them in beautie and goodness, (their heaviness only excepted) so that they be made of purpose, and not one of these common sale pieces, with round barrels, whereunto a beaten souldier will have great respect, and choose rather to pay double money for a good piece, than to spare his purse and endanger himself.” Truly, the fraternity have always, we find, been of doubtful honesty: always making “sale pieces.”

“Threepenny skelp iron” is made from an inferior quality of scrap to that from which “charcoal iron” is made; but unlike it, there is no pretension of quality. Its inferiority is not denied; it is poor in quality, and suits parties who cannot buy better. The method of preparing is by an air-furnace, forge, tilt and rolling mill, as before described. The greatest strength of a bar 11-16ths broad by 3-16ths thick, containing 1·5468 solid inches, is 7,840 lbs.; or equal to an internal pressure of 3,841 lbs. to the inch of tube. One particular fact attaches to all kinds of inferior iron —the greater the mass acted upon by the rollers the greater the variation of strength. This arises entirely from the increased sponginess of the metal, and its greater expansibility. For instance, a rod 1-16th thicker, is 15 per cent. weaker in proportion; and so on to the greatest extent. But on the other hand, it is capable of recovering a great increase of strength by cold hammering; greater than better iron. A considerable quantity of this iron is sold to engineers, and used in the construction of locomotive and other engines; the price and uniformity of texture in grain fitting it for that purpose.

“Twopenny” or “Wednesbury skelp” is almost too bad to be used in making an article which may endanger the limbs of our fellow creatures, and is now little used, fortunately. It is made of an inferior scrap to the former, in precisely the same manner; and in point of strength is still lower. The bar is generally 1 and 1-16th inches in breadth, by 3-16ths thick, the solid contents 2 inches and 25-64ths, and will bear a weight of 7,840 pounds; consequently the strength will be 2,840 pounds to the inch of tube.

This is a great falling-off in strength; and I would ask any one who values the safety of his hand, if he would like to risk it, by using a gun made of iron possessing so low a degree of strength, as compared to the force of the charge it has to bear? Let him recollect that the force of the charge may be increased by a variety of circumstances. The pressure of a certain quantity of powder, on which a certain weight of shot is placed, is so many pounds to the inch; and if you double that weight of shot, you nearly double the pressure. In estimating the force of pressure, the opposing friction is also to be taken into account. If the gun be allowed to get very foul, then friction is increased, and of course a still greater pressure is thrown on the tube of the barrel. All these circumstances being taken into consideration, I repeat, that *no barrel is safe, whose power of resistance is not more than double the strength of a charge of sufficient force for general shooting*. Every bad gun should be thrown aside as unsafe, or used with the greatest caution. Bad and inferior guns are made from the foregoing material; and not many years have elapsed since it was thought good enough for military arms.

“Sham damn skelp” is made from the most inferior scrap. I should not have mentioned this description of iron had I not seen hundreds of barrels made of it, all which are utterly unfitted for the use of any person who cares at all for his safety. I have met with them frequently under the dignified name of twisted barrels. Guns that are fitted up at from ten to twelve shillings each are not of course patent breeched, but are made to appear so by staining them generally blue, and by having a couple of bands to imitate platina, across the squares. A projecting part is welded on to the side, into which the nipple is inserted, and the lock joints neatly under it. Many of them are good imitations; but only take the barrel out of the stock and the deception is instantly apparent, as it is rarely carried further than the outside. The beautiful way in which the barrels are painted to imitate fine twist, catches the eye of the simple countryman, who is generally the dupe of this artifice; and the persuasive eloquence of the itinerant hardwareman, seldom fails to extract from the pocket of his unsuspecting purchaser sometimes thirty or forty shillings of his earnings for what the *modest trader* rarely pays above fifteen shillings. Many are the anathemas vented, when the deception is found out by some one more knowing than the dupe, who not unfrequently purchases his experience at the expense of a finger or a hand. It is astonishing what a quantity of this rubbish is disposed of by hawkers who infest market towns and villages with guns for sale.

But the English peasant is not the only dupe of this species of knavery. Thousands of these guns are sent monthly to the United States, to the Brazils, and South America; where they are disposed of, among the poor Indians, in exchange for skins and furs.

They are all understood to be “proved.” How many are so who can tell; but that some of them are not, there can be no doubt.

It is said that the manufacture of these guns is a great support to the gun trade of Birmingham. In one respect it is, certainly; yet would not the interest of the trade be advanced, if we were to manufacture none of so inferior a quality? “But then,” it will be urged, “we could not compete with our rivals in Germany and the Netherlands.” True, we should not be their rivals in the production of rubbish; but the superiority of our guns would then command a better market. By sending to the market an article no better than theirs, we have made foreigners indifferent about the purchase of ours: they say “The English guns are no better than the Belgian or German; we may as well purchase one as the other.” The force of this remark is illustrated by the state of the African trade. The base kind of articles we supplied them with some years ago, has produced a distrust of our manufacture, which will not easily be removed; and a similar distrust is engendered by the same cause in the minds of our present customers. It is much to be deplored that the eagerness for present gain, should render men blind to the consequences of their conduct, and lead them to prefer the immediate gratification of their avarice even to their own future prosperity; to say nothing of the welfare of the trade of the country.

The method I suggested of testing all iron in the bar would go far to destroy this trade. I have not thought it worth while to test this iron. But twist barrels are made of it. Should the reader meet with a double gun so made, let him avoid it: it is unsafe, unless it be so heavy as to be unmanageable.

A great many long rifle barrels are made of this iron, principally for the American trade; but from their immense weight, and the small charge of powder required, there does not exist the same danger from their use.

Fowling-piece barrels made of it may be generally recognised by the smallness of the bore and the thickness of metal. As the charge of powder used in proving is very small when compared with the charges for proving guns of a wider calibre, we need not be surprised that many of those that are proved stand proof.

“Swaff iron forging” is a profitable branch of forging carried on in Birmingham under the above title. It is a metal which is composed of iron and steel filings, chippings of breeches, pieces and cuttings of the ends of the screws, lock-plates, cocks, the rough borings of barrels, and all other small scraps found in gunmakers’ and other workshops. These are collected by the boys in each shop, and when they have accumulated, are sold to the “swaff-forger,” the proceeds being considered as drinking money. They are forged into bars of iron by attaching them together and immersing them in diluted sulphuric acid; then, after draining it from them again, and placing a large iron pan full in a hot situation, they become cemented together by the action of the oxide. The compound is then taken from the pan, by turning it upside down, and is put into an air-furnace heated to a welding heat, being thence removed and beaten into a bar: three men with light hammers beating it as quickly as they do in welding a gun-barrel. This iron is sold to the gun-work forgers, for the forging of the patent breeches, lock-plates, furniture, and other parts of the gun which they think worthy of good iron; but since cheapness has become so much the order of the day, the use of this iron is confined to the forging of best gun-work, cast iron being thought quite good enough for common gun-work.

CHAPTER V.

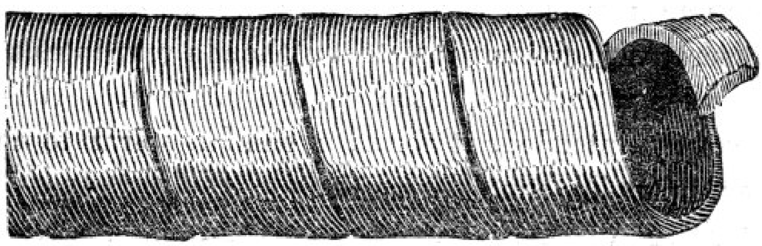
GUN-MAKING.

In this chapter I shall briefly describe the process of the manufacture of guns of all qualities, commencing with barrel-welding; which, in importance, is inferior only to the *quality of iron* in the routine of good gun-making.

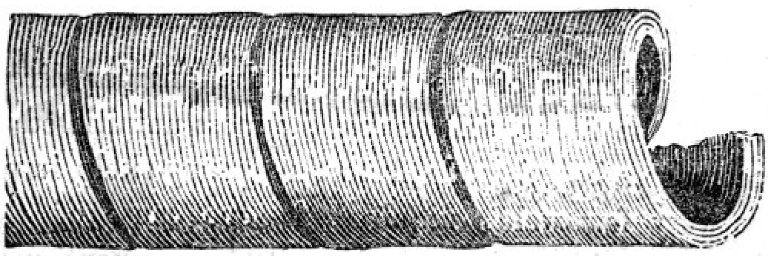
Birmingham, and the surrounding districts, are the only places in England where barrel-welding is practised. The superior advantage possessed in having coal nearly (if not entirely) free from the presence of the sulphuret of iron, which has always been found a considerable hindrance to the obtainment of clear and good barrels, is greatly in their favour. For a considerable period individuals in London contended with the Warwickshire welders; but being an unequal contest, it ended in favour of the provincialists. This is to be regretted, as there can be no doubt but that greater reliance could be placed on the material of the London manufacture. But a considerable drawback existed with the latter: they made only one sort of barrel, and that the best. Now it is requisite to have a fire fitted for the purpose of welding best barrels—tempered, as it were—and this can only be effected by some hours' using, which is generally employed in the production of a number of very inferior barrels. As the London people made no common guns, and needed no inferior barrels, they welded their best barrels in a raw, untempered fire; and hence arose the admitted inferiority of their work. The late Mr. Fullard struggled long and hard in the competition; but with his death, barrel-welding ceased in the metropolis. Indeed it would have been highly imprudent and unprofitable for any one to have entered upon such a speculation; there being no certainty of success, but rather of the contrary. The Birmingham barrel-welders are wonderfully clever smiths: they cannot be excelled. If *ridden with a curb*, they do well; but no opportunity must be given them, or to a certainty they will "bolt" from the true path.

The metal rods are twisted by means of two iron bars, the one fixed the other loose. In the latter there is a prong or notch to receive one end; and when inserted, the bar is turned by a handle. The fixed bar preventing the rod from going round, it is bent and twisted over the moveable rod like the pieces of leather round the handle of a whip. The loose bar is unshipped, the spiral knocked off, and the same process recommenced with another rod. The length of all the spirals depends on the breadth of the rod: for instance, the stub-twist has sixteen circles in six inches long; a rod of five feet will make a spiral of only seven inches; while iron, of an inch in breadth, will make a spiral of as many inches long as there are twists: hence the reason why best barrels have more joinings than common ones of equal length.

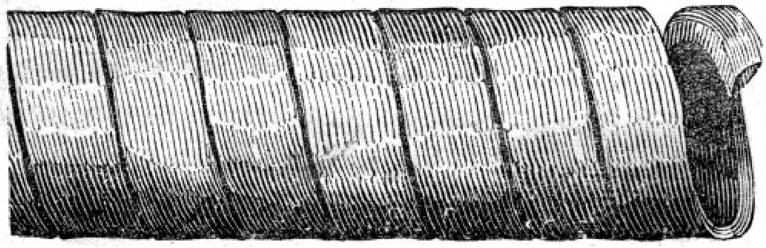
The Damascus being rolled into rods of 11-16ths broad forms a spiral with the appearance shown in the accompanying woodcut.



The fancy steel barrels and others, where the rod is formed of more than one piece, such as the stub Damascus, &c., is of rather greater breadth, like the representation below.

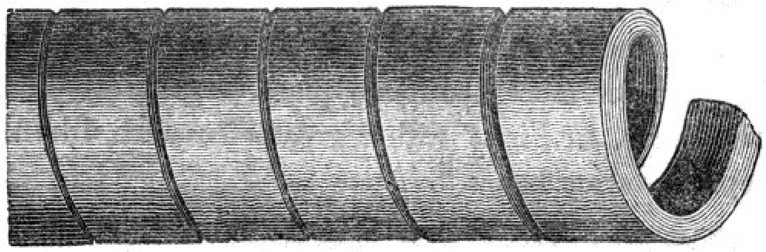


The iron made from stubs and steel, and plain fibrous steel, is invariably rolled down into rods of 6-16ths broad, forming a spiral, as below.

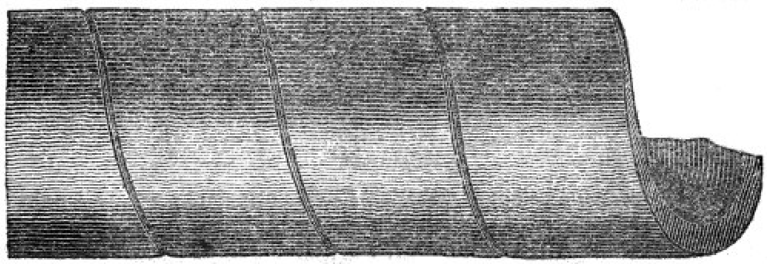


A proper attention to the fineness of the spiral will always enable an amateur to detect any attempt at imposition.

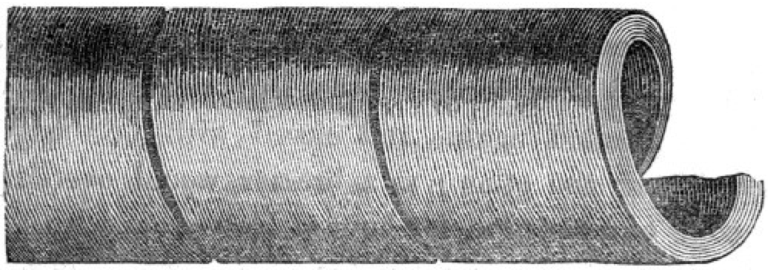
The spiral formed from the rod of charcoal iron has a somewhat different appearance; but in cases where it is intended to supply the place of the real stub iron it is of corresponding dimensions, and in general very difficult to detect without a very intimate knowledge indeed of the nature of iron. When honestly intended, it forms a similar spiral to the accompanying one.



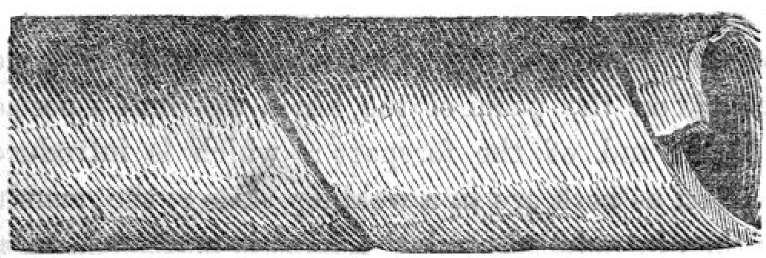
The wideness of the twist, or the angular direction of the fibres, will enable the most uninitiated to recognise a barrel made from threepenny skelp iron: the very few welds required, is one cause of the cheapness of barrels made from it. Judgment may be formed of it from the following representation.



Twopenny, or Wednesbury skelp is coarser in the spiral still, and running so angular as not to be very difficult to detect.



All iron formed in spirals, as a matter of certainty, forms *twist barrels*—the parties whose use they are intended for, seldom know or care for anything further than having “a twist barrelled gun.” The advantage of *sham damn* iron being twisted is all imaginary: if used at all, it may be twisted; but those who value their safety would consult it best by tying a large stone to such a gun and sinking it fathoms deep. But to satisfy those who may fancy such things, I give a woodcut of the spiral ready for welding.

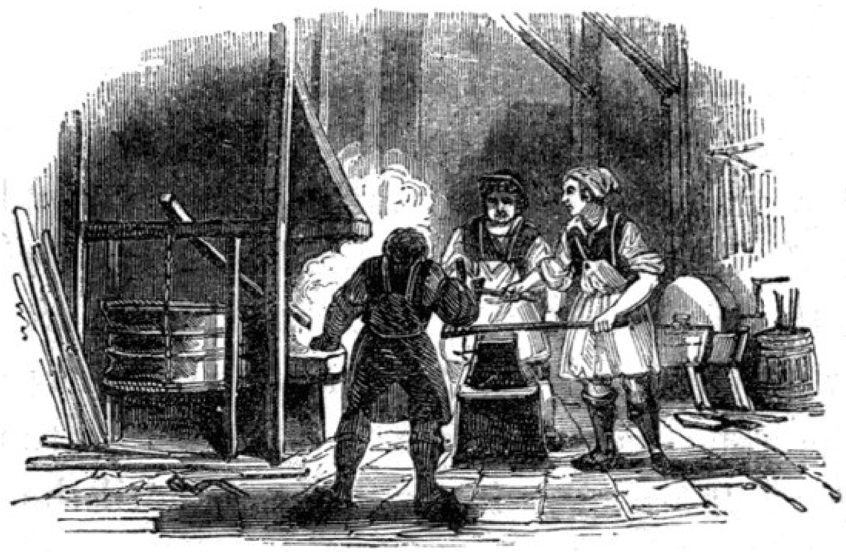


The spirals being thus formed, the welders commence their day's work. The batch consists of a foreman, one on whose skill all depends, and two subordinates, whose duty it is to blow the bellows, strike, &c.

They proceed to weld probably a dozen long common barrels for the American trade; which are generally composed of the inferior iron mentioned before, rolled into two lengths of different thicknesses. These skelps are heated, and beaten on a groove until they form a tube half closed. They are then heated again, and closed with one edge over-lapping the other; as a brazier would over-lap the edge of a tin pipe, for boys to blows peas with.

Having got the two lengths of the whole dozen turned into tubes, they proceed to weld the longer length or forepart, by heating it sufficiently for four or five inches, introducing a mandril of the required size to suit the bore wanted, and then beating it into a perfect tube, in a groove on the anvil, of corresponding diameter; heating it again and again, until the joint is closed the whole length. They then proceed with the other eleven foreparts, and advance the whole to that stage before welding on the breech lengths; which are now partially heated by laying on the outskirts of the fire, to be in readiness: they are then closed the same as the foreparts. The end, when about to be jointed, is opened a little on the peam of the anvil, to admit a portion of the end of the forepart; which is introduced as soon as both are in a welding state: the mandril is then introduced, and the joint is perfected, in less time than we have occupied in the description. The other part of the tube is closed, and the barrel is then complete. If, however, the breech part is to be square or octagon shaped, it is not welded in a groove, but on a plain surface.

Competition has reduced this department of the trade to a low ebb; thousands of these sort of barrels being now annually welded for about eightpence each: if to this we add one penny farthing per pound for six pounds of iron, we get a forged gun barrel for one shilling and threepence halfpenny. This is certainly a poor remuneration for sweating over a furnace containing from two to three hundredweight of intensely heated coal. The introduction of welding by the rolling mill, will eventually supersede this arrangement; a matter to be regretted only on the score of its answering the purpose of preparing the fire for best welding. Of late years rolling has nearly superseded this description of welding.



They now commence the welding of twist barrels. Spirals that are intended for the breech end, are heated to a welding heat for about three inches, removed from the fire, and jumped close by striking the end against the anvil. Again they are heated, and again jumped, to ensure the perfect welding. They are then beaten lightly in a groove, to make them round. The neatest part of the process consists in the joining of the points of the two rods, so as to make the barrel appear as if it had been twisted out of one rod. The ends of the two rods are a little detached, brought from the fire, and applied to each other; a gentle tap is then given, and the union is perfect in an instant. The rapidity and dexterity with which this is accomplished, ought to be seen to be duly appreciated. This trouble is only taken with the best barrels. In the manufacture of barrels of an inferior description, the ends of the rods are cut in a sloping direction, and when welded together, become quite square at the part where the pieces are joined. In a finished barrel the points of junction are easily recognised. By tracing the twist, a confusion will be found to exist for about an eighth of an inch, every six or seven inches; and from this appearance you may conclude that, for a barrel so joined, the welder had not the best price. Having joined the whole of the spirals, three inches are again heated to a welding heat, the mandril is introduced, and the tube hammered, in a groove, to the size required. This operation is repeated until the whole length is finished.

Then follows hammer-hardening: that is, beating the barrel, in a comparatively cold state, in a groove, with light hammers, for the space of half an hour. This is a most important part of the process. It closes the pores, condenses the texture of the metal, compresses a greater substance into less bounds, increases greatly the strength of the barrel, and renders it more elastic. Yet this is seldom done, unless specially requested; and then a gratuity is, of course, expected either in money or beer. A few pots of the juice of Sir John Barleycorn will infuse more strength into your barrels than you could purchase for ten times the amount in money; as they have the effect of making the hammers descend with increased velocity.

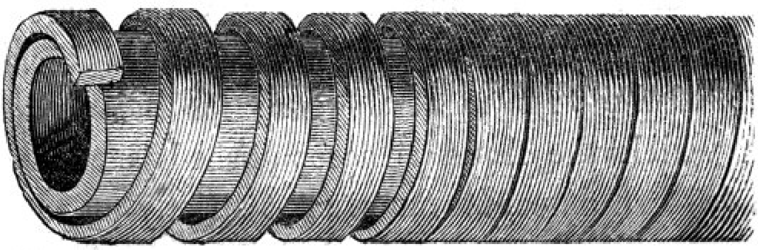
If all barrels were hardened in this manner, their shooting powers would be increased, and they would not be so liable to burst in the hands of the sportsman. This, however, cannot be done, unless the purchaser either sees it done himself, or has it done under the superintendence of some person on whom he can depend. The Birmingham workmen, if well paid and well looked after (to counteract the bad habits they have acquired from being employed in the manufacture of so large a quantity of goods of an inferior quality), would produce an article superior to any that could be produced, at the same cost, in any other part of the world.

The Belgian welders do their work at considerably less cost in coal than our English workmen. Coal, it is well known, is very dear in Liege, and necessity may have taught them the extreme of economy both in the size of their fire and the duration of it. They effect this by adding to two-thirds of coal, beat into dust, one-third of clay; the latter is mixed with the coal by being put into a wooden barrel, the two well stirred up together, and the water drained from it. Even this mixture is used sparingly: the fire being scarcely larger than might be held in the two hands, while with us little short of two hundredweight suffices: which is unquestionably a great and unnecessary waste. True the Belgian does not get through the great quantity of work the Englishman does by having "*a great many irons in the fire*" at once; but he certainly does it well and clean: the quantity of earthy matter in the Belgian's fire gives a great heat, which also is retained longer; and it is also free from any excessive quantity of particles of charcoal.

All twist barrels undergo a similar round; the time and care bestowed upon them depending entirely on the price, which varies from one pound per pair down to eighteenpence, and in some instances lower.

In a former work I noticed the introduction of a villanous system of covering or plating barrels with fine iron over a body of very inferior iron. I here quote that description:—

The deceptions practised in this branch of manufacture are numerous, and injurious to the trade. For instance, if you wish to have a heavy single barrel made from Damascus, or any of the best irons, and you send to the manufacturer the weight of iron required, the probability is, that unless you superintend the manufacture yourself, iron of an inferior quality will be introduced into the inside of the spirals. By this fraud they obtain iron worth threepence a pound more than that which they knavishly insert into the barrel. I had been repeatedly told of this practice, but was incredulous. However, I gave an order for four very heavy rifle barrels to be made of Damascus iron. They were made; but on pickling these barrels for the purpose of showing the figure of the Damascus, I discovered that the iron seemed to be much more easily eaten away at the muzzle than on the surface. This led me to examine them, when I found that the inside was entirely composed of iron, over which the covering of Damascus had been twisted. But for the pickling, this fraud never would have been detected; yet for these barrels I was charged at the rate of two barrels for each. Since this occurred, I have subjected many heavy barrels to examination, and have found the fraud to be very common. The practice is not only dishonest, but spoils the gun, by destroying the shooting power, in consequence of the metals, being of different temperatures, not acting together at the moment of expansion.

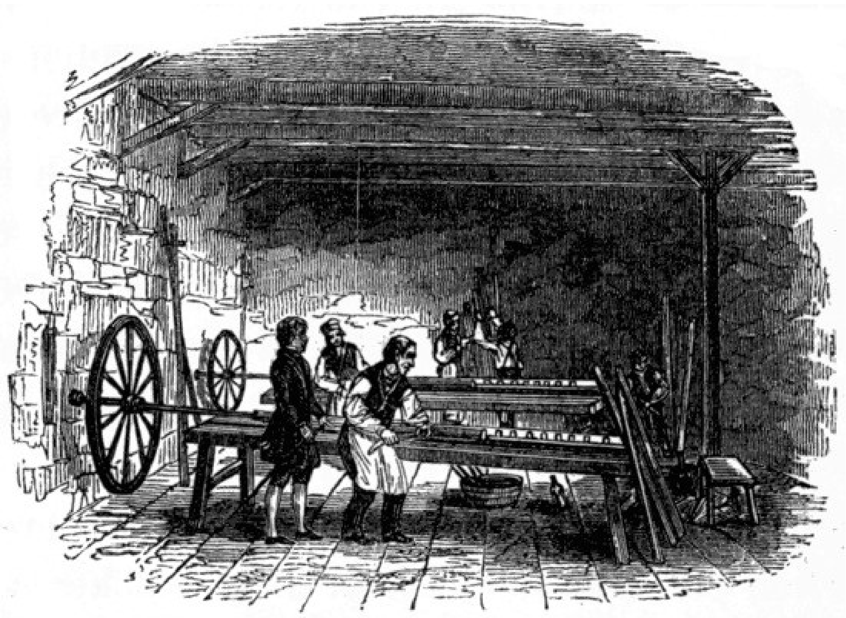


Veneering or plating barrels is more extensively practised in Belgium than in any other nation we are acquainted with; they do not conceal it, but they use equally good iron, though not ornamented iron: of this there is much doubt. The method of accomplishing this is by having the iron required rolled down into ribbons of a thin description; these are twisted spirally round a tube of common iron having the fibres running length-ways, or parallel with the bore. The accompanying cut will convey an idea of this method.

Many will ask what inducement have the welders to take this extra trouble? Gain. The cost of Damascus is 7½*d.* per pound, and the iron they use for this purpose is only 1¼*d.* A pair of barrels take 14 lbs. of iron; say 6 lbs. of this is Damascus plate, costing 3*s.* 9*d.*; 8 lbs. is common, amounting to 10*d.* instead of 5*s.*, or a saving of 4*s.* 2*d.* a pair. A splendid profit if you order one hundred. The borer charges less, the iron is softer, the filer has less, and all items clubbed amount to something. The facility with which welders can do this is wonderful; it clearly establishes their ability, and proves their claim to be considered the cleverest *blacksmiths* on the face of the earth. It is not only the best descriptions of iron they plate with: twopenny skelp is more in use than any. It is now rare to meet with *painted* barrels: all are *genuine twist barrels*, *warranted*; for they are mostly all plated, even down to the gun costing but fourteen shillings, wholesale price.

This is a subject of serious importance; one which the gun-makers, both metropolitan and provincial, should resolutely condemn; for safety as well as goodness of shooting cannot be secured in perfection with any barrels so constructed. I have met with plated barrels in guns which cost the purchaser thirty-five guineas, and I have detected them in some of the first makers' guns; for the *perfection* with which the fraud is accomplished is wonderful, and few can detect it who are not strictly up to "the dodge." The application of a portion of sulphuric acid into the tube at the breech end of the barrel, is the best way of showing the fraud; for, in most cases, it is all bored out at the thin portion of the muzzle, and the application there would, under these circumstances, be no test.

I have frequently been applied to by many masters in the trade for advice in the recommendation of a barrel-maker. It is at all times an invidious task to act as a selector for individuals, and to give praise to one man over another; more especially where the merits of workmen approximate near to each other. But in barrel-making, a man, to be a master of his trade, should not only be a good workman, breeching and filing well, but should possess a good eye in putting barrels together (for here everything depends upon the eye) and finishing them highly: these are only a portion of the abilities a barrel-maker should possess. Several of the London barrel-makers are exceedingly good workmen, for I have tried them all; but only converse with them, and you find the technicalities of the work is all they can discourse upon: the iron, the vital principle, is Greek to them; they know nothing about it, and care less. How can these men be guides in the right direction? They may have seen barrels welded; but, if so, it is only a matter of chance: even in Birmingham, where this can be seen daily, nineteen out of twenty know nothing theoretically. You will frequently hear them heaping *anathemas* on a hard barrel, when floating it, and wishing the man who invented steel barrels "*in the shades below*." Ask these men's opinions, and if they expect to have the job of filing the barrels, they will surely recommend you soft iron, stub-twist, or charcoal-iron.



Boring and grinding gun-barrels generally take place under the same roof; the borer occupying a very small shop, the grinder a large one. Two men and two boys are generally found in a shop. There are four benches, to each a spindle, in which there is an oblong hole to receive the end of the boring bit. The barrel is secured on a sort of carriage, which is at liberty to traverse the whole length of the bench. A boring bit is then selected of suitable size; it is put into the spindle, and the point introduced into the end of the barrel. A sort of lever is then taken and hooked on to a kind of staple, or a piece of hooked iron (a number of which are fixed in one side of the bench the whole length), and passed behind the carriage to force it up to the bit; this is removed and fixed again, until, by forcing up the carriage, the boring bit has passed through the whole of the barrel. During this operation a stream of water is kept playing on the barrel to keep it cool. A bit, of larger dimensions, is next introduced and passed through; then others of still larger dimensions, until the whole of the scales or blacks are entirely bored out; or until the barrel has become so large in the bore, as to preclude any further boring with safety. If the scales are of great extent, the fault is the forger's, and the loss will consequently be his. If the barrels be found perfect, they are sent back to the filer, or he comes to inspect them, in order to ascertain whether they be perfectly straight in the inside; if not, to make them so.

The necessity of great care and attention to this point, must be very obvious; for, if not perfectly correct at this stage, it will require more skill and time to get it correct afterwards than the generality of barrel-makers are inclined to bestow.

When the inside has been found to be all right, the barrel is ready for grinding. Many barrel-makers turn their barrels entirely by self-acting lathes, and thus obtain a correct taper from breech end to muzzle. Experience has clearly convinced us that this is not the best shape, but slightly hollow towards the muzzle is preferable, as additional weight there is decidedly injurious, and the shooting of barrels of lighter construction is decidedly better.

The generality of Birmingham barrels are ground to the size required on large stones, which revolve at a terrific rate. The skill acquired by many of the workmen is astonishing. Over and over again, have we seen barrels coming from the mill put into the lathe, and found almost as true as if they had been turned. They have a method of allowing the barrel to revolve in their hands at half the rate of the stone, and by this means they grind them so fine that many would be puzzled to determine whether they had been turned or ground, were the barrel smoothed lengthways merely to take out the marks of the stone. We have seen the squares of a rifle barrel ground to as perfect an octagon as the eye could assist in forming. Best barrels are generally turned after they are ground. Inferior barrels are struck up with a large rubber, or smooth, by boys; in some instances by women.

There is one advantage derived from grinding barrels, namely, that the friction of the stone being continuous, the temper of the barrel is not so much affected as where the tool in the slide-rest is cutting a considerable portion at once; for all barrels are best, and superior to their compeers, which require least metal to be either ground or turned off their surface, as there is a density on the outer which is not in the interior portion. The harder the material, the less the extent of this objection.

To obtain the true form, it is important that they should be turned. The way of fixing them in the lathe is by having a number of plugs or mandrils, which are perfectly true, and of various sizes, to fit different bores; these are centred and put in the lathe; a carrier is then secured on a part of the plug that projects out of the breech-end of the barrel, and then put into the face-plate of the lathe, which carries it round. The leading screw that travels the slide-rest, is then set in the angle to which the barrel is to be turned (though some lathes have not the power of alteration, but turn all barrels in one angle); the slide is next adjusted to the thickness of the muzzle wanted, and, when all is ready, the lathe is set going; the leading screw is turned at the same moment by the machinery connected, which keeps the tool cutting sufficiently keen to turn a barrel in about twenty-five minutes. This being done, nothing more is required than a fine smooth file to remove the marks of the tool.

There can be no doubt of the superiority of this mode of turning barrels, if due care only be taken with the tool. If it get blunted by any scales or impurities, it is apt to tear pieces out of the barrel, similar to the rings that may be noticed in a slovenly bored barrel, owing to dirt getting on the edges of the bit. In turning a barrel by a common lathe, it is fixed in the same manner as before; about an inch of the surface at the breech and the muzzle is turned to the diameter wanted; the rest is then removed, and half an inch more is turned four or five inches from either end; then another half inch, at another distance of four or five inches, and so on, according to the length; making an allowance each time in the depth of the turning, according to the taper of the barrel. The iron between these cuttings is then filed off by floats the lengthways of the barrel, or more frequently ground off; this is a sure mode of getting the barrels perfectly straight on the outside, and without any of those hollows and shades which may be always discovered in an ill-made barrel. It is astonishing how beautifully many barrels are struck by the float. The mode of turning by the lathe is, however, cheaper, and is now confined to military barrels.

There is a great diversity of opinion as to the proper inclination of a pair of double barrels. It is needless to state the precise distance at which the converging lines drawn from the centre of each barrel, and indicating the inclination of the barrels to each other, should come to a point. If we take the point of convergence of those lines at 2½ yards, it will follow that, at 40 yards, each barrel, were it fixed in a vice, would throw the centre of its charge six inches on the opposite side of the mark fired at; but if the gun be fired from the shoulder, the recoil will invariably cause the gun to swerve outwards, so that at that distance it will never fail to throw the shot in a good direction for the mark or bull’s-eye.

The subject may be understood by the following observations. All tapering substances, when laid together were the taper extended, would come to a point at a certain distance. Gun-barrels are made to taper towards each other, and some more than others. To make them uniform, it requires that they should be reduced or flattened, so that the thick or heavy end should join closer, to allow the point of convergence to be extended to a greater distance. If, then, we take two barrels two feet eight inches long, and having a solid substance of metal at the breech of 3-16ths of an inch each and 1-16th at the muzzle; it requires the difference 4-16ths to be multiplied 45 times (there being that number of lengths in 40 yards) to ascertain what distance the points of the different lines are from each other: which will be eleven 4-16ths of an inch, or five 10-16th inches from the centre or line of sight. If you wish to reduce it from the centre, you have to join the barrels so much nearer at the breech; or should the inclination be too little, the muzzle must be jointed closer. As, however, all guns are now made very heavy at the breech, they very seldom require any closing at the muzzle: though it is customary to do it, and to a great extent; but it is owing to the ignorance of the nature of shooting.

Different lengths require a difference in the height of the rib. A greater height is also required for a person accustomed to use a crooked stock, and less height for one accustomed to the use of a straighter one; and so on. Few barrels are to be met with in which the elevation is sufficient. This is a species of innovation much practised by gunmakers of the present day; but whatever merit there may have been in the original invention, there is none in “the improvement,” as they term it. Take any of the modern barrels, and calculate what is the real elevation of them, and you will find it is not equal to the distance that charges will droop at forty yards, when we consider the very large charges of shot that many are accustomed to use, without a corresponding quantity of powder. It remains then to be decided what elevation a gun should have for that distance.

I have tried the experiment some hundreds of times with guns of all descriptions, both with a rest and from the shoulder, and standing as firm as possible; by turning quickly round, and firing (as we might do were a bird to spring in a situation where we could only get a snap shot) against targets such as are used in military ball-practice, being about six feet high, and by means of which one can perceive where the body of the shot had struck. I have also fired against the steep sides of sand-banks, on which, from their smoothness, you can tell every shot that has struck them. My conviction is, that almost all guns charged (as is the custom) with heavy charges of shot, droop full twelve inches in forty yards; though by using small charges of shot you will find them to be thrown much more correctly than the heavy charges; so that it is possible to make a gun too high on the rib for a shooter who thinks more powder and less lead preferable to much lead and little powder.

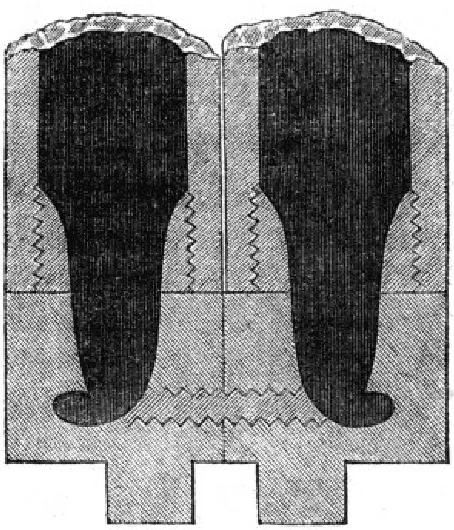
The elevation I have given will be found to be as near what is requisite as possible, if we continue to load as heretofore; if reduced charges of shot be adopted, a less elevation will suffice. To ascertain what elevation at the breech for the above scale is requisite, take the thickness of the breech and muzzle, and multiply the difference by as many times as there are lengths of your barrels in the forty yards, and you will then ascertain what elevation they give of themselves; and to make up the difference wanted, must be the elevation of the rib, which may be calculated in the same way as the barrels; the length of the barrels being the only way of obtaining a correct idea of the height required. If making woodcock guns, less elevation is required, the distance of shooting being shorter. In large guns a greater elevation is necessary. We believe, however, Colonel Hawker has fallen into an error, when he says that long guns require a greater elevation than short ones. Does not a long gun keep the shot more together? Is not more force generated? and is not the initial velocity greater than in a short gun? If these be facts, why is more elevation required if the shot do not droop? We apprehend the Colonel means, if the same height be required to be given above the mark. Nothing can be plainer than this—that if one pair of barrels be four inches longer than another, and the elevation the same, there cannot be as many lengths in the forty yards of the longer barrels as of the shorter, and hence the difference when multiplied. I think, therefore, he cannot have taken into consideration the superiority in their shooting; for there cannot be a doubt that, if a gun keep the shot together longer, it cannot require that allowance for drooping which a shorter gun does.

As soon as the barrels are properly jointed; care must be taken to see that they are perfectly level. If the barrels are not level, it will be impossible to shoot correctly, as one barrel will throw the shot above, the other below the mark. This being done, the barrels are bound together and brazed with hard solder or brass, for about four or five inches. Greater injury cannot be done to barrels than by this pernicious practice; for they cannot be brazed without being heated to a white heat; and by this heat all the advantages derived from hammering are dissipated at once: the condensation is gone, and the strength is reduced at least 12½ per cent. And for what purpose? Under the pretence that the barrels are firmer and not so liable to become loose. This is a point trivial in importance compared to the excellence and strength of the barrel; for even if they have received no more hammering than is necessary in the forging, they are still injured to the extent of 12½ per cent.: for even beating them when hot improves them much, provided they be not heated again; but if they have been cold hammered, the injury is full 30 per cent. This circumstance shows how little the principles of gun-making are understood by the first gun-makers, the brazing of barrels being practised by all.

Mr. Wilkinson admits this, for he says—“The practice of brazing the barrels is decidedly injurious, by softening that part more than the other; but if they were only soft soldered, the inconvenience would be far greater, as the barrels would be liable to some accident by the repeated expansion and contraction that takes place in firing, as well as by the force required to turn out the breechings.” I can only say that I have had considerably more than five thousand pairs of barrels made and put together with soft solder only, and not one pair has come asunder from any of the causes mentioned; nor ever will, with fair play. On the contrary, barrels brazed can never be sound; for at some distance from the part heated for brazing, you cannot get the barrels re-tinned effectually, and thus for a considerable space between the soft and hard solder, there is no cohesion at all. Barrels brazed together only for three or four inches at the breech-end, can never be sound: they almost invariably become so rusted under the rib, in a few years, as both to seriously injure the barrels, and force the rib upwards; therefore, if you hard solder at all, do so from breech to muzzle, as that will be preferable to partially doing it. I feel quite satisfied, and can prove it to demonstration, that this is undoubtedly the most injurious process to which iron can be subjected; and I believe the prejudice with which the London barrel-makers stick to this practice is productive of considerable injury to them: more especially when we recollect that they are the advocates (in practice) of a very inferior quality of Damascus barrels: an iron very susceptible of injury. The Belgian barrels, and French also, are of good iron; and I fear not contradiction in asserting their inferiority to English barrels mostly consists in the foolish practice of brazing them together from end to end. Both chemically and mechanically it is a practice for which no valid excuse can be offered.

All barrels should have solid ribs for at least eight inches from the breech: they tend to lessen the vibration of recoil, as well as to render the barrels more sound and firm. No maker either understands science or studies quality, who advocates brazing and hollow ribs.

The invention of the patent breech was the emanation of a scientific mind; for it has been productive of more real benefit to the progress of gunnery than any other improvement of the last two centuries. Experience and study in the theory of guns and gunpowder, give the mind a much more enlarged view of the subject, if regulated by the established laws of true and sound principles: a want of thorough knowledge induces the individual to draw conclusions prematurely, and thus he is apt to fall, and to lead others, into error. I confess, that, together with many hundreds more, I once concluded that the great advantage of the patent breech arose entirely from the loose state in which the powder was preserved while in the breech, and its thus being more instantaneously ignited. But I have already shown that the quickness of powder is, in a great measure, the greatest drawback to its efficacy, and I am clearly convinced that compression, in most instances, is beneficial, by retarding the ignition to a certain extent. Here, then, is proof positive, that we have been on the wrong scent, and running after a "Will o' the Wisp."



There is the clearest evidence, that the only advantage to be derived from any conical form of breech, does not arise from any peculiarity attached to the ignition of the gunpowder, but solely from the effect of the angular shape; conical form being best suited, or presenting the least direct surface, to the action of the exploded fluid: the angles receive the blow and throw it off at the same opposite angle, and so on, without receiving any amount of force from the element striking it, and thus the elastic fluid is enabled to be resisted efficaciously. The cone becomes and forms an artificial solid base, to a certain extent; and as such, it is much more beneficial than the same quantity of powder ignited on a flat surface—as a common plug breech, for instance; for here the direct quantity of space on the face of the breech receives the same impulse as the ball projected, and is acted upon in precisely the same ratio in proportion to their different weights. In a musket of 11 lbs., the comparative weight of gun and ball is as 1 to 176; and exactly in that proportion will be the distribution of impulse from the expellant fluid. It thus becomes a plain question between the patent breech and the flat surface of the plug. The two halves of a parabola inverted, or the shape of a parabolic spindle, will be the best shape, according to the laws of science. The representation given on page 209 is as near as I can get the engraver to represent my views of the best shape of breech.

A great variety of forms have been advocated and puffed; some of them of the most unscientific description possible: but it matters not; for if a zealous advocate could be found to puff well the advantages of the old matchlock, he would find believers; so prone are mankind to be deluded by the veriest quackery. The absurdity of exploding gunpowder in a *shell* at the breech of a gun, and persisting in the advantage of it, is certainly tilting at a windmill. It will be asked how it is that Government do not adopt the patent breech in the musket? I answer, because of a want of science in the direction, and an imperfect system of experiments. In fact, they say they do not find any advantage from the patent breech in a musket: that the range is as great without it as with it.

Government never considers the personal comfort of the private soldier, or it would have long ago used the patent breech for military arms; for, setting aside the propellant advantage, the recoil is (as near as I have been able to ascertain) under the same circumstances, as one to two in favour of the angular breech. This is no exaggerated statement: I have tested it, and will stake my reputation upon its accuracy. But the superior knowledge of projectiles which artillerists have obtained since the extensive introduction of chambers to nearly all descriptions of ordnance, is the clearest proof, were any wanting. The use of the Gomer form of chamber, is nearly universal in brass guns: the shape is the frustum of a cone with a spherical bottom. The inutility of enlarging on, or describing, the various shapes or plans of breeching, will be apparent; my intention being to point out the science of the question, not the folly of every invention.

There have been many good gun-lock makers; but they have, I fear, decreased much of late. From the great demand for second-rate goods, they are rarely called upon to make a first-rate article; and thus, from being so little accustomed to make any but inferior locks, they, of course, are out of practice. Instead of the manufacture of the best being encouraged, it is becoming every day more rare to meet with a good one. There is a great degree of skill displayed in the making of locks, though to the casual observer it is not apparent. On the simple hanging of the swivel depends all the smoothness of the play of the main-spring; and on the placing the hole for the scear-pin depends the sweetness of the scear playing on the tumbler. Many who now pass for excellent workmen would find this a difficult undertaking, simple as it may seem, without a pattern by which to work. All locks for percussion should have the greatest strength of mainspring at the moment they strike the nipple, or as it is termed, when the lock is down. On the pitching the scear depends the cutting of the bents, and on their formation, the danger of the lock catching at half-cock, when the trigger is made to pull easy; but these observations will be understood by a lock-maker better than I can explain them.

The quality of all locks depends on the price they cost filing, and unless you pay the workman a proper remuneration, you may rely on having them somewhat inferior, or in accordance with the price: but this requires a workman to point out; so that any person who is not a first-rate judge, is completely dependent on the honesty of the workman.

There is more real science displayed in the construction of a gun-lock than mechanics in general imagine. The placing or hanging of the swivel on the arm of a tumbler, is an arrangement of leverage partaking of the multiplicate; as the weight when at full cock, is lessened by the lever bringing the moving force in the immediate vicinity of the axle, and when down on the nipple, increasing or multiplying that force by the divergence. The Barside lock possesses this advantage to a greater degree than has yet been obtained by any backwork lock yet made; though I perceive no hindrance, if properly understood and tried: it is only needful to obtain a greater length of arm, and a proportionate length of swivel.

The family of the Braziers, of Wolverhampton, have long been celebrated for the goodness of their locks; which arises solely from the fact that they take more pains, and will not manufacture any but the best: for it would be ridiculous to suppose that there are not plenty of men equally as good, and probably better, workmen than themselves in the kingdom, were they properly encouraged, and confined to making nothing but first-rate articles. The Braziers have apprentices and journeymen, and it is preposterous to imagine that they file the tenth part of the locks they furnish to the trade; but yet they have always, and deservedly, obtained a much better price than any other lock-filers out of London. Several of Brazier’s workmen have of late years commenced manufacturing on their own account, and now most excellent locks can be had from W. Evans, of Bath-street, Birmingham, who for many years held the first place in Joseph Brazier and Sons’ manufactory.

The operations of false breeching, jointing locks, stocking, &c., are merely mechanical; requiring, certainly, great skill and ability, but yet involving no principle further than is contained in the proper suiting of the shape to the make of the user. An endless variety of opinions has always existed, and always will exist, as to the description of bend or crook best fitted for rapid shooting, as flying or running. I have instructed, and with success, too, many young shooters, who by commencing with a long and straight stock, have attained a perfection in shooting scarcely to be excelled; and they never entertain afterwards any wish to change either length or bend. Therefore I recommend to all beginners to use as long and as straight a stock as they can *conveniently* bring to the shoulder. All practised shooters have generally so accustomed themselves to one shape, that it would be prejudicial to change. The practice of throwing off a stock at the butt, or bending from the hand to the heel-plate, in a direction to the right, so that the eye may get more readily in a line with the centre of the breech and the sight, is a practice not to be defended on scientific principles. The body will suit itself best; and if the stock be not too straight, the eye will always find the true line.

The percussioning of a gun (as the fitting-in of nipple, boring breeches, filing cocks, &c., is termed,) is also a mechanical operation, requiring workmen of the very best abilities. The desideratum to be obtained is nearly a direct communication into the barrel, and an absence of unnecessary angles, antechambers, &c.; therefore it is needful that, in a double gun, the nipples should be inserted as near the centre of the breeches as they can be conveniently placed, with the nipples standing, not upright, but at an angle of 45°; so that the blow of the cock shall be in or as near a line with the imaginary upright of the nipple as possible.

The various plans of copper cap, copper tubes, and I know not how many other devices, will be discussed under the head of guns and shooting.

Finishing the stock, polishing, engraving, hardening, &c., strictly speaking, involve no science of consequence, and as such it is scarcely necessary to occupy the attention of the reader respecting them. The best method of staining barrels is by the following recipe: but one material fact must not be overlooked. A considerable difficulty exists in staining barrels all steel; in such a case, therefore, the acid should not be so much diluted.

1 oz. muriate tincture of steel.
1 oz. spirits of wine.
¼ oz. muriate of mercury.
¼ oz. strong nitric acid.
⅛ oz. blue stone.
1 quart of water.

These are to be well mixed, and allowed to stand a month, to amalgamate. After the oil or grease has been removed from the barrels by lime, the mixture is laid on lightly with a sponge every two hours. It should be scratched off with a steel-wire brush night and morning, until the barrels are dark enough; and then the acid is destroyed by pouring on the barrels boiling water, and continuing to rub them till nearly cool.

The Birmingham people brown their barrels of inferior quality in the following way, to make them look equal to the best. They dissolve as much muriate of mercury as can be taken up in a dram-glassful of spirits of wine; this solution is mixed with one pint of water, or as much diluted as the person requires. A small quantity of the mixture is poured on a little whitening, and laid on the barrel with a sponge, rather lightly; as soon as dry, it is brushed off, and a fresh coat is laid on; and so on until the barrel is dark enough, which is generally about two days. The effect that the mercury has on every one of the joints of the fibres is wonderful: it never fails to make them, in two or three days at most, a beautiful brown; while the other parts, being harder, remain, comparatively speaking, quite light. The rust is killed by hot water, but after that, the barrels are suddenly immersed in cold water; which has the effect of heightening the brightness of both the colours. The appearance is beautiful, and equally as fine to the eye as stub-barrels browned in the same way; though this process is mostly used for the charcoal iron and the threepenny iron barrels. The only method in which there is no deception, is the smoke brown or stain; and, plainly speaking, this and no other is the reason the gun-makers condemn it. As the acid is decidedly weaker, and of course less liable to impart injury to the iron, no barrel can be browned by it, to look well and fine, but the best; or, in other words, none save those possessing steel in their composition.

The method of staining is this: the barrels are anointed with a little vitriolic acid, to cause the iron to receive the effect of the gas more readily; it is then washed off, and the barrels rubbed dry. The forge fire must then be lighted, and blown up with coal possessing as much hydrogen gas and as little sulphur as possible. When the coals are burnt till they give out a clear white flame with no black smoke around it, the barrels must be passed gradually through that flame backward and forward, until the whole are covered with a black sooty covering. Place them in as damp and cool a cellar as can be procured, and allow them to stand for eighteen hours; at that time, if the place is sufficiently damp, the iron parts will be found covered with a red rust, while the particles of steel still retain the original sooty coat. Scratch these off with a steel brush, the same as by any other method of staining; then take a piece of linen cloth, and wash or polish the barrels with water and a little washed emery; when the steel will be found of its original bright colour, and the iron a shade darker, with the outlines of both distinctly preserved. Rub the barrels dry, and again pass them through the flame precisely as before; but above all things be careful not to allow them to remain in the flame till they become hot enough to melt the solder. When you have once passed them through, do not be in a hurry to pass them again; but in both be guided by moderation: neither allow them, after the first time, to stand to rust more than twelve hours each time. Polish them as before, and you will find them a shade darker at every smoking. Persevere, until they become as dark as you wish to have them. The utmost you can obtain is a fine purple-black colour on the iron; and on the steel, a shade inclined to a copper colour: but if proper attention be paid to the polishing, it will not change much from its original colour.

The barrels are taken out of stain in the same way as in the other recipes, by hot water; but you must continue to scratch or brush them longer, for by that means you obtain a greater gloss. The principle of this stain is simply thus: the hydrogen gas contained in the coal acting on the iron (from being of a softer nature than the steel, which it does not affect), and the flame also possessing a quantity of tar, it is imperceptibly embodied by the iron during the action of the oxide; and, when finished, by filling up the spaces created, it becomes decidedly more impervious to damp or wet than the other stain, which is entirely composed of the oxide of iron.

The only objection to this brown has been found to arise from the discharge of the black colour from the softer parts of the barrels; as it being but coal tar, the sweat of the hand, hot water in washing, &c., invariably extract it in a comparatively short time.

The recipe, for the Birmingham imitations, is as follows:—

1	oz. sweet nitre.
½	oz. tincture of steel.
¼	oz. blue vitriol.
6	drops nitric acid.
14	grs. corrosive sublimate.
1	pint of water.

When the barrels are dark enough, drop a few drops of muriatic acid in a basin of water, and wash the barrel slightly, to brighten the twists.

This last process is borrowed from the Belgians. In the working of their extremely fine Damascus barrels, they found a very great difficulty in staining them so as to produce a clear and distinct figure. The way they now proceed is either to eat away the particles of iron, leaving the steel prominent and the barrels bright; or they polish them extremely fine from end to end, and then blue them in a stove with charcoal. The process is thus described in the notes to a German translation, by Dr. Schmidt, of Weimar, of my last edition of the “Science of Gunnery.”

"The method of browning the Damascus barrels, which are so much admired in England for their distinctness in colour and beauty of figure, is obtained very simply: namely, first burnish the barrels very fine; then cover them with bone oil; pound, or drop, or strew wood-ashes all over; then heat them in a cage of wire filled with charcoal, until you obtain a dark first blue; after they are cold, mix a small quantity of sulphuric acid in water (a quarter of a pint with so many drops); then take a hard brush and apply it to the barrel, when the acid will extract the colour from the steel, leaving the iron with its greater adhesion covered with the blue colour. Great care must be used and skill displayed to keep a good colour and not to extract too much."

This we cannot do, because we solder with tin.

The "Belgian Damascus" barrels are generally "eat up," as it is technically termed. "Pickled" is the term also used to describe the process, which is simply eating away the softer metals from around the steel or harder material. The best preparation for this purpose is 1 lb. of the sulphate of copper (known as blue vitriol) dissolved in a gallon of soft water, at the boiling point, and continued boiling in an earthenware vessel, until the quantity is reduced by evaporation 25 per cent.; let it cool, and then pour it into a leaden trough or bath. The barrels, when properly secured at the muzzle and breech-ends to prevent the liquid getting into the interior, are immersed therein. The solution will act sufficiently upon the metals in the space of from fifteen to twenty minutes; care being taken to remove and carefully wash them with cold water, and then, after observing the progress of the *pickling*, re-immersing them as before, until the operation is complete. Then pour boiling water over them, and scratch them well with a steel brush, which will eventually give that beautiful bright "wavy" surface much admired by many people. Laminated steel barrels also look very well, after being subjected to this operation.

Having now detailed as much of the "*modus operandi*," as the patience of the reader will admit, I shall endeavour to give a peep into the "*sanctum sanctorum*" of the gun-makers' workshop. I have shown in detail what course ought to be pursued in the construction of guns of the best quality only; and before proceeding further shall finish this part of the subject. I am not, as some would say, "going to expose the *whole* secrets of the trade:" oh no, only a portion.

There are six qualities or varieties of mixtures of iron for barrels of best quality. The plate-facing contains two kinds finished, composed of steel entirely, but of different degrees of carbonization; one is composed entirely of a laminated series containing many scores of distinct laminæ in the thickness of the sides of the barrels, twisted and beat into tortuous shapes. The other, of larger laminæ, but showing the edges of the laminæ at an angle with the length, and thus appearing larger than, if presenting the side or end of the plates.

Care must be taken that the great proportion of the fibres shall always run round the tube, so that the greatest portion of strength may be obtained, together with a beautiful figure. The cost of this arrangement is considerable, as it involves a great waste of metal, and occupies a considerable time to work and re-work—twisting, faggoting with the bars placed in various forms, at acute angles to each other, at right angles, plaiting three or four rods together, as a lady does her hair, cutting these into pieces, faggoting and welding them into one, and, in short, undergoing an endless routine of manipulations, which it would be strictly unprofitable to detail, but are all productive of cost. An ingenious man may work and improve metal of this nature until its cost equals the price of silver; and, if judiciously done, improving it still, even until he has wasted 90 per cent. of the original material.

The ultimate characteristics and properties of iron have, as yet, never been ascertained: it is capable of being condensed until it becomes nearly, if not quite, equal to the specific gravity of silver or lead. No pursuit, mechanical or philosophical, presents so great and so beneficial a research, to the whole civilized and scientific world, as iron. I could twist and retwist iron, until, from the beautiful and interesting results, it would become with me a sort of monomania. I wonder not at the variety of patterns in a Damascus sword-blade: the mind conveys me to the scene, and a regret arises that I did not live in those times; yet still it is but a mechanical arrangement directed by an ingenious mind, and the ultimate benefit, apart from the beauty, is more than imaginary. However, it proves that the Orientals were artists, and that they were appreciated: were this the case now with us, we could do all they ever did, and more.

Laminated steel is now a great fact. It is a name stereotyped in Belgium, Germany, France, and America, as well as in the place of its birth—England; and orders come from all quarters of the globe for the celebrated laminated steel. Every writer of eminence is loud in its praise, and justly so too; for about its merits there is no mistake. No combination of metals ever yet before tried since the birth of gunnery, can equal it, either in density, ductility, or tenacity. A laminated steel barrel has never been known to burst. "Reputed" laminated steel barrels have been burst, but no real one ever. Nor is it probable, save from malconstruction. Through inattention in the welding the best of metal may be burnt; but the better the iron, the greater the difficulty. Steel is more liable to melt than burn; so that, with care and skill on the part of the workman, it will very seldom indeed occur. But that chance is provided for, as far as human judgment can do, in entrusting such barrels only to first-rate and steady workmen. Such men are no doubt, to a certain extent, scarce; but they may yet be found: the Birmingham welder of proved skill and ability is inferior to none in the world. Laminated steel barrels are more scarce than welders.

Although the various manufacturers of Europe have complimented me by adopting the name of my invention, yet I am sorry to add it is but in name: there are very few even tolerable imitations of them. The cost is the "bugbear:" the name costs nothing, and can easily be assumed; but to make laminated steel barrels is quite another matter: it touches the pocket, and interferes with the profit; and it is only in very rare cases indeed—although the order may be explicit as words can make it—that the real article is supplied. There are very few makers in Birmingham who in reality make “laminated steel.” Steel barrels are more plentiful: they care not so much for the price of the metal; it is the after repeated manipulations that are evaded: the labour and loss of material is too much, and is necessarily “shirked,” and argument is always met with the answer, “We see nothing in it.” Yet the words “laminated steel” are to be found engraved upon barrels of the lowest quality of iron of which double barrels are made. Iron twist is subjected to a similar process to that already described as employed in producing Damascus iron, and which may be termed common iron Damascus. Thousands of guns are made from this kind of metal, and yearly sent to the United States of America; yet all are unblushingly represented as “laminated steel barrels.” The actual price charged for these sort of guns in the United States I know not, but have no doubt for the whole gun it is about equal to what would be the prime cost of a pair of real laminated steel barrels alone.

Purchasers should be fully acquainted with the fact that it is impossible to produce laminated steel barrels at a low figure: labour, high-priced, skilled labour, is always costly; and talent must be paid for in all parts of the world. The attainment of high class barrels at a low figure, as a rule, is an impossibility; and the maker who would pretend, promise, or undertake to make a laminated steel barrelled gun under 15*l.* to 20*l.* is an arrant deceiver: he could never profitably carry out such an intention, even if he possessed the ability to produce the article. For judgment, skill, and ability, as well as labour, are required to produce laminated steel barrels. Steel alone is not laminated; and that is another difficulty: fortunately there are not many persons capable of effecting it. My method of laminating steel is kept as much out of sight as possible, as a means of self-protection.

Stub Damascus is by many makers called “steel:” both first and second class stub; and any attempt to reason them out of the absurdity is a hopeless task. Many of the highest class makers still doggedly stick to stub Damascus, and insinuate underhandedly that the benefit of steel is doubtful: few do it openly; but I feel sorry to record the fact that prejudice on this point is still rampant.

On the superior shooting properties of steel barrels I will enlarge in another place.

The Exhibitions have told very beneficially on the future of Birmingham; the fact of standing highest in every competition will do (and has done) more to remove the prejudice entertained against Birmingham manufacture than aught beside. Sportsmen begin to understand the fact that it is better to order their guns direct from the manufacturer than from the mere salesman, who can only take his goods on trust, and warrants without knowing that he can justly do so. Any system that would identify the maker with his work would do all that is necessary to emancipate Birmingham from the stigma which prejudice has entailed upon her name; and from which I hope to see her rise rapidly yet. But I do not wish to see her rise on the reputation of London: would that all Birmingham guns were like those of London makers; or superior to them, if possible.

In addition to the serious evil of producing guns of such great inferiority in material, and dubbing such barrels “laminated steel,” a far more serious one is the practice of unscrupulously adding to such guns the names of makers who have spent the majority of their lives in obtaining a name for their manufacture; thus robbing them indirectly of what is dear to all honest men—reputation. Few are judges sufficiently qualified to detect a spurious gun of this description; and the name thus forged reflects unmerited discredit on a maker who would scorn to allow such an article to leave his manufactory: but as long as the standard of moral honesty is so low, both among merchants and manufacturers, such things will be. Men may excuse themselves for affixing the names of men and firms to inferior or worthless guns by the plea of having been ordered to do it by the exporters, but they are not the less doing a moral wrong, in thus aiding in a deception which profits them not. But such practices will continue, until the sense of right and wrong becomes more conscientious, and trade morality rises to a higher standard than at present.

I have every reason to believe, and have not the least hesitation in stating the fact, that not only is the epithet “laminated steel” added to guns the barrels of which do not contain a particle of steel, but that a far more serious misrepresentation and injury is perpetrated by affixing the words “William Greener’s Laminated Steel, indestructible by Gunpowder,” to many guns not even of middling fair quality, but the veriest rubbish ever manufactured. That this is a species of forgery there can be no doubt; yet the law of this country affords no remedy to effectually prevent and punish the rascality of offering for sale an article fraudulently professing to be what it is not, to the injury of the purchaser as well as the manufacturer whose good name is thus maligned. Forged “Greener’s” are to be found principally in the American markets; where batches of ten and twelve have been seen in various parts of the States, principally in the hands of “itinerant merchants.” They are, I believe, pretty plentifully produced in “Liege,” also; where, in fact, forgeries on all our principal makers are produced.

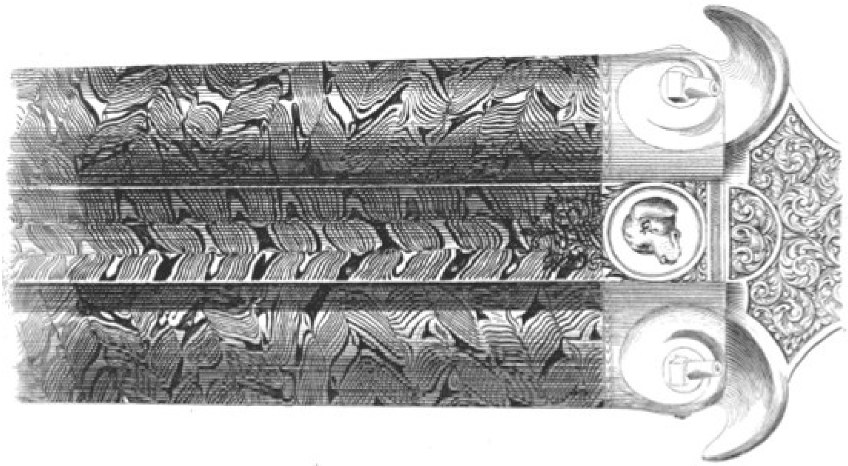
As the law provides no effectual remedy or punishment for such rascality, I now, in order to lessen it as much as possible, mark every gun leaving my manufactory with a “*private mark*” in addition to its number; and on reference to me, giving a description of the gun purchased “and its number,” information will be returned of the private mark, which will stamp the article as real or spurious. If the gun has no number reference is useless, as I number every gun that I send out, and the want is certain proof that it is a forgery. But with a view to lessen the evil as much as can be, I may here say that the best double gun, with case complete, that I can make will be freely given to any individual who will produce evidence which will enable me to expose all parties concerned in such nefarious dealing, and justify me in holding them up to public reprobation: which will be done as certainly as proof can be adduced.

There are ample fields of commerce in gunnery yet to be developed, were articles produced suitable for use, not for show or deception. Inferiority of manufacture combined with deception is the worst course ever adopted by any community. If Birmingham would repudiate such a course, and refuse to make worthless articles, attending more to quality than cheapness, the gun trade would be more prosperous than it ever has been.

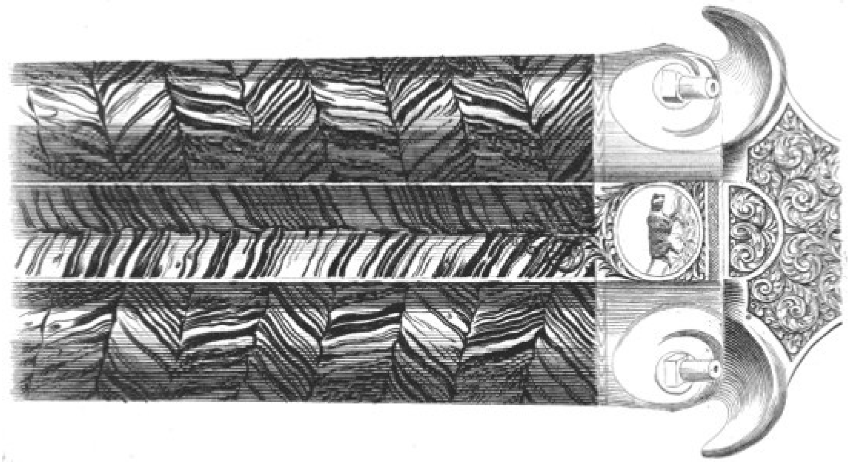
Time is rapidly realising the recommendations I have put forth of the great benefit to be obtained, not only in steam boilers, but various other mechanical constructions, by the use of higher qualities of metals. We have now even “steel ships” as well as steel guns, giving double the strength, with half the weight; and if all manufacturers of high class machines adopted the same principles, an immense saving would be effected in the long run, from the absence of repairs alone, in addition to the greater durability of the machine.

There ought to be no accidents from the breaking of railway carriage axles: such an occurrence as the breaking of an axle is an everlasting disgrace; for axles could be constructed that no known “fair application” of strain could possibly break. A simple combination of steel and iron faggoted in segments, as before described, and rolled hollow, would enable axles to last double the time of those at present in use: 40,000 miles travelling is stated to be the maximum distance an axle can be safely trusted; the destruction being mainly due to the heating in the journals, or to galvanic action changing the fibrous iron into crystalline in the immediate vicinity of the bearing. Axles constructed of different metals, as steel and iron in conjunction, would not be so affected; and might be rendered still less likely to be so by a small hollow in the centre of the axle. But this is a digression; though I may be pardoned for it, in consideration of the importance of the subject.

PLATE. II.



DAMASCUS BARRELED GUN



FANCY STEEL BARRELED GUN

The opposite plate (No. 2) represents my mixture in imitation of Damascus; the process necessary to produce it, as well as its companion, has already been described. These two also come under the head of best barrels, as they are costly, and when honestly made (not plated) constitute, with the defects before enumerated, good barrels.

The cost of a really good first-rate gun must and will always vary, according to the circumstances of manufacture or the peculiar arrangements of the manufacturer. Joseph Manton is entitled to the gratitude, not only of the present generation of gun-makers, but of all succeeding ones, for this reason,—he not only gave a character to English guns, but so linked his name with improvements, that it will never be forgotten. His was the mind to know and appreciate the value of good workmanship; he elevated the English artisan with himself, and raised the gunmaker to the acme of mechanical skill: for, without invidious comparison of the ability required in other professions, we may say that a first-rate workman as a *gun-maker*[11] (*I mean only a gun-maker*) is one of the very best mechanics England can boast of, or in truth any part of the world. Gun-making is the profession of a man of mind: any man or any workman cannot make a gun, working by square and rule entirely, as other mechanics do: no, the true *gun-maker* is an artist, and Joe Manton made him so.

[11] Barrel welders, borers, lock-filers, &c., are not technically gun-makers: the latter are those workmen who, having barrels, locks, wood for stock, &c., make them into a gun. It has been customary to say gunsmiths; but this appellation can be applied to the worker in iron only.

It is true, we have not now that complex machine, the flint-lock gun, in which Joe so peculiarly excelled; but we have a more simple and a more efficacious one in the percussion gun. He was not so fortunate in the latter as the former; but all men are at fault sometimes, and he could not be expected to fondle the child of another: no, it was for the first improvement of the *workmanship* of the gun, that his memory must be revered. The English gun, at the outset of his career, was as far inferior to what he left it, as the tawdry manufacture of the continent is to ours of the present day. The prices he obtained were enormous certainly; but all men should be paid well, who can prove they possess extra brains and ability: he remunerated his workmen on this scale, and he unquestionably had the best set the world ever saw. We can, at this period, far excel them, for the *pupil* sometimes exceeds the *tutor*; but this arises from laying firmly the foundation of a superior system.

All my ambition has been to be able to make an article that cannot be exceeded in goodness and neatness, combined with taste, by the generation in which we live. In proof of this success I may mention that the two First Class Prize Medals in the Great Exhibition of 1851; two more in 1853 at New York; and, lastly, two at Paris in 1855, were awarded to me.

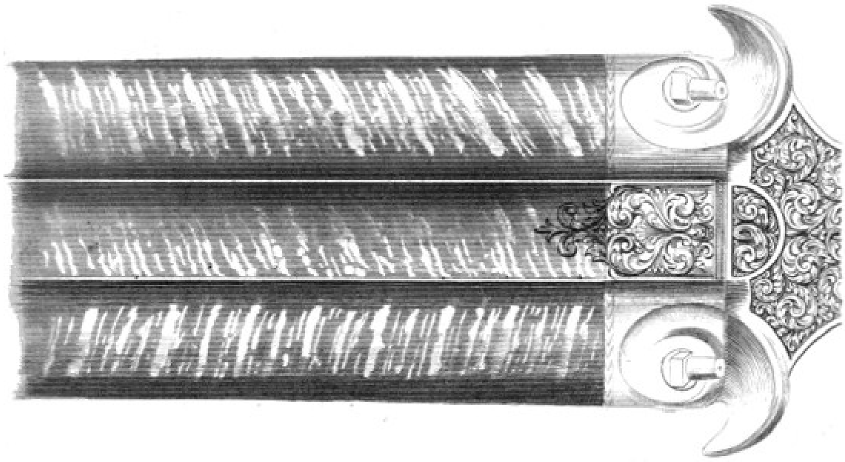
The best gun, or as good a one as ever was constructed, or ever will be, should yield the maker a profit at 35*l*. Cheaper it cannot be made, if it be *honestly the best*. I have studied and estimated the cost both of town and country-made guns, and am aware that the London maker would be barely remunerated at this rate, owing to the extra expenses he is liable to. But I also know, without doubt, that as good guns can be, and have been, made in Birmingham as ever were produced in London: the facilities Birmingham possesses will always tell in that competition. Westley Richards is an example; for not much better guns can be manufactured than he produces daily, as most London gun-makers full well know. Let but some individual, with the head and the *cash*, try the experiment of making guns himself at Birmingham, and a fortune would be the result; as better workmen, if well looked after, cannot be found in the world. But their talents are now prostituted in the production of inferior articles; and when wanted are, of course, *amiss* for any great effort. Birmingham is a workshop where if one tool does not suit you you can get another: if a barrel be faulty, or locks inferior, you can have a new one in the time a London house would take in ordering it. These remarks are not dictated by any feeling of dislike to the metropolitan makers, but from a conviction of their truth. Establishments like Joe Manton's are not met with in London now-a-days—not one house in the business can maintain them.

I cannot possibly have any wish to depreciate. What benefit would be gained by it? But I cannot praise the London manufacturer against conviction; and I am unfortunately too much in the secret: I know too well where and how the vast majority of London guns are made. Why keep up a distinction that does not exist? Why call a gun London-made because the seller rents a shop and calls himself a gun-maker? Why not at once say, "Our manufactory is in Birmingham, as we find we can make both better and cheaper there." This is truth, and ought to be told. It is now the extreme of folly to say, "These are *Brummagem* guns:" that term only applies to the "*rubbish*," the low priced article, which no honest man has hardihood enough to brand with his own name, but substitutes that of some deceased member of the *fraternity*. But when sensible London tradesmen so far forget themselves as to designate the produce of a "*brother chip*" as "only Birmingham guns," without ever having seen or examined that work, *I feel sensitive on the point*; for though the term is strictly correct, yet the meaning is slanderous.

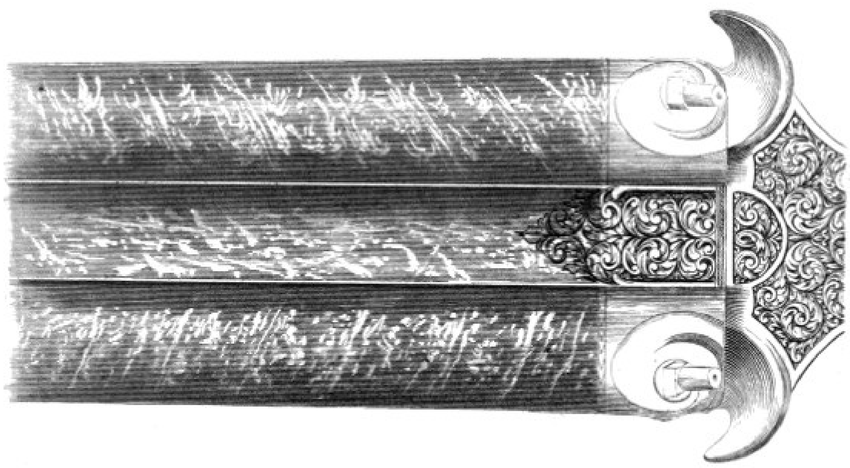
I have always written and impressed upon sportsmen the imperative necessity of obtaining the very best gun that hands could produce; I urged this sincerely, and for doing so feel myself entitled to the gratitude of all gunmakers who delight in good work. Yet instead of the merit of my work being appreciated, I have unfortunately had to contend with the secret revilings of those who possess not the heart or ability to compete with me. "A fair field and no favour" has ever been my motto; and, without egotism, I can safely offer to make a gun or guns against any maker in the world. I do not claim this ability exclusively; for I can name several in Birmingham, who, if they have the price, will not be far behind. I may fearlessly point to the fact that throughout the whole breadth of England every gunmaker is a copyist of my patterns. Three months after the opening of the Paris Exhibition, imitations were found in every gun-maker's shop in Paris, labelled, "Fusils de chasse a l'Anglais."

Both the Belgians and French are making vast strides in competition with us. In Liege they have very recently purchased guns by most of our celebrated makers as models; and every part of the gun is being imitated to the greatest nicety. I have before alluded to twenty-six of Westley Richards' guns, forgeries, having been sent to London; in truth they have taken us as a model, and if we do not *keep going ahead*, depend upon it we shall be hard run. In every respectable maker's shop abroad you will find proof of this fact. I brought to England several specimens of their productions, and amongst others a pair of imitation "Braziers' locks;" these have been shown to many makers in Birmingham, and pronounced unanimously a fair pair of locks: indeed no workman in the kingdom but would have taken them to be of English manufacture. In Paris they carry their imitation, *if possible*, farther still. I saw in Le Page's establishment some very good work indeed, and said so; remarking that they were very *little inferior* to our best English guns. "*Inferior*, indeed!" said he, "we consider them quite as good, I assure you:" showing evidently a wish to *have them as good*. The French may excel us in the laudable desire to improve. Their periodical Exposition is a proof of this. We should have our "Exposition" also. Look at the national importance it would give to our artists in all metals! how many bright men would then spring into notice! what an impetus it gives to competition. Artists and sculptors exhibit the effects of their genius: why should not gunmakers also? The highest skill is required in producing a gun: a first-rate gun is indeed a work of art. Why is it not done? "Self" is the stumbling-block. The first makers "*par excellence*" do not encourage it, being jealous of being beaten by some provincial. There wants unanimity, a co-operative feeling, both in London and Birmingham. A well-arranged "Mutual Improvement Society" would be the means of driving the "*rubbish*" out of the market, and the sordid manufacturer into a reformation of his ways; it would show him that honesty in his manufactures is as essential as honesty in his outward dealings. I lament that this untoward feeling should exist; more especially in Birmingham, where they possess all the elements for future prosperity: but these are blighted, from the want of an expansive, liberal feeling to each other. I hope to see this state of things attained soon: the seeds of improvement are taking root.

PLATE. III.



STUB TWIST BARRELED GUN



STUB DAMASCUS BARRELED GUN

The plate (No. 3) opposite represents stub twist and stub Damascus; the former, if properly attended to in manufacture, will long hold its station in the construction of good guns. An excellent second-rate gun can be made for about 20*l.*, with case, &c. At this time there are a great number made at this price: in fact, very few cost more; even those of the best production of Birmingham. Superior articles to any yet produced could be made there, if occasion demanded it, and if there were a sufficiency of heads to direct and control. The generality of gunmakers in Birmingham are merely mechanics, and when you say this, all has been said that can be: a vast majority of excellent workmen have never fired a gun, and know nothing, strictly speaking, of its use. A gunmaker, in the true meaning of the word, is, or ought to be, an enthusiast; delighting in, and living for, his art alone; without being clogged with prejudice or with a stubborn mind that refuses to advance, but animated by a spirit to conceive and realize the emanations of genius.

I have already sufficiently enlarged upon the inferiority of barrels made from charcoal iron. A great quantity of these guns are made or got up for the general factors, who take orders for everything, from "a needle to an anchor;" but they manufacture nothing, and only employ their money *for a moderate return*. The hardwareman is the principal seller of this description of guns; he generally pays between eight and ten pounds each for them, and retails them at from twelve to fourteen pounds, if he can make his customers believe that they are as good as they can get elsewhere for twenty pounds. I have known a tradesman of this kind sell more guns in a season than three gun-makers in the same town during the same time. A certain portion of the warranty was correct, "that they were as good as could be got elsewhere for eighteen pounds;" for the articles, as far as barrels and locks are concerned, are identically the same.

Unfortunately, the generality of gunmakers are content to live like the snail, who cares not how the world goes, so long as his house remains whole above his head; rather than try to improve their productions, or to meet the exigencies of the times, they are content to allow the trade to be injured by the influx of worthless articles, to their own loss and the discredit of the business generally. The enormous prices which gentlemen have been charged for provincial-made guns of the most inferior quality, has driven them to obtain still worse at a less cost. An honourable and tradesmanlike method of conducting business will always be appreciated, and if a gun be required at a low figure, an honestly-made article might be furnished at a price to suit the customer, and of equal and mutual benefit to buyer and seller. But this will not do: high prices or no orders is the rule. It would do very well if nothing were manufactured but high-priced articles, as good in quality as they pretend to be; but few provincial makers have the means to do this: an establishment sufficiently large can only be supported in certain districts. I must be excused for making these remarks, as I have both the interest of the maker, combined with that of the sporting world, in view, and have no other end to serve. I do not include all, only a part of the profession in these strictures, for there are many honourable exceptions.

The ironmonger receives these inferior guns, and disposes of them as stub-twist barrels: he knows no other, nor would he care if he did. A flashy outside is very captivating to the novice; but one or two years' use will soon show the quality of the article: the wood then shrinks, the glue and wax wash out of the fittings, and an apparently crazy and breaking-up constitution displays itself most clearly: for work put together at a certain price will have only a certain duration. Were I free of the gun-making profession entirely, and asked for my conscientious advice in the purchasing of a gun, I should decidedly say, buy a gun from no one who has not a character to lose; who is not only answerable for the article he sells, but also capable of judging of the quality, and appreciates the value of good materials. The trade is over-run with swarms of Jew salesmen and others, who cannot, nor ever will be, able to duly understand and appreciate the responsibility attached to the profession of a gun-maker.

There have been individuals in Birmingham who realised considerable sums by manufacturing guns of this quality only for two or three sale shops of puffing celebrity in London, and so extensive are their orders still, that an engraver is kept in full employment by them, the excellence of whose forged imitations of names, &c., is wonderful: so devoid of shame and debased in intellect do men become from perseverance in evil. Joe Manton's guns have become like pictures of celebrated masters; had he produced one per hour during his existence, he could not have made one-half of the number that bear his name.

Guns made of threepenny skelp iron are plentifully to be met with in sale-shops and pawnbroking establishments; they generally bear false colours and hail from fictitious ports, and are bedecked with painted stocks and tawdry imitation gold and silver ornaments; but as to the mechanical arrangement, to use a Brummagism, they are as if they had been pitched together. A decent gun could be made with barrels of this quality, if constructed a little heavier than usual; and it would be perfectly safe, and suited for the use of those who could not purchase better: if firm and soundly fitted up, with decent locks, sound stock, &c., it would be worth about eight guineas; but you can get them by the hundred in Birmingham for 3*l.* 15*s.* each, and, if you particularly wish it, at 2*l.* 15*s.*, or less; and single guns, with plated barrels, about half that sum.

We have now reached the utmost limits of civilization, and are about to pass the great desert, where science is never seen or heard of, except it be in the pretences of an inventor of deceptions: things of wood and iron, called guns. Pocket volcanoes would be a fitter title, or portable exploders—for no one can possibly expect anything but destruction who uses such compounds of dangerous contrivances. But for the edification of those who use such, we give the prices of each part and cost of manufacture of them: the statement is literally true; and, except that by possibility the items may vary a penny or two, the whole is substantially correct.

Cost of Material and Workmen's Prices for making Double and Single Guns, with "Twopenny" or "Wednesbury Skelp Iron" Twist Barrels.

DOUBLE GUNS.

	s.	d.
Double barrels, twist, patent breeched	12	0
Pair of locks	2	0
Wood for stock	0	6
Set of cast furniture	0	5
Stocking	2	0
Screwing together	3	0
Percussioning	2	0
Polishing and engraving	1	0
Varnishing (including painting)	0	6
Browning	0	6
Finishing	3	0
Ramrod, tip, and worm	0	6
Small work, nails, escutcheons, wood, screws, &c.	1	0
£1	8	5

SINGLE GUNS.

	s.	d.
Single barrel, twist, &c.	5	9
Lock	1	0
Wood for stock	0	6
Set of cast furniture	4	0
Stocking	1	0
Screwing together	2	0
Percussioning	1	0
Polishing and engraving	0	8
Stock varnishing and painting	0	4
Barrel browning	0	4
Finishing	2	0
Ramrod, tip, and worm	0	6
Small work, &c.	0	8
	16	1

Common iron barrels plated with this iron can be furnished by barrel-makers, double for eight shillings per pair, single for four shillings each; which deducted from each, gives double complete, 1*l.* 4*s.* 8*d.*, and single 14*s.* 4*d.* each; and for these we have known the factor charge the ironmonger, double: 3*l.* 10*s.* each, and 1*l.* 15*s.* single; so it is strictly an imposition on both sides, one charging 5*l.*, and the other 3*l.*

Now for the next: bad as is the preceding, this is infinitely worse; the former costs two-pence per pound, the present varies from one penny to one penny farthing per pound. “Sham damn iron” is similar in nature to brass; a metal with fibres certainly, but they are like the fibres of willow compared to oak: it is an iron soft and spongy, capable of being condensed to an immense degree. All slave gun-barrels are made of it. Mungo Park detailed some of the lamentable atrocities committed by these guns bursting. The many thousands of mutilated wretches who have lived to curse the cupidity of their fellow-men, form not a bright side in the picture of human nature; but were you to bawl into the ears of those employed in the construction, all these and a thousand more such direful effects of their handiwork, you would not abate one in the number of these man-traps.

Cost of Guns made of Sham Damn Iron.

DOUBLE GUNS.

	s.	d.
Double barrels, plain iron, with side huts, per pair	7	0
Locks	1	6
Wood for stock	0	6
Stocking	1	2
Furniture	0	5
Screwing together	2	0
Percussioning	1	4
Polishing and engraving	0	9
Varnishing and painting stock	0	4
Painting twist barrels	0	4
Rod, tip, worm	0	4
Small work	0	7
Total	16	0

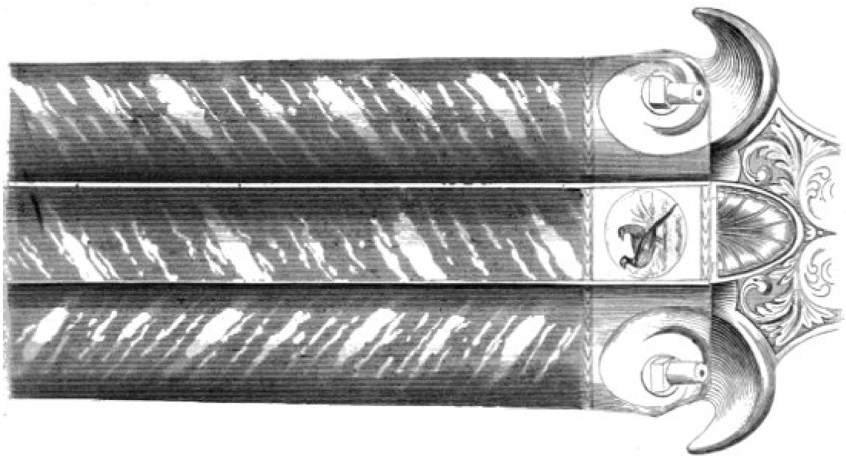
SINGLE GUNS.

	s.	d.
Single barrel, ribbed and breeched	3	8
Lock	0	9
Wood for stock	0	6
Stocking	0	8
Furniture	0	4

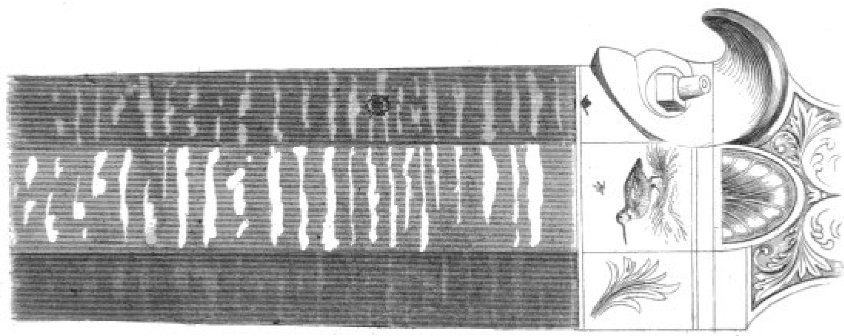
Screwing together	1	4
Percussioning	0	9
Polishing and engraving	0	6
Varnishing and painting stock	0	4
Painting twisted barrel	0	3
Rod, tip, worm	0	4
Small work	0	4
Total	10	9

The above guns are sold to the factor, at 20*l.* and 12*l.* the score respectively. The Jews sometimes get even them at that, or a lower price, as money happens to be plentiful or scarce. There is a description of tradesmen in this town of hardware, whose establishments bear the euphonious titles of the "*slaughter shop*" and "*blood house*;" and in these emporiums of the productions of the needy; may be obtained gunnery of all kinds, as well as all other material, the productions of Birmingham. If the article costs little manufacturing, it costs these men still less. The slaughter-master is a cormorant, who swallows the substance of the weak, and once past his awful jaws he cannot be made to disgorge. Here itinerant hardwaremen find an abundant supply: he has always a stock. The wants of the poor are always pressing, and the gun-making portions of the inhabitants of Birmingham are not *over provident*, seldom caring for what to-morrow may bring forth. The painted pair of shams is faintly portrayed in the opposite engraving (Plate 4); and the uninitiated may be able to detect what I have endeavoured to acquaint them with.

PLATE. IV.

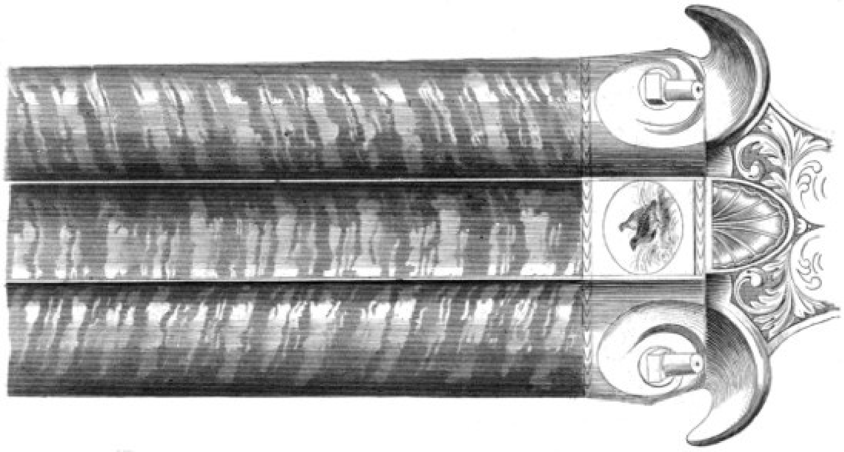


CHARCOAL IRON BARRELED GUN

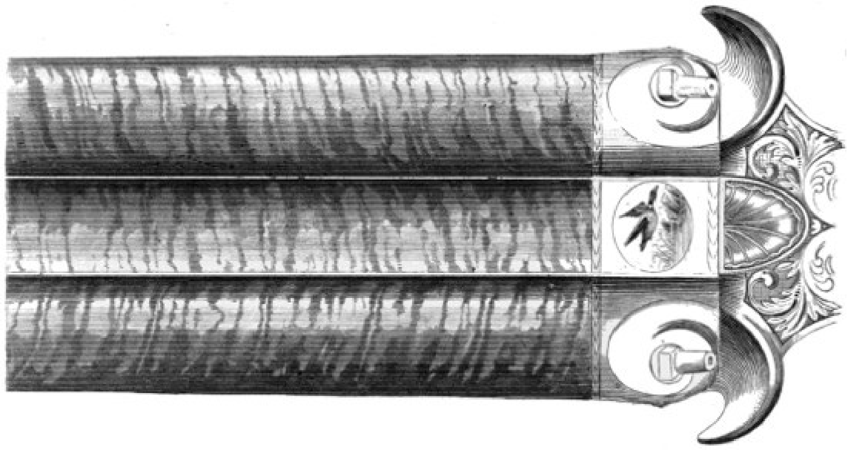


THREEPENNY IRON BARRELED GUN

PLATE. V.



TWOPENNY IRON BARRELED GUN



A SHAM DAMN BARRELED GUN

I shall just give the cost of the various items in the fitting-up of an imitation gun for the African market, combined with an *imitation* musket for the same; the former is not so desperately bad as the latter, the one being barely half an inch in the bore, the other full three-quarters of an inch, and yet their weights are not dissimilar.

You can have a shipload of these for 5*s.* 9*d.* each. It is satisfactory to know that they send powder with them of *corresponding quality*.

Cost of "African guns" alias "Park Paling."

	s.	*d.*
Common musket barrel, or birding barrel	2	0
Lock	0	4
Stock	0	4
Stocking	0	5
Brass furniture	0	3½
Screwing together, and finishing	0	9
Polishing and hardening, hammer, &c.	0	4
Steel rod	0	3
Browning and painting barrel and stock	0	4
Small items	0	3
Total	5	3½

CHAPTER VI.

THE PROOF OF GUN BARRELS.

For a considerable period subsequently to the introduction of the manufacture of gunnery into England, there existed no public proof, or test, for the goodness and safety of barrels; further than that the feeling of the maker induced him to protect the limbs of his customer. Even so early as the seventeenth century, the bias of human nature to evil began to be displayed in the production of materials for guns, the use of which was attended with loss of both life and limb. In consequence of the frequent bursting of inferior guns, the Company of Gunmakers of the City of London instituted a proof-house, to which the barrels of respectable makers were all sent to be proved. The East India Company required all their muskets to undergo the same test; hence it became a custom to have barrels proved there: many also underwent an extra test on the premises of the manufacturer; so jealous were sportsmen, and so necessary was it deemed to provide against any possibility of accident. Thus it was shown clearly that laws are not always required to carry out certain results, but that it is sometimes preferable to allow matters of this kind to be arranged according to the knowledge of the parties interested; for frequently when an individual is aware that there is a law under which, in case of need, he can shelter himself—as many do at this day in case of guns bursting—he becomes careless: he has always a ready answer, “I can assure you the barrel was proved; and there must have been some unfortunate cause for her going: you could not have rammed the wadding home, or you must have put in an extra charge,” and such like excuses. It is never for a moment supposed that there was any insufficiency in the proof.

The great demand for rubbish of a villanous description during the existence of the slave trade, induced some philanthropic gentlemen in Birmingham to found a Company, with suitable premises, for the proof of all gun barrels; and an Act of Parliament was obtained in the year 1813, incorporating the body. The first Act proved insufficient, as the Birmingham makers found easy means of evading it; so they had to obtain a fresh Act in 1815, by which parties receiving any barrel to rib, stock, &c., without its having previously been proved, became liable to a penalty of twenty pounds, and not less than twenty shillings: it also enacted that any person or persons making and selling any gun, the barrels of which had not been proved at either this or the London proof-house, became liable to the same penalty; and it further enacted, that any person or persons forging the stamps or marks of either of the two proof-houses, should be liable to the same penalties, and in default of payment, to a certain term of imprisonment, &c. It also ordered, that all barrels be proved with the quantity of powder in proportion to the various bores enumerated in the table.

The severe, but just, strictures cast upon the lax nature of this Act of Parliament, and the equally lax way in which its provisions were carried out (individual benefit being held to be the most important element in the interpretation), imperatively called for an immediate improvement. The heavy denunciations which I felt bound to visit on the defective working of this “miscalled proof of gun barrels” in my former works, at length opened the eyes, not only of the sportsman and the trade, but also of the Government; and (I believe in 1854) it was intimated to the proof companies of London and Birmingham that the time had arrived “*when gun barrels should be proved in reality*;” and that if the initiative was not taken by the trade, the Government were prepared to introduce a public Act of Parliament for that purpose. The natural consequence followed, and in 1855 an Act was passed entitled “The Gun Barrel Proof Act 1855,” by which most extensive powers are delegated to the two companies.

The clause of most vital importance enacts that all gun barrels shall be proved twice; first in the rough, which is called provisional proof; and secondly, when the barrels are soldered together, breeched, and percussioned. Thus, in a comparatively finished state, when all the necessary reductions and other operations have been effected, the barrels become properly tested. Not only the metal of the barrels and the soundness of the breeches, but the screwing in of the nipples is proved—a most important check on a very important branch of workmanship, and which if imperfectly done renders the gun dangerous.

The first regulation enacts that “barrels are not to be made up unless proved, and marked as proved.”

2nd. Small arms are not to be sold or exported unless proved, and marked as proved.

3rd. Barrels provisionally proved and reduced in strength are to be deemed unproved.

4th. Barrels reduced so that the mark does not represent the proof are to be deemed unproved.

5th. Barrels with marks defaced are to be deemed unproved.

6th. Barrels with marks removed are to be deemed unproved.

7th. Barrels are to be marked according to scale.

Here follows a list of offences:—

XCIX. Every person committing any of the following offences shall for every such offence be guilty of a misdemeanour, and shall at the discretion of the court be sentenced to imprisonment, with or without hard labour, for not more than three years, to wit:

1. Every person who forges or counterfeits any stamp or any part of any stamp already or hereafter provided or used by either of the two companies for the marking of any barrel:

2. Every person who sells or parts with the possession of any such forged or counterfeit stamp or part of a stamp, knowing the same to be forged or counterfeit:

3. Every person who knowingly marks any barrel with any such forged or counterfeit stamp or with any part of such forged or counterfeit stamp:

4. Every person who makes up any barrel so marked, knowing the same to be so marked:

5. Every person who sells or parts with the possession of any barrel so marked, knowing the same to be so marked:

6. Every person who forges or counterfeits or by any means whatever produces an imitation upon any barrel of any mark or of any part of any mark of any stamp already or hereafter provided or used by either of the two companies for the marking of any barrel:

7. Every person who sells or parts with the possession of any such mark or part of a mark, knowing the same to be forged or counterfeit or an imitation:

8. Every person who transposes or removes from any barrel to any other barrel any mark or any part of any mark of any stamp already or hereafter provided or used by either of the two companies for making any barrel:

9. Every person who shall have in his possession or who shall part with the possession of any mark or any part of any mark so transposed or removed, knowing the same to be transposed or removed:

10. Every person without lawful excuse, the proof whereof shall lie on him, having in his possession any such forged or counterfeit stamp or part of a stamp, or any such forged or counterfeit mark or imitation of a mark, or any such transposed or removed mark, knowing the same respectively to be forged, counterfeit, imitated, marked, transposed, or removed:

11. Every person who cuts or severs from any barrel any mark or any part of any mark of any stamp already or hereafter provided or used by either of the two companies for the stamping of any barrel, with intent that such mark or such part of a mark be placed upon or joined or affixed to any other barrel:

12. Every person who places upon or joins or affixes to any barrel any such mark or part of a mark so cut or severed:

13. Every person who, with intent to defraud, uses any genuine stamp already or hereafter provided or used by either of the two companies for the marking of any barrel:

14. Every person who forges or counterfeits, or by any means produces an imitation upon any barrel of any mark, or of any part of any mark, of any stamp of a foreign country registered by the two companies pursuant to the provisions of this Act.

C. Every person committing any of the following offences shall for every such offence be subject to a penalty as follows, to wit:

1. Every person selling or exchanging, or exposing or keeping for sale, or exporting or importing, or attempting to export or import from or to England, or having in his possession without lawful excuse (the proof whereof shall lie upon him), any barrel having thereupon any mark of any forged or counterfeit stamp or part of a stamp already or hereafter provided or used by either of the two companies for marking any barrel, or having thereupon any forged or counterfeit mark or imitation of a mark of any stamp or part of a stamp so provided or used, or having thereupon any mark of any stamp or part of a stamp so provided or used, such mark having been transposed or removed thereto from any other barrel, shall for every such barrel so sold or exchanged, or exposed or kept for sale, or exported or imported, or attempted to be exported or imported, or so in his possession, forfeit not exceeding twenty pounds:

2. Every person selling or exchanging or exposing or keeping for sale, or exporting or attempting to export from England, any small arm, the barrel or barrels whereof are not under this Act duly proved and marked as proved, shall for every such barrel forfeit not exceeding twenty pounds:

3. Every person fraudulently erasing, obliterating, or defacing, or fraudulently causing to be erased, obliterated, or defaced from any barrel, any mark or any part of any mark of any stamp already or hereafter provided or used by either of the two companies for the marking of barrels, shall for every such offence forfeit not exceeding twenty pounds:

4. Every person delivering or sending or causing or procuring to be delivered or sent for sale, or under pretence of sale, or removing, consigning, or transmitting, or causing or procuring to be removed, consigned, or transmitted for sale, or under pretence of sale, any small arm, the barrel or barrels whereof are not duly proved at the Proof-house of the Gunmakers' Company, or the Birmingham Proof-house, or some other public proof-house established by law, and marked as proved, shall, for every small arm so delivered or sent, or caused or procured to be delivered or sent, or removed, consigned, or transmitted, or caused or procured to be removed, consigned, or transmitted, forfeit not exceeding twenty pounds.

The preceding list of offences against the proper conducting of the gun manufacture have been found, after nearly three years' experience, to fulfil the intentions of the framers[12] of the bill. Undoubtedly a much more healthy tone has been given to the constitution of the trade; and it is to be fervently hoped that it will entirely eradicate the evil of producing such a vast amount of worthless and dangerous guns. The double-proof has been too much for many of the "sham damns." No doubt much remains to be done even yet; but the trade is progressing towards convalescence, after this severe purging. With these remarks I shall introduce schedule B of the new Act.

[12] I had the honour of being one of a committee to frame the clauses.

SCHEDULE (B.)

RULES AND REGULATIONS APPLICABLE TO THE PROOF OF SMALL ARMS.

Classification of Small Arms.

First Class.—Comprising single-barrelled military arms of smooth bore.

Second Class.—Comprising double-barrelled military arms of smooth bore, and rifled arms of every description, whether of one or more barrels, or constructed of plain or twisted iron.

Third Class.—Comprising every description of single-barrelled birding and fowling-pieces for firing small shot; and also those known by the names of Danish, Dutch, Carolina, and Spanish.

Fourth Class.—Comprising every description of double-barrelled birding and fowling-pieces for firing small shot.

Fifth Class.—Comprising revolving and breech-loading small arms of every description and system.

Rule of Proof.

The gunpowder used for proof shall be of equal quality and strength with that which is now used by the Honourable Board of Ordnance.

The balls used for the proof of barrels of all classes shall be of lead, and spherical, and of the size and weight prescribed by the scale for proof.

Barrels for arms of the second class and of the fourth class, and for breech-loading arms of the fifth class, shall be proved provisionally and definitively, and barrels for all other arms shall be proved once definitively.

Conditions precedent to Proof.

Barrels for arms of the first class shall not be qualified for proof until they shall be in a fit and proper state for setting up.

Barrels for arms of the third class shall not be qualified for proof until they shall be in a fit and proper state for setting up, with the proper breeches in; and all barrels lumped for percussioning shall be proved through the nipple hole, with the proper pins or plugs in.

Barrels for arms of the second and fourth classes:

For provisional proof:—If of plain metal, shall be bored and ground, having plugs attached, with touch-holes drilled in the plugs, of a diameter not exceeding one-sixteenth of an inch. If any touch-hole shall be enlarged, from any cause whatever, to a dimension exceeding in diameter one-tenth of an inch, the barrel shall be disqualified for proof. Notches in the plugs instead of drilled touch-holes shall disqualify for proof. If of twisted metal, they shall be fine-bored, and struck up, with proving plugs attached, and touch-holes drilled as in the case of plain metal barrels.

For definitive proof:—The barrels, whether of plain or twisted metal, shall be in the finished state, ready for setting up, with the breeches in the percussioned state, break-offs fitted and locks jointed; the top and bottom ribs shall be rough struck up, pipes, loops, and stoppers on. All rifle barrels must be rifled; the top and bottom ribs of double barrels shall be struck up, pipes, loops, and stoppers on, the proper breeches in, and the thread of the screws shall be sufficiently sound and full for proof.

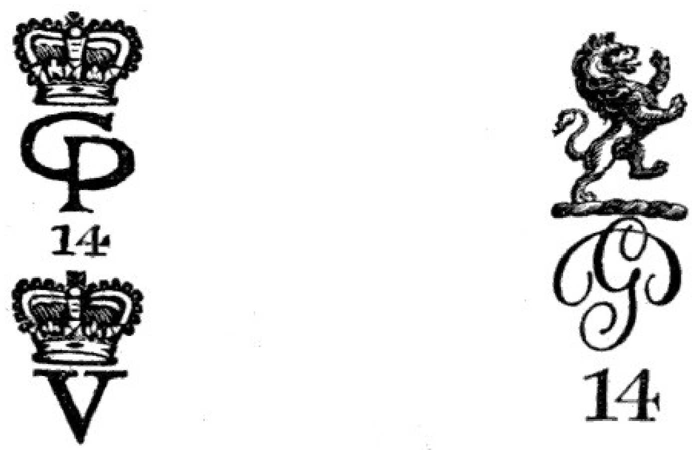
Barrels for revolving arms of the fifth class shall have the cylinders with the revolving action attached and complete.

Barrels for breech-loading arms of the fifth class shall be subject to provisional proof, according to the class to which they belong, and to definitive proof when the breech-loading action is attached and complete.

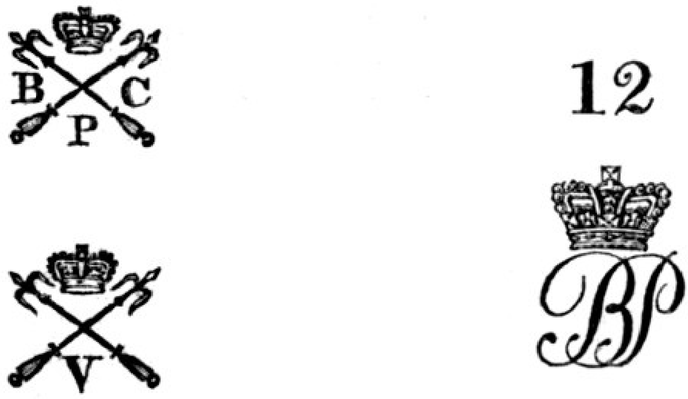
Marks of Proof.

The marks applicable to the definitive proof shall be the proof and view marks now used by the two companies respectively.

The marks applicable to the provisional proof for the Gunmakers Company shall be the letters (G.P.) interlaced in a cypher surmounted by a lion rampant, and for the Birmingham Company shall be the letters (B.P.) interlaced in a cypher surmounted by a Crown.



London marks.



Birmingham marks.

Mode of affixing Proof Marks.

On arms of the first and third classes the definitive proof mark and view mark shall be impressed at the breech end of the barrel, and if the barrel be constructed with a patent breech, the view mark shall be also impressed upon the breech.

On arms of the second, fourth, and fifth classes, the provisional proof mark shall be impressed at the breech end of the barrel; the definitive proof mark and view mark shall be impressed upon the barrel above the provisional proof mark; and if the barrel be constructed with a patent breech, or with revolving cylinders or chambers, the view mark shall be also impressed upon the breech, or upon each of the cylinders or chambers with which the barrel is connected, as the case may be.

On all barrels the gauge size of the barrel shall be struck, both at the provisional and at the definitive proof.

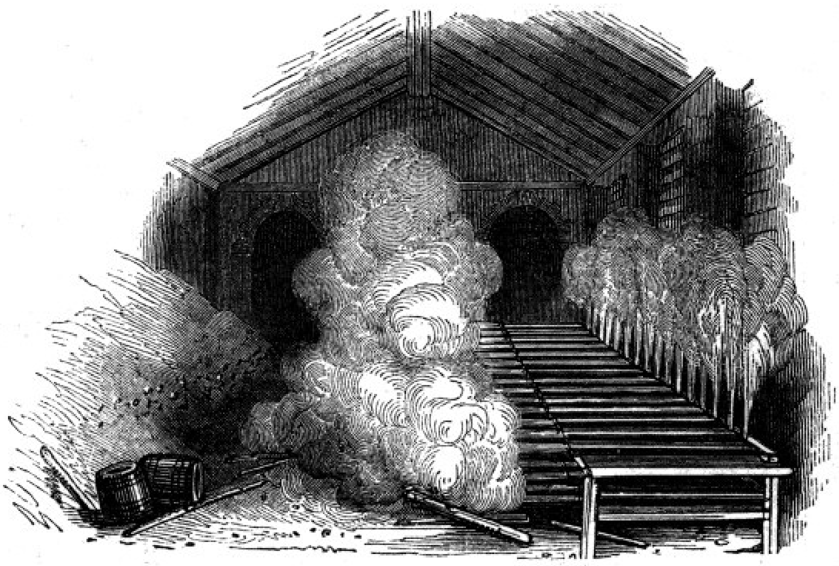
The Scale following shows the Proportions of Gunpowder applicable under the foregoing Rules and Regulations to the Proof of the various Classes of Arms as distinguished by the Trade Numbers indicating the Calibre.

Number of Gauge.	Diameter of Bore by Calculation.	Diameter of Balls for Proof.	Weight of Balls for Proof.	Charges of Powder for Proof.								
				First Class.			Second Class.					
				Definitive Proof.			Provisional Proof.			Definitive Proof.		
	inches.	inches.	grains.	grains.	ozs.	drs.	grains.	ozs.	drs.	grains.	ozs.	drs.
1	1·669	1·649	6752	4812	11	...	4812	11	...	2406	5	8
2	1·325	1·305	3342	2324	5	5	2324	5	5	1162	2	10½
3	1·157	1·107	2211	1531	3	8	1531	3	8	766	1	12
4	1·052	1·032	1649	1176	2	11	1176	2	11	588	1	5½
5	·976	·956	1315	930	2	2	930	2	2	465	1	1
6	·819	·899	1090	766	1	12	766	1	12	383	...	14
7	·873	·853	931	656	1	8	656	1	8	328	...	12
8	·835	·815	812	602	1	6	602	1	6	301	...	11
9	·803	·783	720	492	1	2	492	1	2	246	...	9
10	·775	·755	646	465	1	1	465	1	1	232	...	8½
11	·751	·731	586	437	...	16	437	...	16	219	...	8
12	·729	·709	535	437	...	16	437	...	16	219	...	8
13	·710	·690	493	410	...	15	410	...	15	205	...	7½
14	·693	·673	457	383	...	14	383	...	14	191	...	7
15	·677	·657	425	383	...	14	383	...	14	191	...	7
16	·662	·642	399	369	...	13½	369	...	13½	185	...	6¾
17	·649	·629	374	369	...	13½	369	...	13½	185	...	6¾
18	·637	·617	352	342	...	12½	342	...	12½	171	...	6¼
19	·626	·606	334	301	...	11	301	...	11	150	...	5½
20	·615	·595	316	273	...	10	273	...	10	137	...	5
21	·605	·585	300	273	...	10	273	...	10	137	...	5
22	·596	·576	287	246	...	9	246	...	9	123	...	4½
23	·587	·567	274	246	...	9	246	...	9	123	...	4½
24	·579	·559	262	232	...	8½	232	...	8½	116	...	4¼
25	·571	·551	251	232	...	8½	232	...	8½	116	...	4¼
26	·563	·543	242	232	...	8½	232	...	8½	116	...	4¼
27	·556	·536	231	232	...	8½	232	...	8½	116	...	4¼
28	·550	·530	223	232	...	8½	232	...	8½	116	...	4¼
29	·543	·523	214	205	...	7½	205	...	7½	102	...	3¾
30	·537	·517	207	205	...	7½	205	...	7½	102	...	3¾
31	·531	·511	—	205	...	7½	205	...	7½	102	...	3¾
32	·526	·506	194	205	...	7½	205	...	7½	102	...	3¾
33	·520	·500	—	191	...	7	191	...	7	96	...	3½
34	·515	·495	182	191	...	7	191	...	7	96	...	3½
35	·510	·490	—	191	...	7	191	...	7	96	...	3½
36	·506	·486	172	191	...	7	191	...	7	96	...	3½

37	·501	·481	—	191	...	7	191	...	7	96	...	3½
38	·497	·477	162	178	...	6½	178	...	6½	89	...	3¼
39	·492	·472	—	178	...	6½	178	...	6½	89	...	3¼
40	·488	·468	154	178	...	6½	178	...	6½	89	...	3¼
41	·484	·464	—	164	...	6	164	...	6	82	...	3
42	·480	·460	146	164	...	6	164	...	6	82	...	3
43	·476	·456	—	164	...	6	164	...	6	82	...	3
44	·473	·453	139	164	...	6	164	...	6	82	...	3
45	·469	·449	—	150	...	5½	150	...	5½	75	...	2¾
46	·466	·446	133	150	...	5½	150	...	5½	75	...	2¾
47	·463	·443	—	150	...	5½	150	...	5½	75	...	2¾
48	·459	·439	127	150	...	5½	150	...	5½	75	...	2¾
49	·456	·436	—	150	...	5½	150	...	5½	75	...	2¾
50	·453	·433	122	150	...	5½	150	...	5½	75	...	2¾

Number of Gauge.	Diameter of Bore by Calculation.	Diameter of Balls for Proof.	Weight of Balls for Proof.	Charges of Powder for Proof.								
				Third Class.			Fourth Class.					
				Definitive Proof.			Provisional Proof.			Definitive Proof.		
	inches.	inches.	grains.	grains.	ozs.	drs.	grains.	ozs.	drs.	grains.	ozs.	drs.
1	1·669	1·649	6752	3850	8	12¾	3850	8	12¾	2406	5	8
2	1·325	1·305	3342	1859	4	4	1859	4	4	1162	2	10½
3	1·157	1·107	2211	1225	2	12¾	1225	2	12¾	766	1	12
4	1·052	1·032	1649	941	2	2½	941	2	2½	588	1	5½
5	·976	·956	1315	744	1	11¼	744	1	11¼	465	1	1
6	·819	·899	1090	612	1	6½	612	1	6½	383	...	14
7	·873	·853	931	525	1	3¼	525	1	3¼	328	...	12
8	·835	·815	812	481	1	1½	481	1	1½	301	...	11
9	·803	·783	720	394	...	14½	394	...	14½	246	...	9
10	·775	·755	646	372	...	13½	372	...	13½	232	...	8½
11	·751	·731	586	350	...	12¾	350	...	12¾	219	...	8
12	·729	·709	535	350	...	12¾	350	...	12¾	219	...	8
13	·710	·690	493	328	...	12	328	...	12	205	...	7½
14	·693	·673	457	306	...	11¼	306	...	11¼	191	...	7
15	·677	·657	425	306	...	11¼	306	...	11¼	191	...	7
16	·662	·642	399	295	...	10¾	295	...	10¾	185	...	6¾
17	·649	·629	374	295	...	10¾	295	...	10¾	185	...	6¾
18	·637	·617	352	273	...	10	273	...	10	171	...	6¼
19	·626	·606	334	241	...	8¾	241	...	8¾	150	...	5½
20	·615	·595	316	219	...	8	219	...	8	137	...	5
21	·605	·585	300	219	...	8	219	...	8	137	...	5
22	·596	·576	287	197	...	7¼	197	...	7¼	123	...	4½
23	·587	·567	274	197	...	7¼	197	...	7¼	123	...	4½
24	·579	·559	262	186	...	6¾	186	...	6¾	116	...	4¼
25	·571	·551	251	186	...	6¾	186	...	6¾	116	...	4¼
26	·563	·543	242	186	...	6¾	186	...	6¾	116	...	4¼
27	·556	·536	231	186	...	6¾	186	...	6¾	116	...	4¼
28	·550	·530	223	186	...	6¾	186	...	6¾	116	...	4¼
29	·543	·523	214	164	...	6	164	...	6	102	...	3¾
30	·537	·517	207	164	...	6	164	...	6	102	...	3¾
31	·531	·511	—	164	...	6	164	...	6	102	...	3¾
32	·526	·506	194	164	...	6	164	...	6	102	...	3¾
33	·520	·500	—	153	...	5½	153	...	5½	96	...	3½
34	·515	·495	182	153	...	5½	153	...	5½	96	...	3½
35	·510	·490	—	153	...	5½	153	...	5½	96	...	3½
36	·506	·486	172	153	...	5½	153	...	5½	96	...	3½
37	·501	·481	—	153	...	5½	153	...	5½	96	...	3½
38	·497	·477	162	142	...	5¼	142	...	5¼	89	...	3¼
39	·492	·472	—	142	...	5¼	142	...	5¼	89	...	3¼
40	·488	·468	154	142	...	5¼	142	...	5¼	89	...	3¼
41	·484	·464	—	131	...	4¾	131	...	4¾	82	...	3
42	·480	·460	146	131	...	4¾	131	...	4¾	82	...	3
43	·476	·456	—	131	...	4¾	131	...	4¾	82	...	3
44	·473	·453	139	131	...	4¾	131	...	4¾	82	...	3
45	·469	·449	—	120	...	4½	120	...	4½	75	...	2¾
46	·466	·446	133	120	...	4½	120	...	4½	75	...	2¾
47	·463	·443	—	120	...	4½	120	...	4½	75	...	2¾
48	·459	·439	127	120	...	4½	120	...	4½	75	...	2¾
49	·456	·436	—	120	...	4½	120	...	4½	75	...	2¾
50	·453	·433	122	120	...	4½	120	...	4½	75	...	2¾

N.B.—Revolving Arms of the Fifth Class shall be proved once only, and such Proof shall be by the Scale laid down for definitive Proof of the Fourth Class.



As soon as a number of gun barrels are loaded according to the foregoing scale, they are taken to a house or detached building, standing apart from other offices. (The woodcut represents the interior accurately.) The house is lined throughout with thick sheet iron, and the windows, which resemble Venetian blinds, are constructed of the same metal. Iron frames are laid the whole length of the room; on these the barrels of various qualities, when about to be fired, are placed. In the front of these frames lies a large mass of sand, to receive the balls. Behind the frame, on which the twist barrels are fixed, lies another bed of sand; in which, on the recoil, the barrels are buried. Behind the frame, on which the common barrels or muskets are tried, a strong iron bar is placed, having a number of holes large enough to receive the tang of the breech, but not the barrel. The barrels being thus fixed, it is impossible for them to fly back. A groove runs along the whole length of each frame, in which the train of powder is strewed to ignite the charges, upon which the barrels are laid, with the touch-holes downwards.

When everything is ready for the proof, the windows are let close down, the door is shut and secured, and an iron rod heated red hot is introduced through a hole in the wall. On igniting the train, a tremendous explosion takes place. The windows are then drawn up, the door opened, and the smoke dissipated. The twist barrels are found buried in the sand, the common ones are thrown forwards; some are found perfect, others burst to pieces. It is rarely that best barrels are found burst; more frequently they are bulged, or swelled out, in places which are faulty, or of a softer temper. Those that are found perfect, are then marked with the provisional punch of different sizes (but having the same impression), according to the quality of the barrel. In London and Birmingham they have now an additional punch, containing the number of the bore by which the barrel has been tried. This mark easily enables the observer to discover whether the barrel has had any considerable quantity bored out after proving. Those that are bulged are sent to the maker, who beats down the swellings, and sends back the barrels to be proved again. They generally stand the second proof, though we have known a barrel undergo four proofs before it was marked. The common barrels are required to stand twenty-four hours before they are examined; when, if not burst, any holes or other material imperfections are made quite apparent by the action of the saltpetre. Such barrels are, of course, sent back unmarked. Those that are found satisfactory are duly stamped and taken home.

The importance of the gun trade to England may be estimated from the number of barrels proved during the last year, 1857, of which the following is a correct statement:—

Provisional Proof.

Plain iron barrels		185,776
Twisted barrels		136,804
Saddle pistol barrels		33,480
Best pistol barrels		962
Common pistol barrels		2,066
Revolving and double barrel pistols		57,106
	Total	416,194

Definitively proved, 70,100, being principally double barrels.

This is in Birmingham alone; no doubt the London Company prove to the extent of 200,000 yearly, which may also be debited to Birmingham, as the barrels are all welded, bored, and ground before being sent to London. In addition to these may be counted the Government contracts of some hundred thousands yearly.

The passing of this Act of Parliament levelled all distinctions between London and Birmingham proved barrels; they are now treated precisely alike, and one is equally good with the other.

CHAPTER VII.

THE SCIENCE OF GUNNERY.

"Science begins at the point where mind dominates matter, where the attempt is made to subject the mass of experience to the scrutiny of reason. Science is mind brought into connection with nature."—Cosmos.

A new era in the science of gunnery may be dated from the commencement of the latter half of the nineteenth century; and long before its close other improvements may be effected which shall eclipse even those of our day. A new elementary principle has been infused into the science. Rifles are now really weapons of the highest order; in truth we may be said to have only recently become acquainted with the principles on which they should be constructed. Little of science had hitherto been applied to them; as military arms they were neglected for centuries, to be ushered into notice at last by the unassisted efforts of private individuals; Government, to whom arms were of the greatest importance, having systematically neglected all improvement, by invariably refusing pecuniary aid, the only grease at all calculated to overcome the friction retarding the wheels of progress. It is an old proverb, that "one extreme begets another," and when changes are once started, the difficulty is to stop them; the tendency is to rush on from one alteration to another, before we are really well acquainted with what we have so hastily thrown aside. Improvement does not always follow a change; the human race, and the English more especially, have an inordinate desire for "the marvellous;" and multitudes of "wonderful discoveries" and inventions of the utmost value are heralded daily by the ever eager press, often to be as hastily forgotten, or discovered, even by their promulgators, to be myths.

Improvement, to be at all beneficial, must bring with it all the elements of improvement; and to render it easy of attainment, none of its essential points should be costly. In gunnery more especially, it is essential to avoid all unnecessary friction, excess of recoil, and waste of gunpowder; whilst, at the same time, transport of the gun must not be cumbersome, and durability in all its points is essential.

How few study the subject in all its bearings! How rapidly conclusions are jumped at! Even in getting range, if it is to be purchased at the cost of other essential principles, it is not economy to sacrifice several even moderately valuable principles for the sake of range alone. The experience of the present age has shown that all our important discoveries have their limits: the locomotive cannot be used with advantage beyond a certain limited speed; steam vessels attempted to be propelled at an unusual velocity have but a very brief endurance, and rapidly decay. All matter has power only to effect a certain amount of work, and this is endured best at a medium application; showing most clearly that "the race is not always to the swift or the battle to the strong."

Experience is required in the greatest of modern inventions. Electricity, at a moderate immersion, subjected to a moderate superincumbent weight, is an effectual messenger, swift as thought; but when overweighted by immersion to depths where the superincumbent pressure amounts to thousands of pounds upon the square inch, then the messenger becomes paralysed, and refuses to obey man's will; showing very clearly that until that pressure be artificially removed by insulating the conducting wire in tubes equal to restrain or keep from it that enormous load, the lasting success of an Atlantic telegraph is very doubtful. Many similar instances might be cited to show the necessity of considering well the established laws of nature, and their bearing on the object pursued. In no science is this of more importance than in gunnery; and the hundreds of useless inventions in gunnery are to be ascribed to the non-observance of these rules. The two-grooved rifle, the "steam gun," "the sciva," "Warner's long-range myth," and many other inventions equally absurd, engage the attention for a time, but soon vanish: in fact, all experience shows that improvement can only be effected in accordance with certain established principles of nature and practical science.

Iron, in quantities sufficient for all reasonable requirements, is a dutiful servant; but, when required of colossal proportions, it refuses to obey: giving us a hint from nature, that we should be content with moderation.

All the principles appertaining to science are based on certain established laws; the unsoundness of one renders the superstructure unsound also; and any deductions drawn from unsound principles are comparatively worthless. Gunnery, as a science, must be in uniformity with truth in all its parts, or no science exists in its arrangements. This will be best illustrated by dividing the subject into several heads: 1st, the explosive power and its velocity; 2nd, the retarding agents, air and friction; 3rd, the construction of the projectile tubes; and 4th, the form of projectile best calculated to attain a perfect result.

1st. The explosive power. Gunpowder has been stated by different authorities to liberate its gases with very different degrees of rapidity. Hutton has given to it a much greater rapidity than Robins has evidently even surmised; though, no doubt, as we have already shown, high velocity in gunpowder depends on several circumstances—the degree of purification of its ingredients, their intimate mechanical mixture (that the elements may exert their affinities with the utmost facility), and, lastly, the degree of granulation observed: and in addition, the suitability of the tubes or vessels for carrying on correctly such important experiments. Robins and Hutton unquestionably may be regarded as the English, if not the European, authorities, and any work on the science of gunnery would be very incomplete without their valuable elucidations.

Previously to the researches of Robins, the theory of atmospheric resistance was but imperfectly surmised, and when he made his statements of the immense resistance which the fluidity of the air offered to projectiles in a high state of velocity, they were treated as the idle chimeras of a speculative brain; and yet he only was enabled to estimate the real effect of the explosive nature and force of gunpowder to a very limited extent: indeed, so limited, that Hutton, only twenty years subsequently, speaking of Robins' theory, says, "Mr. Robins and other authors, it may be said, have only guessed at, rather than determined. That ingenious philosopher, in a simple experiment, truly showed that, by the firing of a parcel of gunpowder, a quantity of elastic air was disengaged; which, when confined in the space only occupied by the powder before it was fired, was found to be nearly 250 times stronger than the weight or elasticity of the common air. He then heated the same parcel of air to the degree of red hot iron, and found it in that temperature to be about four times as strong as before; whence he inferred, that the first strength of the inflamed fluid must be nearly 1,000 times the pressure of the atmosphere. But this was merely guessing at the degree of heat in the inflamed fluid, and, consequently, of its first strength; both which in fact are found to be much greater. It is true that this assumed degree of strength accorded pretty well with that author's experiments; but this seeming agreement, it might easily be shown, could only be owing to the inaccuracy of his own further experiments; and, in fact, with far better opportunities than fell to the lot of Mr. Robins, we have shown that inflamed gunpowder is about double the strength that he has assigned to it, and that it expands itself with the velocity of about 5,000 feet per second." On the same subject he further says: —"On this principle it was that Mr. Robins made all his experiments and performed all his calculations in gunnery. But it is manifest that this method of guessing at the degree of heat of the flame must be very uncertain and unsatisfactory, being much below the truth; since all our notions and experience of the heat of inflamed powder convince us that it is higher than that of red hot iron, and, indeed, it has clearly appeared from our experiments, that its heat is at least double that of red hot iron, and that it increases the elasticity of the elastic fluid more than eight times."

Here is evidence, though not conclusive, of the immense force of gunpowder, and also of the progress of knowledge on the subject; yet it clearly shows the evil of coming to hasty conclusions, however well supported by apparent facts, as it has had in this case a tendency to check inquiry and retard the advancement of knowledge. For the extensive experiments of Hutton were but limited in discovery, because they were not carried to a sufficient extent, and thus, they are quite unsuited to the present day. He was satisfied because he had gone further than any of his predecessors; and though he established and clearly proved the soundness of his own theory, yet he could not either view the subject to its utmost bounds, nor yet go sufficiently far, but that others, taking up the question where he left it, may pursue the subject to a much more remote limit. The subject, indeed, was limited to him. He far excelled Robins, no doubt, as he has shown; but that involves no detraction from the merit due to Robins for his experiments and discoveries, no more than any individual proving the subject to be a more extensive one than Hutton did, would excel Hutton; for the value of improvement is more to be attributed to him who lays the foundation, than to him who raises the building. So is it in this case; Robins laid the foundation for an extensive knowledge of the nature and power of the explosive fluids, and Hutton built upon that foundation a certain extent of superstructure, and there he left it, without roofing the building: he considered the question as settled. Common consent has, as yet, received his conclusion as unshaken and uncontroverted; and it is not my intention to make the attempt to controvert it, but merely to show that his deductions fall short of what the principles of gunpowder-making admit—carried out in the more extensive way it has been within the last few years—owing to the limited nature of his experiments. This is rather an extensive position for me to occupy, or endeavour to hold: but I do not mean the size of the *tools* of *experiment* so much as the diversity of them; for exploding ten thousand tons of powder in the same machine and in the same way, would but give the same or similar results; it is the variety and the singularity of experiments that expand and increase the fund of knowledge, and enable the mind to conceive and comprehend the immensity of the power and velocity of this wonderful combination. We have been principally indebted to the exertions of the chemist for means of purifying and extracting from the ingredients which form this astonishing compound force, the impurities and foreign substances which exist, to a certain extent, in all the three, and thus tending to form a more perfect combustion by increasing the affinities.

Hutton shows that gunpowder is but so much condensed air; for he says "We may hence, also, deduce the amazing degree of condensation of the elastic air in the nitre and gunpowder, and the astonishing force experienced by its explosion. It has been found by Mr. Robins, and other philosophers, that 3-10ths of the mass of the powder consists of the pure condensed air, or that the weight of the condensed air is equal to 3-10ths of the whole composition. But the whole composition of the powder consists of eight parts by weight, of which six parts are nitre, one part sulphur, one charcoal; of which the nitre or 3-4ths of the composition furnishes the whole of the condensed air, while the sulphur and charcoal only give the fire that produces the explosion. But 3-10ths of the whole mass of eight parts is equal to 4-10ths of the six parts of nitre, that is 4-10ths or 2-5ths of the nitre consists of condensed air, or the weight of the gross matter in the nitre as four to six, or as two to three; and these two parts, it is probable, are of equal density or specific gravity. Yet the specific gravity of nitre is 1,900, that of water being 1,000, and of air 1·2, which is contained in 1,900, as much as 1,583 times; that is, the air in the nitre must be condensed the amazing quantity of 1,583 times, if its specific gravity be equal to the compound nitre itself.” Also, “The air is condensed in the nitre about 1,600 times, nearly double the density of water, which may well be considered as probably the greatest degree of compression that air is capable of. Hence it may be perceived that a prodigious force must be exerted by nature in generating nitre; and as this great force actually exists in nature, it is very probable that the air in the nitre is thus compressed into the most dense state possible, and in this consists the similitude among the different particles of nitre.”

This extract from Hutton enables us to divest the question of any technicalities, and puts it in so plain a garb that the simplest mind may comprehend it. Now, the great improvement of chemistry has been to extract from the nitre the gross material which is contained in the proportions—2-5ths impurities, and 2-5ths condensed air; thus, half the quantity being useless, the extraction of these alloys gives a greater quantity of condensed gases in the same quantity of matter; for if we take away 2-5ths of the proportions of useless matter, and supply its place with 2-5ths more condensed air, we thus get 4-5th explosive matter in the same bulk of material, and thus simply obtain an immense increase of power without an increase in bulk. We have here evidence of the progress that has been made in the science of explosive force.

Considering the difference between gunpowder in 1783 and gunpowder in 1858, I cannot say, with Hutton, that the force is doubled now to what it was when he wrote; but I believe that this would not be far from the truth; for it must be quite clear—if he is correct (which I believe he is) in saying the force of gunpowder consists in the quantity of explosive matter let loose and expanded by heat—that the greater the quantity of condensed matter we may have in any given weight, the greater the force, and the more rapid the explosion: purified saltpetre thus forming nearly pure gaseous matter; as the diamond is pure carbon. It seems singular, and is rather presumptuous to say, that Hutton was not much of a chemist; but had he been more so, he must have perceived that in the extraction of the foreign matter from the nitre, existed the means of obtaining an increased quantity of explosive power, and a proportionate increase of speed or velocity in that explosive material.

To ascertain the velocity best suited to all projectiles, constitutes the germ of the science; and that we are approaching a new era in even that more intimate portion of the science, is daily apparent. Science shows clearly that if a given force, a quantity to be correctly ascertained, can produce a certain result, the use of more is waste, and unworthy of the seeker after perfection; and thus we have to determine upon, or define, what is the degree or size of gun for certain effects: a mere calculation nearly allied to that portion of engineering which would define what power of engine would work a thousand cotton spindles, or raise a million gallons of water; and all this will eventually be done. Science requires that there should be no excess, no waste, no unnecessary recoil, and all that combined with the utmost range of projectile; this will have to be defined accurately before we can clearly or truly say we are masters of the science of gunpowder. True it is that the granulation of gunpowder gives a clear road to its attainment; but it will be a wearisome journey to reach the summit: yet it must and will be effected, and the nation that first attempts and carries out the attainment, will evince a real love for and mastery of science.

The following practical experiments illustrate the degree of velocity and the effects of projectiles so clearly, that they alone will convey some idea of the high velocity of the evolutions of the gases in gunpowder.

My experiments are, like Robins’, on a small scale; nor would I, like Hutton, try a brass gun of sixty calibres in length, carrying a one-pound ball; for one is strictly more limited than the other, and thus rendered the results laid down by him imperfect: for, as he says, “If you fill the tube with powder you get no greater velocity, as there is not a duration in the confinement to enable the powder to explode.” If he had assimilated the grain of his powder to the gun, he would have obtained a different result; and a knowledge of this fact, I apprehend, makes all the difference. The greatest velocity he obtained was with powder 1½ times the weight of the ball in a gun of sixty calibres in length, and the velocity he then obtained was only 3,181 feet per second. The inferences that probably induced him to recommend others not to endeavour to obtain a greater velocity than 2,000 feet per second, were, like these experiments, drawn from imperfect data. With a ball of an ounce weight in a barrel of sixty calibres, and with 3-4ths the weight of ball in powder, or 12 drachms, a velocity can be given to the ball to equal it in force to 46,875 pounds. The velocity of this ball I leave to the calculations of the mathematical world. But, however, I will give the results of a round of experiments tried to ascertain this; and if the data laid down be correct, that the velocity of a ball must be multiplied by its weight to find the force, the result will be the establishment of a system of velocity never yet dreamt of. I cannot but imagine that there exists some error; though where it is I know not: every deduction I have drawn is consequent upon the results hereafter described.

“The power required to force a punch 0·50 inch diameter through an iron plate 0·08 inch thick is 6,025 pounds, through copper 3,938 pounds. A simple rule for determining the force required for punching may thus be deduced:—

“Taking one inch diameter and one inch in thickness as the units of calculation it is shown that 150,000 is the constant number for wrought-iron plates, and 96,000 for copper plates.

“Multiply the constant number by the given diameter in inches, the product is the pressure in pounds which will be required to punch a hole of a given diameter through a plate of a given thickness.”

Now an idea struck me, that this would form a very good test of the comparative force of gunpowder, and I consequently commenced an extensive round of experiments.

In the first attempt I found the results to vary with the weight of the pendulum of iron plate, and that it was necessary to obtain uniformity of size and surface; as it must be comprehended that the only resisting medium to the pendulous plate was atmospheric resistance, and a dissimilarity of size of surface would invariably give different results. Having a number of plates of the different thicknesses hereafter described, I continued increasing the charge from a definite quantity, until the projectile was driven with sufficient velocity to perforate the plate suspended. The gun selected for this purpose was of heavy material, weighing nearly seventeen pounds, it was three feet long, the metal of the barrel as thick at the muzzle as at the breech, and carried a spherical ball of sixteen to the pound, or one ounce, and which fitted tight with the thinnest patch procurable. The bore was perfectly cylindrical, and plain inside, being polished longitudinally to a high state of fineness. With a charge of twelve drachms of Curtis and Harvey's diamond grain powder, the ball went through the half-inch plate, but went only a few yards further; denoting that the effort necessary had nearly exhausted its velocity and momentum.

The recoil of the gun was of the most severe description, and the shoulder had to be protected for many explosions previous to this high charge. The larger sized grain was insufficient, ten drachms effecting the greatest extent of power it seemed capable of, and it became quite apparent that the tube would not explode more powder, as indications convinced me: when any more was added, a portion came out unburnt.

The force necessary to effect this, by the above calculation, is 46,795 pounds.

The next plate was 7-16ths thick, and a charge of ten drachms punched the piece out clean; nine and a half drachms were equal to it, when the centre of the pendulum could be hit fairly, because there was then an equal resistance from the atmosphere, which cannot exist in cases where the edge of the disc receives the blow.

I got with ease a perforation in a 6-16ths plate, with a charge of either fine or coarse powder, not exceeding eight drachms; a charge of seven drachms of fine grain was unequal to the task; but seven drachms of the coarse showed evidently greater effects produced, though the perforation was not perfect. Six and a half drachms of No. 2 grain penetrated a plate of 5-16ths thick easily, while it took full six and three-quarters drachms of fine grain; five drachms of the larger perforated a quarter-inch plate, but it took full five and a half drachms of fine grain to effect the same; while a 3-16ths plate took three and three-quarters drachms of fine, or three and a quarter of No. 2 grain; and 1-8th plate was easily punched by a charge of two and a half drachms coarse or three drachms fine. I will place the relative results in a table, with the force effected by each:—

Oz.		Drachms.		Punched a boiler plate		Equal in force to	
1	ball	12	of powder	Half-inch	thick	46,875	lbs.
1	„	10	„	7-16ths	„	41,015	„
1	„	8	„	6-16ths	„	35,155	„
1	„	6½	„	5-16ths	„	29,295	„
1	„	5	„	4-16ths	„	23,437	„
1	„	3¼	„	3-16ths	„	17,578	„
1	„	2	„	2-16ths	„	11,718	„

Were I to adopt the established method of calculation, multiplying the weight of ball by the velocity, I should get an answer that would point to the utter impossibility of any such velocity being possible. And yet the result is, according to the rule of figures, correct; but in truth there are exceptions to many rules, for they are only correct when applied to known products.

That the velocity of these balls was much, very much, greater than 7,000 feet per second of time, there cannot be any doubt; it was nearly three times that. Yet I must not conceal the fact, that this punching is the more perfect, the higher the velocity; and it shows how the fibres of iron are separated from a want of vibration to equilibrise the cohesion. Mr. Colthurst found that duration of pressure lessened the ultimate force necessary to punch through metal, and thus it may be that extremely quick pressure may produce the same. Therefore I suspect it is not the most correct theory that calculates force to be accomplished at all times by extreme velocity; there will be found discrepancies in the rule, and one of them arises from no calculation ever having been made with extreme velocities: medium velocities may generally give such conclusions, but the very extreme in this case can never have been taken into consideration at all; as I have very little doubt—in fact, I am certain—that no person ever obtained such high velocity before. It must, and is a vast deal greater, incomprehensibly greater, than any velocity obtained by Hutton; and much more extensive than ever could be obtained, or, in fact, ever will, by any ordnance whatever. I wish much I could have experimented with a gun of greater length and bore, for with one in every way fitted for the purpose, I have no doubt of being able to perforate an inch thickness of plate.

Should any person possessing the opportunity and means, wish to try the experiment, I would advise them to get a barrel of 4½ feet long, 8 bore, to carry a 2 oz. ball, and of a weight to allow of extending the explosion up to 30 drs. of powder; they would then obtain the extent of force I have suggested. There is a certain point to be strictly observed: see that the plate you use is perfectly sound; for if laminated, or composed of various plates not firmly welded and attached, the experiment would be imperfect, as there would be an uneven vibration created, and acting as the hammer does when held against the point of the nail while driving it in, clinches the point, so does the substance in the portions of plate prevent a perforation. An ounce ball, suspended against the back of the pendulum, by the jar or blow it receives and communicates, completely prevents the effect, and the ball is flattened, instead of perforating the object struck: so is it if you place a ¼-inch plate against any support; it thus has the power of perfectly resisting the force of the ball, though fired with considerably more power than is requisite under other circumstances. The effect appears to be chiefly mechanical; the outer fibres are driven in upon those behind them with such quickness that they lose cohesion, or are condensed quicker than the waves of vibration travel, thus giving them no means of communicating the vibration. But when punched, the rapidity of their motion produces in the metal a sound of the most intense vivacity, which plays upon the ear for a considerable period, with rather a pleasant effect. Lead alone is capable of being used in this experiment; except, of course, the precious metals, which it would not be *convenient* to use. Even an adulteration of the slightest quantity of solder is sufficient to prevent the result which lead, pure, will invariably give. Lead projected against lead, if sufficiently thick, cannot perforate, but the lesser portion becomes flattened; a cast-iron ball fired against lead, with a certain velocity, is broken into pieces, affecting the lead comparatively little: showing beautifully the peculiarity of dense incompressible bodies to resist most effectually the greater the velocity with which they are struck. Water will, if struck very sharply with the flat of a sword, act against the blow in a way to splinter the blade into pieces. The greater the velocity with which a ball is fired into water, the less the depth of penetration; thus showing clearly the many excellent properties of dense incompressible bodies as projectiles, and proving the objection that lead is too soft for artillery to be without a foundation, and only entertained from a want of knowledge of its nature.

A point of great importance was exemplified during these experiments; and as the question has lately given rise to considerable discussion, it will be well that the facts should be stated.

At very short distances from the muzzle of the gun the penetration was found to be less than at distances more extended. At five yards the iron plate could not be perforated; at ten yards the effect was much greater, but fifteen yards was the least distance at which it could be said to be effectually perforated; at twenty yards the result was still more satisfactory, clearly demonstrating that bullets gain both in velocity and penetration for a considerable distance after leaving the muzzle of the gun. The following experiments verify this remark:—

In the report of the experiments which were carried on at Cork in 1852, it is stated that the power of penetration of an elongated rifle bullet gradually increases as the range is increased, up to 190 yards.

In order to prove this, experiments were carried on at Enfield for three days with a variety of fire-arms, and different sorts of projectiles. On the fourth day the experiments were repeated with the common musket and Wilkinson’s rifle. The former, at forty yards, gave a penetration of 2·25 inches; and the latter averaged 2·75, in a target of green elm. Again: at ninety yards, the musket penetrated 2·25 inches, and the rifle 3·5 inches. At 120 yards, the musket gave 2·5 inches, and the rifle 3·25. Both being subsequently fired at every successive ten yards up to 220, the result was that the penetration of the musket ball gradually decreased in power as the distance increased, while the elongated bullet gained power of penetration up to 190 yards; after which it slightly decreased.

2nd. Consequent on the velocity of the explosive fluids is the resistance of that aëriform fluid filling all space. It has been calculated that in a vacuum, matter in motion would be a long time in coming to rest; and very providentially it is that nature in her grand arrangements has made one element to control another. In no other portion of nature’s work has anything more wonderful than atmospheric air been produced; its action on the velocity of projectiles is of so extensive a nature, that without clearly understanding that action, the science of gunnery never can be thoroughly acquired. The resistance of the atmosphere is in proportion to the velocity of the attempt to displace it; the higher that velocity becomes, the greater is the resistance. This is shown by the actions of all the fulminates. A quantity of the fulminate of silver exploded on a copper plate will perforate that plate, or, if fired upon a piece of wood, will bury itself in that substance, splintering it in proportion to the quantity. Now, ordinary gunpowder has no such effect as this, because, though it may produce the same amount of expansive gas, it produces it at one-fourth the velocity of the fulminates: the air is driven back upon itself so gradually as to offer no very important resistance; but the action of the fulminates is so rapid and so violent that the high elasticity of the air has not time to yield, and the force is driven into the apparently more solid material, the copper or the wood.

The mode in which atmospheric resistance mostly interferes with projectile force is owing to the columnar form it assumes in the tubes of all descriptions of gunnery. If the velocity of gunpowder be as great as we suppose it to be, the displacement of a column of air must be effected by driving the whole column in a gun-barrel of many inches, into a column probably less than half an inch in height; or, if the length of the tube from the starting of the charge to the muzzle be 38 inches, then will the displacement require a force capable of condensing thirty-eight atmospheres into one, or something like 570 lbs.; without estimating the lateral pressure of that column on the sides of the gun-barrel, which may be safely estimated at one-half more. It may be supposed that the column would be partially in motion for a greater distance than half an inch in front of the projectile; but this is disproved by the fact that time is essential to put aëriform matter in motion, and naturally it never does so at a greater velocity than it is familiarly known to do in the shape of winds: but the fact is better illustrated by the frequent bursting of barrels near the muzzle, caused by a piece of snow or clay, a piece of paper or wadding. Were a current established around this projection it would pass on, but the air strikes these light obstructions when in a high state of condensation, amounting to many atmospheres in one: so many as to be nearly equal to a solid which is more powerful than the barrel; the latter therefore succumbs to it.

The resistance of the air is so highly philosophical a question, that I merely touch on its actual bearings on the passage of projectiles to show how the quantity of force is absorbed or expended in relation to the quantity of the gunpowder employed; which, it may be assumed, is a proportion of nearly one-third of the whole, or a quantity independent of that necessary to give velocity to the leaden projectile, to enable it to overcome the still and uniform impeding agent up to the end of its flight. The rapid exit of the bullet from the barrel, with a resisting influence of this weight into the comparatively insignificant one of 15 lbs. to the square inch, will fully explain how it is that a bullet increases in velocity even up to a considerable distance after leaving the muzzle of the gun; and further showing that in all arrangements of truly scientific gunnery, the increasing resistance must be met by a fresh production of explosive fluid over every atom of space in that tube, where it is demonstrable that the resistance is increasing in a geometrical progression as the point of exit is becoming nearer; so that gunnery, unless all the contingencies are provided for, must necessarily remain an imperfect science.

Intimately allied to the displacement of the atmosphere is the amount of friction. Gunnery is now rid of the anomaly of being assisted by friction: the detention of the projectile in the tube by artificial friction, to enable more force to be generated, is one of those absurdities pardonable only in bygone days. Science is best consulted by lessening friction; guns of steel, with interiors as fine as the polish in a mirror, are found to shoot best: a rough road is but so much force uselessly absorbed; the experience of the last few years having proved that a range of 1,800 yards cannot be accomplished except with barrels having surfaces as smooth as possible.

Rifles, no doubt, are now in use in which, by increasing the degree of spiral, friction is more than doubled, perhaps trebled; but such unscientific constructions are but as one error to counteract another. Unscientifically formed projectiles not having in themselves the principles necessary for true flight, have to receive a counteracting agency in the shape of additional spinning, on an axis coincident to the line of flight, to enable them to range a given distance, with, as it will be perceived, an additional amount of expellant agency; but these cannot be included in the category of scientific gunnery.

3rd. Next to absence of friction is the construction of the gun barrel. Already have we shown that the inner surface of a gun barrel requires to be like glass; next to this it is necessary that the metal should be composed of the most unyielding structure. Metals absorb force in proportion to their softness: a barrel constructed of lead gives the worst result of any metal; in truth, as is the increase of tenacity and density in the tube, so is the increase of range in projectiles. The wonderful results displayed by the use of steel guns of all descriptions bear out this assertion to the fullest extent. A yielding gun barrel may be compared to the dragging of a heavily loaded waggon over boggy ground, which rises in a wave before the wheels during its progress.

4th. Next in importance to the inflexibility of the gun barrel is the form of projectile best calculated to displace the atmosphere during its extended flight. Under the head of Rifles this subject will be more fully discussed; but, as thousands of years have stamped the arrow as being in accordance with nature's laws, it should no doubt be the object of science to approximate the leaden projectile to that form as much as possible, and hence the cylindro-conoidal may be assumed to be the best form of projectile.

That both Jacob's and Whitworth's bullets partake of a certain amount of "*wabbling*" motion after leading the muzzle of the gun is certain, from their length, as well as from the fact that in both the centre of gravity is in the hinder part of the bullet; thus they are both in reality bad in a scientific point of view.

If any merit can be claimed for either, it is on account of the mechanical ingenuity displayed in neutralizing the effects of want of scientific principle. The want of principle, however, is not the only evil, were such guns to come into general use; their manufacture, in the hands of that portion of the gun trade which never estimates consequences, and never studies the theory of the science at all, but manufactures all fire-arms by "rule of thumb," would prove dangerous in the extreme.

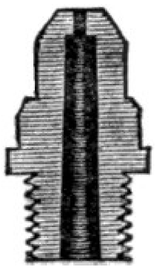
The bursting of barrels in any attempt to project lengthened projectiles is of a very different description to that which ordinarily occurs, on account of the different direction in which the force is applied. In consequence of their greater length, and their increased friction against the sides of the barrel, they are more reluctantly set in motion—*i. e.*, their inertia is with greater difficulty overcome. The result of this is, that in overcoming their inertia the greatest strain is exerted backward, on the breech of the gun; which, if not more firm than usual, is blown out, entering the forehead of the shooter: an accident which would prove fatal not only to the gun, but to the person who used it.

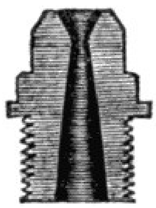
This accident may no doubt be effectually guarded against by strengthening the breech end of the gun as well as the breech itself; but without that precaution it is to be feared that such accidents would be of frequent occurrence.

A considerable error may easily be promulgated, as to the heat necessary to be applied ere gunpowder will explode. A late writer says, it is necessary to raise it to 600 degrees before it is explosive. This is a splitting of hairs, and such a palpable mystification, that it is scarcely worth noticing. But I will explain: if you place upon a plate a few grains of powder, by heating the plate underneath (for instance, on a smith's fire,) you will see the sulphur giving out a blue flame, it being easily fused. As the plate becomes heated to nearly a red heat, the whole explodes, in consequence of the charcoal and nitre not being hot enough to allow the gases generating the heat to be liberated; but as soon as this does take place the explosion ensues. Now, it is a well known fact, that the smallest particle of matter possessing above 600° of heat, will ignite any quantity of powder it comes in immediate contact with; we will suppose with one portion of charcoal, one of sulphur, and one of nitre (it matters not how small they are: a ten hundredth part of the substance of one of the smallest grains of powder would suffice), and if it has the means of communicating to these small portions 600°, this is sufficient, as their explosion induces also that of the very largest quantity: for it ought to be perfectly understood, that a great explosion is but so many millions of small ones combined, and by their united force effecting the great results we see. The ingredients of powder are ground and intimately mixed together on the bed of the mill to the great extent they are, to the end that, if possible, there shall not be in the composition two grains or portions of one ingredient in immediate contact with each other; but that, when the ignition does take place, each may be present to add its peculiar gas, in order that each affinity may be supplied. Thus becomes evident the necessity of a most extensive incorporation, a blending and equal division of mixture throughout the whole material.

The advantage of unglazed gunpowder is here fully shown; for it presents an inequality, a roughness of surface, over which the flame from the percussion mixture cannot travel without igniting some of the prominent parts, and thus the whole. You may glaze powder and make it so smooth that it would be very difficult indeed to ignite; but except that it enables the powder to resist moisture better, it is otherwise very detrimental, as tending both to prevent ignition and lengthening the period of effecting it.

The flame from the percussion powder is of that intense and vivid description, that if a charge of powder in the breech of a gun is loose, the flame will form a mass of condensed air round itself, and driving the grains of powder before it, prevent the immediate contact of the heat and the particles of powder, until the heat is expended; and thus arises a "miss fire." If the powder is up only to the nipple, there being a quantity of air in the tube of that nipple, the explosion of the fluid will drive down this air, and condense it between the powder and top of the nipple to such an extent as to cause a certain "miss fire." It becomes requisite to find a remedy for this, and it can only be done by bringing the powder into the very vicinity of the explosion on the nipple. This can be effected in several ways, but the most perfect is to obtain as direct a communication as possible; a widening of the perforations of the breech, and space to allow the powder free access up the nipple. For this purpose we propose an improved form of nipple. The centre one of the three (here shown in section) is considerably broader and shorter than the others. A cap made broader and not so deep would be an improvement, as bringing the point of ignition nearer the charge, and thus effecting a saving of time; for great and wonderfully quick as is the explosion, it is clear to the senses that it may be quickened. We are not finding fault with the "lightning being too slow," as Colonel Hawker says; but science means perfection, and the nearer we can come to it the better.


OLD PLAN OF NIPPLE.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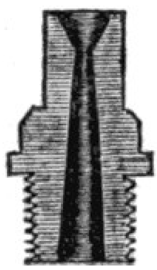

IMPROVED NIPPLE OF 1835.

The nipples now in general use have the smaller orifice at the bottom, and, being lined with platina, never foul. Experience has shown that admitting the gunpowder into the nipple "is not advantageous," especially with large grained powder; by constructing the nipple with the small orifice at the bottom, the largest grain can be used beneficially. As the velocity of the fulminating gas is much greater than "a train" of gunpowder ever can be, quickness is also gained by their adoption. I have used them for many years with great success; nothing but cost deters their general adoption. The passing of the flame through the very small opening in the platina, by this very high impingement, increases its heat to a great extent, ensuring explosion.

The true science of gunnery consists in knowing that a certain force is requisite to effect a certain purpose, or, in other words, to kill at a certain distance; and also how to arrange that force so as to effect the purpose without having any extra *force*, or any waste of powder, nor yet too little, but with a corresponding result: a sufficiency; neither more nor less. This we have shown is attainable by the mechanical arrangement of granulation; for it is useless to use less, or to use an iota more of fine grain powder, if the size larger will effect the purpose without that iota. Propellant velocity is the grand desideratum in all gunnery; the obtainment of this, to the greatest extent, is the power of killing at the greatest distance: all ranges are dependent on velocity; no extreme *range* can be obtained without a corresponding speed.

The very finest powder, it will be perceived, is fitted—perfectly fitted, preferable, indeed—to coarser grain for guns of a short length of tube, where a perfect combustion of the whole charge can be obtained without any waste or want; but as such is quite unsuited for longer barrels: I cannot too often repeat it. The column of air is the ruling power. Look what its effects are by Hutton's calculations, with the very low velocities he obtained! So great as to bring all projectiles he used to a medium velocity, before they were projected beyond a certain distance. Then what must its resistance be where the velocities are trebled? I say trebled, for my powder and the percussion combined have more than trebled the velocities. You must then clearly have a powder of such grain as suits the capacity of your gun. All barrels have a size of grain that will suit them best, and manufacturers of gunpowder will consult their own profit and the convenience of sportsmen, if they assimilate the grain of powder to various sizes; as in shot, to No. 1, No. 2, 3, 4, 5, and so on: eventually this system must be adopted.

This will explain quite clearly how the fact (singular to many) occurs, of short guns excelling their longer competitors, and how frequently a particular maker obtains an immensity of credit for an excellent gun only twenty-two inches: "Beat my Lord So-and-so's of thirty inches!" and how, "When I cut four inches off my double, she shot better than ever she did." All these occurrences are perfectly dependent on a knowledge of the generating of the explosive force, and may be reversed at any time by a person possessed of sufficient knowledge of these facts: put in coarse grain into the short gun, and fine into the long, and the facts will be changed considerably, as will be easily seen. A degree of mystery has hitherto existed as to the cause of this discrepancy; but I trust this explanation will clear it up.

Experiment has shown the error of stating that only a certain quantity of powder could be consumed: the proportion stated was considerably below the actual quantity, as the experiments of punching the plates show; for since twelve drachms can be burnt in a three-feet barrel, therefore ten drachms may be consumed in one two feet eight inches, with a given weight to lift. In addition to this, must be placed the fact of improvement, both in the composition and granulation of the powder; which we have no hesitation in stating has been considerable, within only a very few years, all tending to the quickness of generating force. The granulatory system, if acted upon, will give the sportsman or soldier a completely new power in gunnery; for it must be evident, if we have the means of projecting certain bodies with an extreme velocity, say 5,000 feet per second, it becomes a simple calculation to ascertain the quantity of force and length of tube to give to a certain weight. Take, for instance, an ounce ball in a barrel two feet six inches long. Extremely fine grain powder, from its rapidity of expansion, gives to the ball this velocity at fifteen inches from the breech; the remaining fifteen inches contain a column of air highly condensed, which will inevitably reduce this velocity back nearly fifty per cent., or 2,500, and with that velocity the ball leaves the muzzle. Therefore, as we have already said, it must be evident you have here generated a high speed to be as quickly reduced; and it shows clearly that if a different grain of powder would expand from breech to muzzle, increasing the velocity on a granulated scale until it obtained the highest, or 5,000 feet per second, as the ball left the muzzle, you would save here clear 50 per cent. in force, with less recoil, less internal strain on the barrel, and with exactly the same weight of powder; thus showing that you have just a definite quantity of force in a definite quantity of powder.

The true science of gunnery is the knowledge how to best arrange the collateral parts, so that you may obtain the greatest result with the least means. I have also clearly shown that the resistance of the atmosphere is one, and the principal obstruction in the attainment of high velocities; its resistance being regulated entirely by the degree of speed with which it is wanted to be displaced. Thus it is true, as both Robins and Hutton have shown, that only a certain velocity can be obtained beneficially; though the degree is considerably greater then either conceived, as far greater impetus has been obtained, and projected bodies have ranged much beyond their calculations, and that beneficially too. One drawback on the theory of these gentlemen is their calculating the velocities with iron projectiles; for the heavier the material the more powerful the momentum, and consequently the longer retention of their velocity, from not presenting the same space to the resisting medium, the air.

The development of the system of granulation must and does exercise considerable control over the shooting of barrels of every description. I have already explained what has been hitherto considered the curious phenomena of short and long barrels shooting so dissimilarly, and this illustration completely establishes the fact of the expulsive and repulsive forces being controlled by each other: as either preponderates, so is the result. The open-ended barrel projecting balls, and eventually bursting, is a beautiful and interesting elucidation, both of the force of gunpowder and the stubborn nature of the atmospheric fluid. All these facts are valuable, inasmuch as they lay bare circumstances which have never been satisfactorily accounted for, and enable the mind of lowest capacity to understand the cause and effect.

The superiority of one barrel in throwing shot stronger and more evenly distributed, arises, it will be easily seen, from the absence, or existence of, internal friction, when contrasted with the different degrees of expelling force, and the degree of resistance from the atmosphere; it also accounts clearly for the fact of guns shooting stronger on one day than on another, in fine and in rough weather: the weight, the resistance of the air, is the only cause of the variation; for gunpowder cannot drive back a dense atmosphere as quickly as a lighter one. The cause of guns bursting is to be placed to the account of both air and the generation of the explosive fluid so instantaneously; the solid front which air offers to quick compression, throws the force on the barrel, and the sides of the tube give way because they are weaker: this cannot occur so easily with powder of a more gradually expansive force, therefore safety is consulted in its use, in addition to the numerous advantages it otherwise possesses.

Mr. Blaine, in his Encyclopædia of Rural Sports, has the following: “The increase of metal in the detonator, we think, with Colonel Hawker, to be an essential requisite, first, to resist the quicker, and, consequently, more forcible, expansive force applied by the ignition of the powder through the agency of detonation, and tend to lessen the recoil so much more forcibly felt in most detonators. This increased weight of percussion Mr. Greener, however, objects to, and inquires, ‘Whether some of the best flint guns met with, have not been very light?’ To this we answer, that it was the principle on which the explosion of the flint gun was effected that enabled it to be made lighter, and yet to remain equally safe in using; but we also know, that where it was required to add to the rapidity and force of the ignition, it then became necessary to increase the substance of the barrel.”

Experience teaches the writer, and I dare say it would Mr. Blaine, if he were to experiment to the extent I have done, that there is no rapidity in the ignition further than the closing of that point of ignition by the cock, and no “force” beyond what the comparative instantaneous ignition of the gunpowder in the nipple creates. This is quite sufficient to prevent the further penetration of the percussion flame; and the only increase, to quote his own words, “to resist the quicker, and, consequently, more expansive, force applied by the ignition of the powder through the agency of detonation,” arises from an improvement (as it is termed) in the granulation of the powder, which alone creates the increased expansive force. This will be clearly understood by any one reading this work from the beginning; the only difference between the flint and percussion systems is the stopping of the orifice of ignition in one, and allowing it to escape in the other; for the flame has to travel to *windward* (to use a nautical expression) in the flint; the other has its own accumulating power to force ignition through the body of the powder. This alone constitutes the difference. The necessity for an increase of metal at the breech of a barrel does not arise from any peculiarity in the mode of communicating the fire, but in the increased inflammability of the powder alone. The extreme smallness of grain has effected this more than the use of fulminating flame; and the continuous cry for fine powder, to get better up the nipples, has produced an alteration which is placed wrongfully to the credit of the percussion.

Again, he says, “Mr. Greener, however, would have us acquire this increase of power of resistance, not by quantity of material, but by increased tenacity and elasticity in the metal the gun is formed of, and we agree that it would be a great improvement if it could be brought about. But what is our prospect of it? Is it not the general complaint that gun metal is not by any means what it was? We have shown that it is not; and, therefore, we do not think, as Mr. Greener asserts, that any recommendation of increased weight of metal to the percussion barrel beyond that of the flint gun “is founded on ignorance;” but, on the contrary, that the very reason Mr. Greener gives to prove it, is that which we think affords evidence of its perfect rationality, *the explosive force created*.” The answer given above applies to this also: save on the score of lessening recoil, superior quality is preferable, to quantity.

The shooting powers of gun barrels are dependent on two circumstances—goodness of metal, and a proper shape of exterior: it cannot be too often repeated, *that a gun barrel is a spring*, to all intents and purposes; if you add metal, you add stubbornness, and destroy that expansibility, without the existence of which the barrel is, comparatively speaking, useless. Heavy, ponderous barrels do not propel a charge of shot with either that smartness or degree of closeness that a barrel more scientifically constructed does; you have less recoil certainly, but the addition of half an inch of more metal behind the butt of the breech would do this more effectually, and save you carrying an additional weight. The gradual ignition of powder obviates the necessity of a great thickness of metal in the sides of the barrels; but if it is determined to persevere in the use of peculiarly fine grained powder, you would certainly be justified, nay, required, to have more and better metal than at present, for the electrical nature of the explosion will throw upon the tube that force which would be more judiciously employed in giving impetus to the charge of projectiles.

I have found that expansion will increase the shooting powers of a barrel; but then it must not be the expansion of an unelastic piece of metal, but of metal whose elasticity rebounds with a force equal to that with which it expands; for whatever else you may obtain by creating friction, by boring the breech end of the barrel wider you obtain a greater expansion, as it no doubt has that tendency. We find it an invariable fact, that when barrels are very heavy, compared with their size of bore (if a cylinder), they shoot weak. Also, when barrels are made of irons of different temperatures, where one is placed to prevent the expansion or springing nature of the other, they are never found to shoot well. As a proof of this fact, let any one take the best barrel he ever shot with, and encase it with lead very tight; fire it at a dozen sheets of paper, and see if the effect be equal to what it was when the barrel was unencumbered. On the contrary, it will be found to have shot very weak, though close. Let him then examine the lead; and, if any moderate substance, he will find that the explosion has enlarged it considerably. This experiment I have tried repeatedly, and can vouch for its truth.

The proof of barrels is another fact corroborating the truth of our assertion. What else can occasion the bulging, but the expansion? Where the barrels are possessed of soft and hard portions (which is the result of different tempers of different metals), one expands further than the other, and then, of course, the soft part receives no assistance from the hard, and it does not return to its original state.

Put on a barrel, from the breech end to the muzzle, a number of rings of lead; be sure you have them tight, and not further apart than three or four inches; fire that barrel with a usual charge, and if it be a correct taper for shooting, it will have expanded the whole of the rings an equal distance.

From the observations already made, the reader will perceive that the shooting of all barrels depends on a certain degree of friction. The degree of friction necessary, varies according to the nature and substance of the metal. Those metals that require least shoot best. The object of the friction is to create a greater force, by detaining the charge longer in the barrel. If, then, there should not be an extra quantity of powder to consume, the friction would be a decided evil.

This may be understood by rifle practice, in which we find that a short barrel of eighteen inches, with a certain charge, will throw a ball as straight, and quite as strong, or stronger, than a barrel of three feet, loaded with a similar charge. I account for this fact thus: the barrel of eighteen inches will burn all the powder put into it; the long one can do no more. As soon as the ball has left the short barrel, it meets with no impediment but the air. By the time the ball in the longer one has travelled eighteen inches the powder is all consumed; the volume of air in the remaining eighteen inches acts as a destroyer of the force given to it, and it naturally drops its ball short of the other. Increase the charge of powder to as much as the long one can burn, and then it will throw its shot to nearly twice the distance of the other.

An addition of powder beyond the quantity the barrel can consume is disadvantageous; the reverse will be found equally so. Thus it is with fowling-pieces. The quantity of powder that a gun would burn in the shape of a cylinder, would be too little, when, by altering that shape, you increase the friction. The quantity must, therefore, be increased, or this friction will diminish the force of the shot. It is on this that the mistaken supposition is founded, that short barrels will shoot as far as long ones. It is true that with a small charge, or very fine powder, the short barrel will kill at the distance of thirty yards, as well as the long one; but put in the long one as much powder as it can consume, then try the two at twice the distance, and you will find out the mistake under which you have been labouring.

It is on the nature of the metal that the goodness of the shooting principally depends. That barrel which is possessed of the greatest degree of elasticity and tenacity, will throw its shot strongest and closest with the least artificial friction. It is on the knowledge of the qualities and temperatures of the various irons, and on practice in the art of shooting, that a man’s ability in making guns shoot with precision must rest. All plans are merely methods by which an unscientific maker has most frequently succeeded. It would be no difficult task to produce a hundred barrels which will shoot nearly alike; yet every barrel shall be different in its bore.

The length of friction depends entirely on the length of the barrel. Long barrels require more than short, though the latter require it in a greater degree. A mode of creating friction, much practised by those who are ignorant of the true method, is to bore the barrels as rough and as full of rings as possible. These rings are often taken for flaws; though that may be ascertained by noticing whether or not they have the same inclination as the twist, and whether or not they are at the jointing of a spiral. If they be not, the chance is that the barrel is ring-bored, as it is termed. This roughness, however, answers the same as friction by relief; but barrels thus roughened are very liable to lead, and become foul. While the well-bored barrel will fire forty shots as well as twenty, these cannot be fired more than twenty times with safety and effect.

Each of the barrels in the table below, if 3-16ths thick at the breech, is equal to the pressure stated. The resistance of a charge of shot of one ounce we find to be more than before stated; and the additional increase of explosive force obtained at the moment of ignition, requires the amount to be much greater in computation, therefore, we may safely take a pressure of 1,700 pounds to the inch of tube. The reader will perceive, on reference to the following table, that with the tube filled with powder for an inch in length, which is a small charge, the explosive force will be equal to 40,000 pounds, or nearly 1,700 pounds to the inch.

		Pressure of charge.	Surplus strength.
	lbs.	lbs.	lbs.
Laminated and other steel barrels are equal to a pressure of	6,022	1,700	4,329
Wire twist	5,019½	1,700	3,319½
New stub twist mixture	5,555	1,700	3,855
Old stub twist	4,818	1,700	3,118
Charcoal iron	4,526	1,700	2,826
Threepenny skelp iron	3,841	1,700	2,141
Damascus iron	3,292	1,700	1,592
Fancy twisted steel	3,134	1,700	1,434
Twopenny skelp iron	2,840	1,700	1,140

If the charge he increased to one ounce and a half, the length it occupies, and the lateral pressure by the jamming, will create an additional pressure in proportion, or near 2,550 pounds, as under:—

	Pressure of 1½ oz. shot.	Surplus strength.

	lbs.	lbs.	lbs.
Laminated and other steel barrels are equal to a pressure of	6,022	2,550	3,472
Wire twist barrel	5,019½	2,550	2,469½
New stub twist mixture	5,555	2,550	3,005
Old stub twist	4,818	2,550	2,268
Charcoal iron	4,526	2,550	1,976
Threepenny skelp iron	3,841	2,550	1,291
Damascus iron	3,292	2,550	742
Fancy twisted steel	3,134	2,550	584
Twopenny skelp iron	2,840	2,550	290

A charge of shot two ounces weight will be greater in pressure than barrels of these dimensions are equal to restrain, and, consequently, no barrels should be charged to this extent at any time; but inferior barrels, as a matter of certainty, are sure to give way if so loaded.

		Pressure of 2 oz. shot.	Surplus.
	lbs.	lbs.	lbs.
Laminated barrels, &c.	6,022	3,400	2,622
Wire twist barrels	5,029½	3,400	1,619½
New stub twist mixture	5,555	3,400	2,155
Old stub twist	4,818	3,400	1,418
Charcoal iron	4,526	3,400	1,126
Threepenny skelp iron	3,841	3,400	441
Damascus iron	3,292	3,400	
Fancy steel barrels	3,134	3,400	
Twopenny skelp iron	2,840	3,400	

The foregoing tables show clearly the danger of persevering in using heavy charges of shot; for it must be borne in mind that accidental circumstances will increase this pressure, and never can act so as to lessen it: a foul gun, or a variety of other circumstances, being sure to increase the danger.

Having fully explained the nature of gunpowder, it remains to say something about the other portion, namely, the shot. That a barrel creating explosive force, until the charge is in the act of leaving the muzzle, will shoot better than another which does not do this, there cannot exist a doubt; for this is the germ of the science. Also that the column of air in barrels, where the explosive fluid is sooner expended, acts upon the wadding, and influences the lateral direction of the shot, there can also be no doubt; therefore, more attention is requisite to this point than is generally given. I am quite certain that all well-constructed barrels, both as regards metal and exterior shape, shoot best, shoot so longest, and foul or lead less, than barrels having the aid of friction: soft barrels require it, no doubt, but why make soft barrels? The others cost but little more, and the superiority admits of no question. The quantity of shot is a matter of the first consequence, and I think that I have clearly established the fact, that the less the weight, in proportion to the force, the greater the speed or velocity given to that weight; hence it follows that to be beneficial a certain quantity is suited.

All guns, according to their bore and length, will shoot a certain weight and a certain size of shot best. A great deal of shot in a small bore lies too far up the barrel, and creates an unnecessary friction; and the shot, by the compression at the moment of explosion, becomes all shapes: a circumstance which materially affects its flight. If of too great a weight, the powder has not power to drive it with that speed and force required to be efficacious, because the weight is too great in proportion.

Those who reason from mathematical calculation will object to this doctrine. They will say, the greater the weight the greater the effect. No doubt it is so, if thrown with a proportionate force; but that cannot be obtained with a small gun. We must adapt the weight of projectile force to the power we are in possession of; and from many experiments, I am inclined to think, that a fourteen gauge, two feet eight inches barrel, should never be loaded with above one ounce and a quarter of shot (No. 6 will suit best), and the utmost powder she will burn. A fifteen gauge will not require more than one ounce; and no doubt No. 7 would be thrown by her quite as strong as No. 6 by the fourteen gauge gun, and do as much execution at forty yards with less recoil. Setting aside all other reasons, I should, on this account, prefer the fifteen gauge-gun, if both be of a length; as I find as much execution can be done at the same distance with one as with the other. To render a fourteen gauge barrel superior, Colonel Hawker is right in stating, that it should never be under thirty-four inches; which description of barrel I very much approve. He also says, “You cannot have closeness and strength in shooting combined, beyond a certain degree:” an observation, in the truth of which I fully concur; it being found that where there is a greater degree of either strength or closeness, the other requisite is always wanting. Neither would it be advisable, as the sportsman will find a medium decidedly the best: a medium that will give the shots fairly spread over a space of thirty inches diameter, at forty yards; and so regularly, that a space, which would allow a bird to escape, shall not occur above twice out of five shots, and each shot to penetrate through thirty sheets of paper. It will be found, that a gun doing this regularly, is far superior to one throwing twice as close and not one-half through the paper; as the latter will require four or five pellets to kill a bird, when two of the other would be quite as efficacious, on account of penetrating twice as far.

In favour of small shot, Mr. Daniel’s observations are so pertinent, that I cannot do better than quote him. He says, “The velocity of a charge of No. 7 being equal (we will say nearly) to one of No. 3 at that distance (35 yards), and since small shot fly thicker than large in proportion to its size; and as there are many parts about the body of a bird, wherein a pellet of No. 7 will affect its vitality equal to a pellet of No. 2, the chances by using the former are multiplied in the workman’s favour; for it is the number and not the magnitude of the particles that kills on the spot. They who prefer large shot, and accustom themselves to fire at great distances, leave nearly as many languishing in the field as immediately die. Whereas, those that use small shot, and shoot fair, fill their bag with little spoil or waste beyond what they take with them from the field.” To an old gamekeeper of his (he tells us) he has often put the question, “Why he was so partial to small shot,” and his reply was, “Sir, they go between the feathers like pins and needles; whilst the large shot you use, as often glance off as penetrate them.” No doubt, here Mr. Daniel is as correct as may be. Mr. Blaine says, query? But he ought to be aware, as I suppose he is, though allowing himself to lose sight of principles, that small shot can be, and are, propelled from the barrel with an equal velocity with the larger; it is only in the length of range that the greater triumphs; but if we take thirty or thirty-five yards’ distance as an average, the latter will not “*lead*” in the race. Therefore, the advocates of small shot have unquestionably the better of the argument at this distance; at greater, I will not dispute it, though I have picked up No. 5 shot 300 yards from the spot fired from; larger, No. 3, rarely reaches 400 yards.

Hard shot is not so liable to be mis-shaped, nor does it lose its velocity by contact, as easily as soft.

Under the head mixed shot, Blaine observes, “We do not believe any law in projectiles can be brought forward to prove its impropriety. The mass of shot is propelled by the expansive power of the powder; it is ejected in a mass; and when it separates, each shot carries with it its own share of ejective force, with very little interference with any other, it being evident that the projectile force acting on each shot is in the proportion of its area of dimensions,” &c.

Here is a great mistake. The law of projectiles is not wanted to prove its fallacy; the laws of motion will do that. If you take any number of equal or dissimilar sizes of shot, and place it as a charge is placed in a gun barrel, occupying ¾ of an inch of tube, there is, of course, a wadding between powder and shot; this wadding is, or ought to be, a piston; velocity is communicated to this piston by the explosion; it does so to the shot immediately above it, that to the layers above, and so on until the whole mass is in motion. The velocity behind the piston is increasing to a certain point, where it ceases; then it is that the layer farthest from the piston, having received its maximum from the layers below, travels quicker than its assistants; who, having parted with their force, fall behind in proportion: so does each layer, even until the last one which received it from the piston, having communicated so much to his friends before him, is left without himself. It is an undisputed law in motion that one body may convey to another, by contact, nearly its own velocity, but in so doing, is sure to come to rest immediately. Strike one billiard ball against another, if the blow is centrical, the ball struck receives the motion, the other comes to rest; and so is it with shot: it is only the layers next the muzzle which strikes the target, the remainder fall without travelling the same distance. I have fired three balls from a rifle, and having marked them I found the uppermost projected farthest, and the others in proportion. This is easily proved.

Thus, it is quite clear that in all charges of mixed shot, the larger will extract the velocity from the smaller, and consequently become useless for the purpose intended: this fact is unquestionable.

In speaking of the longest duck or swivel guns, I may instance Colonel Hawker’s account of the performance of such fowling artillery. It appears evident that they do not effect anything like the execution which might be expected from their immense size and capability. The reason of this is obvious. From the great space of the interior, in order to receive that equal pressure on the inch which a common fowling-piece receives, they should be charged in proportion to the increased size; but then, I scarcely need add, they would become ungovernable. In addition to this objection, they could not be forged of malleable iron, so as to be safe; on account of the impossibility of forging a barrel of that weight by hand hammers, and the little probability of hammers ever being invented to work by steam to do it sufficiently quick. The greater the weight of the barrel its strength is gradually decreased, owing to the impossibility of sufficiently beating it throughout the whole body.

It must be well known to any one versed in mechanics, that an anchor-shank weighing some hundredweights is more easily broken than iron one-twentieth part of the weight, which has had the advantage of being forged by hammers where the blows were felt through the whole mass. This cannot be the case in forging large barrels, as the workmen cannot use hammers heavy enough; consequently the barrel is turned out of hand with the pores more open than a piece of cast iron. They have tried this with large guns for the artillery, and it has repeatedly failed, entirely from the want of sufficient power to compress the iron.

All guns, therefore, of an unusual size, are not of strength in proportion to a small gun; hence the reason they cannot with safety be charged up to the corresponding scale. Neither are they of the length they should be, if the bore is to be the criterion. It must be remembered that to be charged in proportion, the pressure on the inch should be as many times the pressure on the inch of the small gun, as the one is the number of times larger than the other. If we come exactly to the real state of the case, we doubt much (when taking into consideration the difference of surface) that the pressure on the inch in the large gun is equal even to that on a small gun. The comparison might be carried up to the largest artillery, and I doubt whether it would come up to this scale; as it is well known that the heaviest guns will not throw their projectile as far in proportion as the small gun, because you dare not generate the force required to do it. The same principle is applicable to artillery as to fowling-pieces.

From the above data, I would say, never make duck-guns above seven-eighths in the bore, if you wish them to kill at a great distance; and not less than fifteen or sixteen pounds weight, and full four feet long; because then you can generate strength sufficient. Therefore, instead of the large stanchion-guns being one hundred pounds weight, they should, strictly speaking, be two hundred, and so on. In proof of this I may just mention that, upon repeated experiments, I have ascertained that a double stanchion-gun, with each barrel of the same bore, weight, and length, as a single gun, will kill further than the latter; simply owing to the advantage of the greater weight of the double gun. I have made observations, when trying moderate-sized and shoulder duck-guns on that fine level piece of sand before spoken of, and by tracing the grazing of the shots I have been enabled to pick them up. The large shot from the duck-gun, mostly No. 2, I found scarcely 400 yards from the spot where she was fired; the small shot, five and six, from a fourteen bore, were repeatedly picked up at 350 yards: thus showing that the large gun had not much advantage; but yet making probable many assertions made of killing at seventy, eighty, and sometimes a hundred yards, with a common-sized gun. By this it appears possible; for shot that will fly that distance must kill, if it hit during its flight through the first quarter of such a range; but then, at a single bird, above fifty-five or sixty yards, it is always twenty to one against hitting the object at all; as the pellets begin to separate rapidly at that distance, though their force is still sufficient, and in large flocks is apt to do execution.

The invention of the patent wire cartridge is rather the production of a scientific mind than the production of chance; though the invention of General Shrapnell contains the principle, and the perfection attained is but the extension of that principle: namely, the means of projecting a number of bodies of a similarity in size without subjecting them to an extreme jamming by the lateral expansion, and thus allowing each to travel his allotted distance without any of his companions robbing him of his speed by impact. The great peculiarity of the wire cartridge is, that being less than the bore, and having no bottom wadding, the explosive fluid acts all around, between the sides of the barrel and the net, by what may not inaptly be termed the windage, and the shot are thus expelled by a cushion-like force, which does not jam or compress them in the way it is liable to by a wadding forcing it outwards. Here the net is of use to keep the whole in a mass; but you must not suppose the same would be obtained by a charge of shot, without a wadding below. The net opens, after leaving the muzzle of the gun. The introduction of bone-dust is intended for, and answers the purpose of preventing the grains of shot being mis-shaped by the compression: during their passage up the barrel they form with the bone-dust a comparatively solid body, and keep the pellets from impact, thus allowing them to go forth into the atmosphere beautifully round and uninjured; and, as such, more likely to travel farther and stronger. The latter arrangement possesses all the science, as the net can be dispensed with; for it aids the combination but slightly, and in no case more than a moderate quantity of good paper would do.

The science of this mechanical construction of projectiles is perfectly in keeping with all the established laws of motion, and more particularly good in thus avoiding the necessity of lateral pressure on the sides of the tube of the gun, the upper end having the means of better resisting the column of air in their progress outwards; for there can be no question but this controls and induces the divergence of the shot in leaving the muzzle. One of the old arrangements, often laughed at, I mean the bell muzzle in old guns, intimates that our ancestors possessed some smattering of science; as the relief in the muzzle of a gun has a tendency, by allowing a gradual expansion laterally, to keep the charge of shot better together: for it is quite apparent that any body severely compressed for a certain distance, expands in proportion when free of that restraint; and the consequence is a tendency to fly off at a tangent, as the friction of a crooked barrel induces a ball to fly in a curve contrary to the bend of the barrel.

The extreme relief we find in some old barrels is certainly not required; but still it clearly shows that the principle was understood and acted upon: the very extreme has been produced by ignorance, as certainly as the suggestion was a proof of knowledge on the part of the suggestor; for many think, if a small dose is good for a patient, a large one must be equally so. Like ourselves of the present day, having discovered that fine gunpowder was advantageous, we have carried the principle so far as undoubtedly to overstep the line to which it was beneficial we should advance; thus clearly establishing the truth of the old adage, “One extreme begets another.”

Therefore, in advocating the adoption of gun-barrels of the very essence of iron, I also say, let that part of the tube whose duty is the generating of force be nearly cylindrical, and let there be a gradual expansion of the bore for a few inches in approaching the muzzle, that the restraint of the lateral pressure may not be too rapidly loosened. But yet let that expansion be so graduated that there shall not be an extreme either way—only a scarcely perceptible relief; yet such as will influence and prevent the divergence of the projectiles to a considerable extent.

Blaine says—“A very long barrel is liable to have the force of its discharge lessened by the increase of counter pressure in the greater volume of internal air in a long than in a short barrel.” The column of air in the barrel is unquestionably calculated to lessen the force of the discharge. But I have already shown that this is completely controlled by the system of granulation. Further, he says—“Its force must also suffer by the loss which the elasticity of the propelling gas experiences in its lengthened transit through an extended range of barrel.” He is here supposing an instantaneous generation of force, which cannot possibly happen; and if it did, would be comparatively useless. But he is evidently on the right scent, if he could only follow it up. Again,—“In such cases, it is probable, that the shot, which should leave the mouth of the piece at the instant when the propelling force has gained its maximum, in a long barrel are detained beyond that particular limit of capacity we have pointed out as inherent in each barrel; and which properties, and which quantities of charge, nothing but repeated and varied trials can teach the owner of the gun.”

This is an excellent illustration of the “theory” of the resistance of the column of air in long barrels with very fine quickly-burnt powder; and could he have pointed out the cause, the explanation would have been perfect; as it must be quite apparent to the reader that it is not the length of barrel which is in fault, but a want of a continuous producing force in the powder; for when all the charge is exploded, the maximum has been obtained. This clearly proves that the charge was too small to keep up that maximum, or that the grain of the powder was too fine, and thus too quickly expended. There is no discrepancy between the fact of long barrels being preferable half a century ago, and short ones now; for it is in the improvement of gunpowder burning in half the time now that it did then, and leaves the question of length of barrel precisely where it has ever been. You may have any length you like in moderation, if you suit the grain of powder to it.

I am quite satisfied to steer between extremes; avoiding alike too small a charge of projectiles and too wide a calibre with too heavy a charge of the former, and preferring a size of bore that gives, under all circumstances, the greatest range with the least amount of explosive material; which neither requires that to be too fine a grain, nor too coarse: namely, a bore of fifteen and two feet six inches long. Under all the above circumstances combined, this size will long hold a position in the front rank of sporting guns.

The Belgians have long been, and still are, our principal competitors in supplying those parts of the world which do not rank gun manufacturing among their staple trade. The cost of labour being small, they have great facilities for producing cheap material; and the extent to which they tempt the eye of those inexperienced in gunnery is quite obvious to the world; but excepting the cheapness of the lower grade of guns, the Belgian products are not at all to be placed on an equality with the well made English manufacture.

In consequence of the relaxation of our custom laws, foreign gunnery is now admitted at ten per cent. duty; and as soon as this change was made, the Belgians sent large quantities of their guns and pistols to London; whence they found their way through different parts of the country. Regular establishments were opened for the sale of their very highly ornamented barrels: ten different varieties were produced, even to the imitation of laminated steel.

These barrels were at first sent in the bored and ground state, in large quantities; their apparent low price and great beauty quite captivated some of the “Brums,” so that for a period they were all the rage; and the Belgians began to boast of the extensive trade they were doing. But nothing in this world runs smooth. “The best laid schemes of mice and men oft gang agee;” and so it was with the Belgian importations. Our proof was not exactly to their liking, or perhaps the iron was not equal to the proof; losses and discoveries began to accumulate: “Too soft, by far,” says one; “They are all plated,” says another; “Filed it through, by jingo!” exclaimed a third; “Common iron, by all that’s wonderful!” protested a fourth; “Oh, twisted iron, under such inimitable Damascus!” growled a fifth: in short, steel over iron turned out to be the secret of the whole business.

It is very probable that such facts as these soon established the inferiority of “the beautiful Damascus and arabesque” of the Belgian manufacturers; and they have, I trust, disappeared for ever from the English market: at least, they are not held in estimation by those qualified to judge.

Their advocates have for years adduced the fact, that the Belgian laws required guns to be twice proved; and our old laws not requiring this, they had certainly a tangible argument; but our improved proof laws have now removed that anomaly, and certainly our proof is now much superior, even to that of the Belgians: so much so, indeed, that I have now before me a letter from a Belgian barrel maker, who, in reply to the inquiry why he did not send any more barrels, says very truly, “your English proof is too severe.”

A very carefully conducted experiment on at least twenty best Belgian barrels, satisfied me of the indisputable fact, that at least nineteen out of the twenty were plated, and principally on twisted iron of the softest description; as was shown by eating it entirely away, by a lengthened immersion in a solution of the sulphate of copper. This may be done in the course of a few hours, leaving the Damascus, and the arabesque plating comparatively untouched. The production of that extremely beautiful figure has to be effected by using metals of considerable dissimilarity in their state of carbonization; the iron evidently being entirely decarbonized before mixing with the steel, and the steel even appearing extremely soft; although, no doubt, much of this would be effected during the heating of the barrels to solder with brass: and it is well known this cannot be done, except by heating them to nearly a white heat.

As this is the universal practice with all barrels which the Belgians finish, a good shooting gun is, by all fixed laws of science, a scarcity with them. But a point of still greater importance arises from this injurious proceeding. In the act of heating two tubes like gun barrels, it is an impossibility to heat them equally, so that neither shall be at a higher temperature than the other; and again in lifting them from the furnace, and in cooling, all are subject to bend by expansion and contraction alone; the result is that perfectly straight Belgian hard soldered barrels are utterly unattainable. To an unpractised eye the bending in and out appears trifling, but professionally, it is a very serious defect indeed; and on that score alone, the Belgian can never compete in quality with our own manufacture. Time, however, will no doubt remedy this; already they are great imitators, and they will, no doubt, become greater. They are competitors whom respectable manufacturers need not fear; and though they eschew the imitation of our higher quality, they imitate, even to the name, the "marks" of our leading makers. I still would welcome and fraternize with them, as highly skilled workers in elaborate mixtures of metals suitable for ornamental gun-barrels.

The French gunmakers have not yet realized the true value of the shooting of their fowling-pieces. This arises, in a great measure, no doubt, from the want of a proper field for improvement. Necessity has always been an important improver, and wild game creating the necessity for good guns in England, a different direction has been given to the manufacturer, owing to the continual cry for long killing guns; and not a doubt can exist that English guns are better constructed for that purpose, than those of any other country. Attention to the shooting has always been the first study of every English gunmaker, and great progress has been made during the last twenty years; indeed, a comparison between the largest "target" of to-day, and the best that Colonel Hawker ever made with his crack Joe Manton, will show a progressive improvement of nearly 100 per cent., not only in closeness of shooting, but also in penetration. All this may not be due entirely to the gun, but in part to the gunpowder; and to the sensible course we now pursue of using less weight of shot, avoiding artificial friction in the barrels, instead of increasing it to retard the shot with the view of increasing its power: also by having the expellant agent accelerative to the greatest extent, closeness and strength of shooting are obtained, with the least amount of recoil possible.

Our French competitors have paid much more attention to the artistic decoration of their guns than to their usefulness; and the universal result of this sort of proceeding, ever since the invention of gunnery, has been a total neglect of their power of extreme projection. The metal, like other portions of their work is, in all cases, manipulated with a view to beauty only; as the fact of their veneering, or plating, their barrels proves.

If at all masters of the science, they must be aware that this weakens the shooting of the barrels, and is an injurious practice. But the greater fact remains, that they continue to fix all their barrels together, by brasing them with brass from end to end, as they do in Belgium; thus lessening the strength of the barrels in point of safety, and nearly destroying any smart shooting power they might have possessed.

The French appear to me to have only reached that stage of progress which we attained forty years ago, when every intelligent mechanic was seeking after that "useless thing," even when attained, "a perfect safety gun;" which, from its complex character, might have been designated "the dangerous gun;" indeed, experience taught (though not without great cost) that few would use it when attained, and the consequence was that it fell into disuse. Our Continental neighbours, however, are mining it with great energy. A little more of our experience, and they, also, will see the folly of the attempt. All the facts go clearly to establish the truth of the assertion, that for all useful purposes they are half a century behind us in the essential part of gun manufacturing. The anxiety shown by all leading Continental sportsmen to obtain a first-class English gun, and more especially of laminated steel, is very strong evidence in support of this assertion. All the guns I exhibited in Paris in 1855 were eagerly bought up at high figures; and I have since executed many orders for France, Austria, Prussia, Sardinia, and Russia, as well as for other northern states.

The display of artistically constructed guns by the French makers in their Great Exposition of 1855, was very great, and by certain classes of sportsmen would be considered superb. My notes, made at the time of inspection, will show better than a description can do, in what state of transition their manufacture is, and how they vacillate between their old and our present style:—

Parisian gunmakers presented 36; Rheims, 1; St. Etienne, 14.

Leopold Bernard, barrel-maker.—Very good work; barrels made of two spirals, inner and outer, with the twist running the reverse way; fine figure; mixture of steel and iron.

Monsieur Gauvain.—Very good sound work; all highly artistic; the cock formed so as to resemble a tree with a snake coiled round it, the head of the snake striking on the nipple. Several other guns of the latest English patterns.

Monsieur Beringer.—Guns ornamented arabesque; a medium show of work; principally breech-loaders.

Monsieur Caron.—Showy, ornamental, very middling.

Lepage and Moutier.—Work good, ornamented, principally arabesque. Game and English scroll pattern, engraving, cocks, &c., but inferior to the English patterns of Gauvain.

Houllier Blanchard.—Good work; designs English; a very novel pattern of figure in the barrels.

Monsieur Le Perrin.—All his guns artistic; raised, embossed, artistic, ornamental, heavy cocks to imitate my shape; one good English pattern soft gun.

Monsieur Lainê.—Good sound work; English pattern of twenty years ago.

Monsieur Andrê.—Good work; ornaments embossed; "Devisme" inlaying; carving and embossing unequalled; several English pattern guns, but of the standard twenty years ago.

"Thomas."—Guns well inlaid; work medium.

Albert Benard, barrel-maker.—Iron very good, but all lined; bar apparently reduced from a mass two inches square, which tenuates the figure extremely, as the bars are only ¼ inch thick.

Gastienne Renette.—All highly artistically ornamented; work good, carving very elaborate. A novel mode of breech-loading: a piece on hinge turns out, a cartridge, slides in return to its place, and a quoin like a wedge forces it up into a chamber; the wedge and head receiving all the force of the recoil.

Lenoir, barrel-maker.—Iron very good; thirty rods in a faggot 5 + 6, and welded and drawn down into ⅜ of an inch square: an enormous elongation of the fibres.

Doye.—Good English pattern-work—nothing else.

Fontereau.—Work, all English pattern; very good.

M. Brunn, successor to Armand and Bourbon.—Highly embossed work: a novel breech-loader; artistic design for cock; female figures with fishes' tails in scroll on to the tumbler.

Guerin.—A novel safety guard; locks while on the nipple at half cock, and full cock; swivel double like a split ring.

May.—A novel safety guard, very likely to break the finger: sure to do it if on an English gun. Breech-loader: central fire, the same as now made by Lancaster.

Loger, barrel-maker.—Bars faggoted 6 + 2, and so formed to imitate laminated steel.

Dufour.—All breech-loading guns; but all work of the first class.

Juelle Magana, barrel-maker, St. Etienne.—Barrels well fitted and figure varying, but not possessing the regularity observed in the Belgian barrels.

Chapellon.—Coutereau.—Exhibit some barrels filled, with a charge of 12 inches of powder, 6½ inches of shot, and warrant them not to burst on firing that charge.

Delabourse, Paris.—Good work "à la Purdey."

Lefaucheaux, Paris, prize medalist, 1851.—Good embossed work; breech-loaders; also very good imitation of English work.

Such is a fair sample of the whole. But the best work by far is that by Gauvain, though not so highly estimated by the jury; but that is in many cases no test of ability whatever—as much depends upon the influence and standing of the individual.

Great exhibitions are calculated to effect great good if properly carried out. In that of the English exhibitors at Paris nothing could be more reprehensible, for the jurors left them to the tender mercies of their foreign competitors. In the case of the gun-makers, nothing could be worse, for the two jurymen appointed by the English Government never, I believe, saw a gun, home-made or foreign; and the fact of my obtaining two first-class medals speaks much for the impartiality of our Continental brethren.

Recoil.

Recoil varies according to the position of the gun; when fired on the horizontal, the resistance to be overcome is the tendency of the projectile to fall to the earth, and its friction as it moves in a line parallel to the earth. When the muzzle is elevated this resistance is increased, because the force generated by the explosion of the gunpowder has to exert its action more directly in opposition to the direction of the force of gravity; and when this force is exerted in a line directly opposed to the centre of gravity, as it is when the gun is fired vertically, then the recoil is doubled, and is made more painful, because the body resting on the earth cannot yield.

A gun fired in the direction of the earth, or in the line of the centre of gravity, would recoil much less (perhaps fifty per cent. less) than when fired vertically; from the very obvious fact, that if the bullet was not kept in position by its friction on the sides of the barrel, it would fall to the ground of itself.

"The recoil of a gun is inseparable from a discharge of its contents—on the broad principle that action begets reaction; it is, therefore, only when the 'kick,' as it is called, becomes painful, that it is essential to avoid or lessen it. Irregularity in the bore of the barrel is a very common source of violent recoil; *contracted breeches* also, but more than all, the contraction of the barrel at its centre, occasion recoil, and that of the most dangerous kind: the expanding flame, during its ignition, presses violently to make its way through the contracted to the wider part, thus also destroying the expelling force. 'Now, action and reaction being equal, it follows, that the weight of the piece being the same, the recoil will be in proportion to the quantity of the powder, and the weight of the ball, or shot; and that with the same charge the recoil will be in proportion to the weight of the piece, or the lighter the piece the greater the recoil.'"—*Essay on Shooting.*

Here is a true exposition of recoil, though not of contractions in the breech; for there the action would not be directly back, but have an inclination towards the muzzle; for the reaction would not have time to tell on the breech, before the charge was out of the muzzle. An extremely spiralled rifle barrel destroys the explosive force of gunpowder, but the effects are not felt in the recoil, being most all expended laterally. Blaine says, "Could we entirely obviate all recoil from a gun, we should not only remove an unpleasant shock to our persons, but there is reason to believe we should much assist the range and force of the shot likewise; although there is an opinion prevalent, that the degree of the recoil is in the proportion of the projectile force." Of this, however, some doubts are entertained, which are warranted by the following fact:—"Mortars with iron beds immoveably fixed in the earth throw their shot to greater distances than guns which are affixed to carriages can do, and which, therefore, can recoil. This has been incontestibly proved, both in large and small artillery. Having suspended a gun barrel, charged with a determinate quantity of shot, from the ceiling by two cords, so as to allow of its recoil, fire it point blank at a target, and mark the result accurately. Now, fix the same barrel to a block, and charge it exactly with a similar charge; then having moved the target fifteen yards further, fire the barrel; it is probable that the last shot, though at this increased distance, will exceed the former, both in range and force.' These and such like experiments are laughed at by the giddy and inconsiderate; but it is by these illustrations that the most important facts are brought to light.

"Projectile force is, therefore, to be increased by resistance; and the knowledge of this fact offers us a practical hint, that when we stand immoveable to our shot, not only by holding the gun tightly to our shoulder, but by also *leaning somewhat forward* in our shooting attitude, we considerably increase the resistance, and, consequently, we not only lessen the shock of the recoil to ourselves, but we aid the force of the shot and extend its range. That such is the case, may be further exemplified by the following experiment:—Throw a hand-ball against any moveable body, and it will displace that body; but the ball will drop to the ground perpendicularly, however hard the body against which it is thrown may be. Fix the same body securely, and then the rebound of the ball will be nearly equal to the force with which it was thrown."

The weight or amount of force with which a gun recoils against the shoulder, is due to, and regulated by, several circumstances. The first and most important is the amount of explosive force generated before the charge is moved and during the act of moving, and the amount of inertia in the body of the projectile. When a quantity of gunpowder is exploded without any resisting weight in front of it, then the column of air gives comparatively a slight recoil; though there is, in fact, considerable recoil, but such as is due to the resistance of the air only, and, consequently, more like a push than a blow. The exact amount of recoil is also due to the difference between, or proportionate weights of, the charge of shot or bullet and the gun; action and reaction being always equal until one or the other body moves; the division then will be in favour of that moving fastest, and hence the obtaining of accelerative velocity: it thus follows, as a truism, that the smaller the quantity of exploded gases that can be employed to first move the charge, the less the recoil.

The advantage of the granulation system is here again most clearly shown; and (alluding again to the law of putting matter in motion gradually) if you would gain the greatest benefit, it is clear that, in the same length of tube, you would, at the termination of the accelerative power, have gained a much greater amount of velocity than could be obtained under any other circumstances with the more violently explosive gunpowder.

Many theories have been advanced, and many conjectures made as to the cause of the recoil of guns; and it must be evident that the causes vary with the form of gun, with the nature of the gunpowder, and the weight; or peculiar arrangement of the shot or bullet. For instance, an ounce of shot, and an ounce of lead in the form of a round bullet, fired from the same gun would give two very different amounts of recoil, when measured by the spring cushion; the ounce bullet not giving much more than half the recoil produced by the ounce of shot. This is owing to the simple fact that the bullet being a compact body, offers only the resistance of its weight, and the simple friction of sliding or rolling along the barrel according as it is tight or loose; but the tendency of the hundreds of shot corns is to "jam and wedge" in the most extreme manner, offering, by their lateral pressure against the sides of the barrel, the greatest amount of friction and reluctance to be driven out: hence the reaction on the gun, and thence on the shoulder of the shooter; and the smaller the size of shot the greater the jamming. Again, the same weight of shot, fired from a 16-bore and a 12-bore will recoil much more in the smaller than in the larger bore, even when all other points are equal; because the charge reaches higher in the 16-bore, thus offering at first a greater amount of inertia. Secondly, there is also more tendency to jam; and, thirdly, the extension of the surface of lateral pressure on the tubes of the barrel must also add to recoil. Dirty guns, it is well known, kick violently, simply from the greater friction, or difficulty of the matter of the charge being put in motion.

The question as to what the actual amount of recoil really is has never been settled satisfactorily; the most erroneous opinions have been given, and assertions equally erroneous have been made, by those who have attended to the subject. To clearly elucidate this question, it is absolutely necessary that the circumstances be reduced to one standard: but the difficulty is to obtain that; for it would vary according to muscular development, the weight and height of the sportsman. Indeed any principle laid down would be liable to be disputed, from the very different way in which every sportsman lifts his gun to his shoulder: if one presses it against his shoulder with a pressure equal to 5 lbs., he will receive a certain amount of recoil; he that presses it with a force equal to 10 lbs. will receive less; and with a pressure of 30 lbs. it will be found to yield the least of all. I will illustrate it in this way. Take a spring cushion (something like the spring machine found at all fairs for testing the force of a man pressing against it), if you allow a gun to recoil against this when the starting pressure is only 5 lbs., it will drive it up to 70 lbs., or nearly so, from the velocity with which you have put the 7 lbs. of matter which is contained in the gun into a long sweeping blow. The next time you try, put the starting point at 10 lbs., and you will find a much less result in the extreme weight denoted; but carry on this experiment, placing the cushion with a resisting force of 30 lbs., and you will find the extreme recoil indicated at from 40 lbs. to 45 lbs., and even up to a higher starting resistance. But to this extent it is not advisable to go, for the strain becomes too great on the handle of the gun-stock, and there is too near an apparent approach to a solid resistance, which it is well-known would break the best stock that was ever made.

Having shown how we may approximately obtain the exact amount of force, and how it may, even with two persons, give different results, I will now state what I have found to be the result of many hundreds of trials made with the view of deciding this question. Before doing so, however, I will further premise that hundreds of attempts have been made at various times by different Governments, and by many talented men, to obtain a correct recoil machine which shall efficiently measure the recoil, and in such a perfect line with the intended direction of the projectile as to obtain accurate results: but this is found to be perfectly unattainable, though I believe the nearest approach to it has been made by Mr. Whitworth during his experiments with the hexagonal rifle.

To prove that it is impossible to get all the circumstances alike, so as accurately to ascertain the exact force of the recoil, one instance only need be cited. Fire your gun at a fixed object, then fire at an object in motion, and to your senses the recoil will appear double when fired at the fixed object; but it is not really so: in the latter instance, the body of the person firing the gun, and the gun itself being in motion, a considerable amount of the force of the recoil is absorbed in overcoming the motion of the gun, and then that of the shooters body, so that the effect is not noticed. I have already alluded to the greater force of recoil felt from the lighter pressure of the gun against the shoulder; here the tendency of the gun and body moving in one direction is to close them together, and the proportion will be as the velocity of that movement. Therefore, to bring this to a conclusion, I find that under ordinary circumstances a 12-bore gun of 7½ lbs. weight, 30 inches in length, with a charge of 2½ drams of No. 5 grained gunpowder, and 1¼ oz. shot, the barrels draw-bored cylindrically, with the least possible easing at the breech ends, and metal of the best laminated steel, will recoil with a force of from 40 lbs. to 48 lbs., or on an average 44 lbs.: this is the most satisfactory conclusion I have been able to draw from my experiments. This of course will vary, as I have shown; and it is also liable to deviations, according to the state of the atmosphere, and other collateral circumstances. Great variations will of course arise from guns of fine or rough insides; guns new or old, well kept or neglected; and in guns bored larger at the breech-ends, in order to give artificial resistance to the escape of the charge. These last are now, I trust, obsolete, except in that abortion of science the “French breech-loading crutch gun;” and as an exception, all ill-constructed guns.

The science of the question may now be regarded as clearly established. Gun-barrels of the utmost tenacity, with insides of a cylindrical form as true as possible, polished as fine as a mirror, with a moderate weight of shot calculated to suit the gun and a good charge of large granulated gunpowder, will give the greatest killing power, with the greatest amount of comfort, or absence of recoil, that is to be found in the pursuit of shooting.

A point of considerable importance in obtaining regular and good shooting—one, however, which is frequently neglected—is that of ascertaining what sized shot is particularly suited to the size of bore used.

The correct adaptation of No. 5 or No. 6 for your particular gun is easily attained. Place in the muzzle an ordinary wadding, press it into the barrel the depth of the diameter of the shot, which should be exactly flush with the muzzle, place as many shot corns on this as you can, without having more than one distinct layer, and observe the size that best fills, in concentric rings, the whole circumference of the bore, leaving no half-spaces unfilled; note whether it be No. 5 or No. 6 shot, and keep to that size for your general shooting. Again, on other occasions you may wish to use larger shot (Nos. 4, 3, or 2); then ascertain by the same method which fills the concentric rings most perfectly: the same should be done with the smaller sizes, Nos. 8 or 9.

The rationale of this proceeding is that any half-spaces are filled by shot from above pressed in upon the lower layer, disfiguring itself and those it comes into contact with; this is multiplied up to the 13 or 14 layers of which the charge is composed, and the inevitable result is that four or five pellets are pressed together until they adhere; either “balling” or leaving empty spaces in the distribution of the charge, to the injury of the gun’s shooting—a defect which may easily be obviated by attending to the instructions given above. One other point may be observed, viz., that if 1¼ give 15½ layers of shot in concentric rings, the charge should be reduced until the rings are complete, for the half-layer will do much mischief by its unequal pressure on the layers beneath it. And it is further necessary to observe that in loading a gun, either with powder or with shot, the gun should be kept as nearly in the upright position as possible: the more upright the gun is held, the more perfectly will it be charged, and the more perfect will be its shooting.

A vast number of useless changes have of late years been introduced into the construction of gunnery; they have died, however, a natural death, as they ought to have done, and have thus afforded additional evidence that sportsmen of the present day only adopt what are really improvements. Great professional reputation in a gunmaker is not now, as formerly, all that is required to command a trial of individual plans of improvement: the improvement must be self-evident; nothing being taken on trust: a *bonâ fide* benefit to the sportsman is essential in the present day to obtain patronage.

There has lately been introduced a very novel improvement in the construction of double gun barrels, in order to overcome that defect long admitted to exist in firing the second shot. It has long been known that in a 40 yards' flight, shot falls several inches; and it is an established fact that few sportsmen can kill with the second shot so well as with the first, although it is certainly within range of the gun. This no doubt arises in almost every case, from the shot having fallen below the object in traversing the greater distance; or, in other words, the second barrel, in order to kill as well as the first, ought be fired six inches higher; but this the best shots find it difficult to do, and it has therefore been proposed to do it for them.

Mr. F. W. Prince, of No. 138, Bond-street, has patented an improvement to obviate this difficulty; this he does by elevating or pointing upward the second barrel, so as to cover the calculated fall in the body of the shot; and the result is, that the second bird is as well aimed at and as efficiently killed as the first. The alteration is so exceedingly simple, and the benefit resulting from it so apparent, that the only wonder is that it should never have been done before; and it being the improvement of a really practical sportsman of the very first class, as Mr. Prince has long been known to be, is sufficient to stamp his invention as worthy of every consideration.

CHAPTER VIII.

THE FRENCH "CRUTCH," OR BREECH-LOADING SHOT GUN.

Sporting in France has never been brought to the same state of perfection as in this country. Grouse-shooting on our wild romantic hills is a very different sport from quail, partridge, or rabbit shooting in the vales and on the hills of the Continent. Wild game requires great energy and perseverance on the part of the sportsman, courage and strength on the part of the dog, and last, though not least, great capacity on the part of the gun. For many years the superiority of the English manufactured gun, as well as of the English gunpowder, and the matchless skill of the English sportsman, have been acknowledged by all the world. All things, however, have their limits—the longest lane has a turning, and a very plausible and insidious innovation has been made to detract from the acquired reputation of the English sportsman, and render his shooting inferior to that of some of our friends on the other side of the Channel.

The French system of breech-loading fire-arms is a specious pretence, the supposed advantages of which have been loudly boasted of; but none of these advantages have as yet been established by its most strenuous advocates. How it is that the British sportsman has become the dupe of certain men who set themselves up for reputable gunmakers I know not. It is certain, however, that by these acts they have forfeited all claim to the confidence of their too confiding customers, and that they never could have tested the shooting properties of their guns. With regard to the safety of these guns, they display an utter want of the most ordinary judgment; and this is abundant proof that they considered neither their safety, nor (what is also of importance) the economy of the whole arrangement, as regards their manufacture or their use.

Guns are perfect only so long as they possess the power of shooting strong and close, with the least available charges. The period has passed when barrels were bored by rule of thumb, without any well-defined intention; the workman being ignorant as to whether he would have the bore of the barrel cylindrical, or (as was frequently the case) in the form of two inverted cones, and thus he continued to bore at the barrel until it was utterly useless, or until by chance he hit upon a tidy shooting bore. Barrels are now constructed so nearly alike, that it is no stretch of truth to assert that ninety-six or ninety-eight barrels out of a hundred can be made so nearly alike in their shooting, as to render it very difficult to discover the real difference between them. Yet, in the face of this high state of perfection certain English gunmakers introduce, and recommend to their patrons as an improvement, a description of gun possessing the following negative qualities:—First, there is no possibility of a breech-loader ever shooting equal to a well-constructed muzzle loader; secondly, the gun is unsafe, and becomes more and more unsafe from the first time it is used; and, thirdly, it is a very costly affair, both as regards the gun and ammunition. Nor are these negative qualities at all compensated for by any of the advantages claimed for these guns by their advocates; this assertion I now proceed to establish.

In the first place recoil has been an important obstacle to contend with, ever since the invention of fire-arms, and the methods of lessening recoil have engaged the special attention of all inventors up to the present day; on this important point, indeed, very much depends. Gunnery is good only when recoil exists in a minimum degree. Force, whether it be that of the gentle "zephyr," or of the mammoth steam-boiler which is capable of moving thousands of tons, can always be measured, and the friction of steam against the tube through which it passes can be measured also.

The time was, when guns were so imperfectly constructed, that the recoil and friction of the charge against the barrel destroyed more than half the force generated by the explosion of the gunpowder; and this loss of force having been obviated, by finely polishing the interior of the barrel, as well as by improving the metal of the gun, has rendered English guns superior in their performance to those manufactured in any other country. Breeches of a conical form offer the greatest resistance to the action of aëriform bodies in a direct line; this is the principle of what is best known as "the patent breech:" to speak of which would be a waste of time, as nothing more is required to support its superiority than the fact, that in well constructed artillery of every country, the interior form of the breech or chamber is more or less conical. Thus we see that by adopting the crutch gun, we have to give up one of the oldest and most universally acknowledged principles in lessening recoil—namely, the conical form of the breech—and to adopt the very reverse of this: namely, the old right-angled, flat-faced breech, upon which recoil can exert its utmost force with the certainty of its reaching the shoulder of the unfortunate user.

Secondly, to enable the gun to be loaded with a cartridge which shall keep its place, a complicated arrangement is necessary. On inspection of the barrel, it will be perceived that a cavity has been formed larger than the bore of the barrel, and that this in some cases only tapers toward the further end. This cavity exactly receives the cartridge, and the gunpowder is inflamed in a space much larger than the barrel, which it has afterwards to pass through. The charge of shot is also started in a larger space than that which it afterwards has to traverse, and the column must of necessity become contracted and elongated before it can escape from the barrel. The first consideration is at what cost of force is all this effected? Thirty per cent. would certainly be a shrewd guess; and who is there conversant with the nature of gunpowder hardy enough to gainsay the fact?

I here present the reader with the measurement of a pair of barrels—bore 12, diameter of the cavity 10, or two sizes difference,—tried at the celebrated trial of Breech versus Muzzle-loading fire-arms, which took place in April last, in the court at Cremorne. The following are the results of the trial:—

Class 1 comprised twelve bore double guns, not exceeding 7½ lbs. in weight; the charge for the breech-loaders was three drachms of powder, and one ounce and a quarter of shot; that for the muzzle-loaders, two and three-quarter drachms of powder, and an ounce and a quarter of shot. The question will be asked why were both not charged alike? and the answer is, because the advocates for breech-loaders well knew the loss of power caused by the enlarged breech end would require a larger quantity of powder; yet, with this advantage, the result was a verdict in favour of the muzzle-loaders of nearly two to one. I quote from the *Field*. The aggregate number of pellets in the targets from breech-loaders was 170, the penetration 19. The aggregate number of pellets put in by the muzzle-loaders was 231, the penetration 48; and this was effected with a quarter of a drachm of powder less.

Few will doubt that this must be the inevitable result. Force cannot be expended and retained: we "cannot eat our cake and have it." If force is destroyed by friction, it is as useless as if it had never been generated. So much, then, for the shooting qualities of the breech-loader.

And now comes the question, of much more importance than the shooting qualities of these guns: namely, can all this force—30 per cent., in fact, of the whole charge—be thrown away with no worse result than the mere wasting of the powder? Is there no change taking place in the barrel of the gun every time it is discharged? Iron and its combinations are as certainly limited in their duration as is human life itself. Every bar of iron is capable only of resisting a certain amount of pressure; every successive strain on its fibres deteriorating it more rapidly; and whether it be the mainspring of the lock, or a gun-barrel itself, a certain number of strains will destroy it. This being the case, how much more rapidly must a breech-loader be destroyed where 30 per cent. of the charge is always "absorbed" on the sides of the barrel in the cavity alone. This a lengthened experiment will prove; though the fact is so self-evident, that no experiment is required to demonstrate it.

Caution in gunnery is absolutely necessary under the most favourable circumstances, and disregard of perfection in the construction of a gun is quite unpardonable; then what shall be said of that member of society who, with all those facts before him, can say to his customers, "I advise you to have a breech-loader: they are really good guns?" In what estimation such a tradesman must be held I will not venture to say. Much more might fairly be said against these guns, but I sum up the whole in the following damnatory sentence: Breech-loaders do not shoot nearly so well, and are not half so safe, as muzzle-loading guns.

It is said, and truly, that a breech-loader can be charged more rapidly than a muzzle-loader; but I hold this to be no advantage, for this reason: all guns can be loaded more quickly than they are fired, and the tendency of all barrels to absorb heat, puts a limit to rapidity of firing; indeed, after ten rapid shots with each barrel, both guns would be about on an equality. Another question is, can breech-loaders be used longer than muzzle-loading guns, without cleaning? My opinion is, *they cannot*. At the trial already spoken of, after twenty-two shots had been fired from the breech-loaders, the cartridge-cases had to be extracted from the barrels with a hook, and in several cases it was necessary to cut them out with a knife; whilst a muzzle-loading gun without friction would have gone on to a hundred shots without being wiped out. There are few plans or presumed improvements which have not some redeeming points; but in the case of breech-loading fire-arms it is quite a task to find even a resemblance to one. All the advocates for breech-loaders whom I have ever met with yield, with this acknowledgment: "I must admit that I never liked them; but so many gentlemen are asking for them that I was compelled to make them, to keep my customers." This is, no doubt, the truth; but it is calculated to lead to serious calamities: for it was apparent to hundreds, at the Cremorne trials, that even the best and newest breech-loading guns permitted an escape of gas at the breech to an extent that I never thought possible; and if this occurs in new guns, what will happen after a single season's shooting, should any one be found sufficiently reckless to use a breech-loader so long?

No fear need be entertained that the use of breech-loaders will become general; manufactures on false principles soon show themselves worthless, however pertinaciously they may be puffed off. The number of accidents arising from the use of breech-loading fire-arms has not been very great as yet; though I have already heard of several very serious cases, from the use of well-made guns: let us consider what would be result if the workmanship was inferior?

There is one other point to which I may briefly allude before dismissing the breech-loader to the "tomb of all the Capulets." The majority of guns on this principle merely abut against a false breech; and, from the fact of there being no connection either by hook or by cohesion, the explosion causes a separation between the barrel and the breech to an extent which would scarcely be credited. This may, however, be satisfactorily demonstrated by binding a small string of gutta percha round the joint, when after explosion the string will be found to have fallen in between the barrel and the breech; thus showing that the muzzle droops in the act of being discharged, which must must materially influence the correctness of fire.

The recoil of an ordinary 12-bore gun, loaded at the muzzle, varies from forty to forty-eight pounds, seldom exceeding the latter; that of a breech-loader varies from sixty-eight to seventy-six! And this quite independently of the enormous force which is exerted on the sides of these enlarged breech guns. The shoulder left in the barrel, too, is a formidable barrier for the charge to pass by; and, in doing this, the circle of shot in immediate contact with the barrel becomes disfigured and misshaped, so as to insure its flight only to a very short distance. In the muzzle-loader an average of 180 shots strike a target of two feet six inches diameter; but breech-loaders of the same calibre will rarely put in 120 shots; showing a clear loss of 60 pellets. This is due to the enormous jamming they have undergone in passing from the greater to the lesser area of the barrel. It is said that the paper of the cartridge fills up this enlargement; but any one who knows what the force of gunpowder is, must also know that paper intervening between the charge and the sides of the barrel would be condensed at the moment of explosion to one-fourth its original thickness.

CHAPTER IX.

THE RIFLE.

The Rifle has at length taken its place among scientifically improved weapons. Mathematicians laboured long and earnestly to develope the important principles involved in it, and which lay hidden like latent heat, only waiting for the moment when they were to be extracted, as they were at length by experiment, the result of necessity: indeed necessity has done more for the improvement of gunnery than all the mental toil and labour bestowed on the science itself. The philosopher has sought in vain for that which mechanical skill unpatronised and unheeded forced upon the world, and that, too, in spite of prejudice and contempt; and the present generation see improvements brought out which were predicted generations before—as the following quotation from Robins clearly shows:—“Whatever state shall *thoroughly comprehend the nature* and advantages of rifle pieces, and having facilitated and completed their construction, shall introduce into their armies their general use, with a dexterity in the management of them, they will by this means acquire a superiority which will almost equal anything that has been done at any time by the particular excellence of any one kind of arms, and will perhaps fall but little short of the wonderful effects which histories relate to have been formerly produced by the first inventors of fire-arms.”

That the result here predicted has now been obtained no one can doubt. Greater extension of range is yet attainable; but accuracy of range amounts already to almost mathematical precision. All that is now required is, that the same principle should be applied to the heaviest projectiles; and when these are projected under precisely the same laws, experience will further establish this principle, that “the heavier the body in equal velocities the less the deflection from atmospheric resistance.” When this is demonstrated the present order of things will be reversed; heavy ordnance will exceed the shoulder rifle in extension and accuracy of range, whilst the shoulder rifle will again fall back to its former state of comparative inferiority.

Barrels were first grooved or rifled at Vienna, about the year 1498. The original object of grooving or rifling the barrels was to find space for the reception of the foul residue produced by discharging the rifle, and thus to diminish the friction of the bullet as it was forced down by the ramrod. During the next twenty years a spiral turn was given to the groove, and bullets were used with projections to fit the grooves, the degree of twist or spiral varying as the skill of the gun-maker thought best.

The difficulty of loading rifles has at all times been a drawback to their universal adoption as warlike weapons, and it has been reserved for a humble individual to achieve that which all the talent devoted to it for three centuries had hitherto failed to accomplish.

A multitude of claimants have “put in their plea” for a share in some part of the invention; and it may benefit not only the present but also the future generation, if we give a succinct account of the approaches made by different men towards the present established principle, and show the bearing each had in bringing about the revolution that has taken place in the science of gunnery.

The earliest notice of an elongated bullet is Robins’s “egg-shaped,” which gives to the hemispherical end the centre of gravity, thus establishing the first essential principle; but theory and practice were here sadly discordant, for its wild uncertain flight, caused by the small end acting as a rudder, rendered his theory useless, and it soon died of a natural death.

The next innovation on the spherical principle of bullets was the attempt made by the late Sir Home Popham to introduce elongated sphero-cylindrical bullets into cannon, with grooves and projections on the exterior to impart a spinning motion, which should be sustained by the action of the atmosphere; but this, like Robins’s idea, survived only a very short time. The next in rotation is a description given by Captain Beaufoy, in his work on the rifle called *Scloppetaria*, and published, we believe, in 1808. Captain Beaufoy gives a drawing of an elongated bullet one and a quarter diameters in length, having a hemispherical cavity accurately corresponding in shape to its counterpart at the opposite end. “This,” he states, “he had heard was beneficial from the fact of the rush of atmospheric air into the vacuum created, thus inducing a forward motion by the kick *à posteriori*.” This apparently was but a surmise, an idea never carried out, for in the same work a degree of spiral grooving is advocated with which the action of this bullet, had it ever been intended to be expansive in principle, would be quite incompatible.

Next comes the celebrated Joseph Manton with his invention, intended to give a spiral motion to the ball by the cup of wood already described under the head of rifled cannon. This very idea has since been revived by General Jacob; and in 1822 Captain Norton introduced to the notice of the Government his “Rifled Shell” for the explosion of an enemy’s tumbrils. This was of necessity an elongated hollow bullet, containing a small charge of gunpowder, which was ignited by the explosion of a cap on a nipple, screwed into the fore-end of the leaden shell.

Here, no doubt, was a partially expansive bullet; for the bullet would be driven in upon itself, and thus expand from the weakness of the hollow shell; this near approach, however, to the invention was not intentional: the sole object in view was the action of the shell, and no more importance was attached to its expansion, in Captain Norton’s estimation, than to the bullet described by

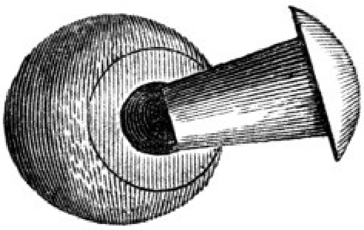
Captain Beaufoy in his *Scloppetaria*. It is only within the last few years that some friend, with more acumen than the gallant officer, discovered his near approach to the subsequent invention, and a claim has been made on his behalf which he himself never dreamt of, during the many years we were battering at the doors of prejudice; closed as they were against military innovation.

In 1826, Capt. Delvigne proposed to use an elongated bullet: “having observed that when a bullet was forced in by the old system of the mallet, its diameter was increased perpendicularly to the axis of the barrel, he came to the conclusion that by giving a chamber to the breech of the rifle, and loading with an elongated bullet having just sufficient windage to enter freely, two or three taps from a steel ramrod would flatten it sufficiently to make it take the form of the grooves, into which it would certainly penetrate when fired.” This contrivance was, however, found to be useless for military purposes; for after a trial, extending over two or three years, by the Garde Royal in Algeria, it was given up in 1830. This, then, is clear proof of an attempt to construct an expansive bullet, and conclusive evidence also of its failure.

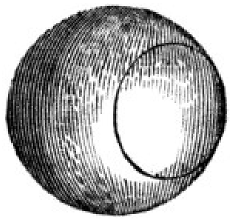
From 1830 to 1839, no evidence can be found of any progress having been made by these inventors. In 1836 I had the honour of producing the first perfect expansive bullet. During the winter of 1835 and the spring of 1836, I made an extensive series of experiments in order to overcome the effect of the very extensive windage existing in military muskets at that time; better known in the present day by the name of “Old Brown Bess.”

The mean diameter of the bore was ·760, the diameter of the bullet was ·701, or of the better understood gauge of 11 and 14 bore, thus leaving more than three sizes for windage. To obviate this great discrepancy by expanding a bullet from 14 to 11 bore, so as to destroy the windage, was the first consideration; and, indeed, the first great step towards that change of which we have as yet only seen the beginning. I here give a representation of my first attempt, and the observations made upon it in 1841:—

Five years ago I perfected and laid before the Board of Ordnance a new plan or system of constructing expansive balls, which is accomplished by having two dissimilar portions. An oval ball with a flat end and a perforation extending nearly through, is cast; a taper plug with a head like a round topped button is also cast, of a composition of lead, tin, and zinc, as below.



EXPANSIVE BALL
BEFORE USING.



EXPANSIVE BALL
WITH PLUG DRIVEN HOME.

The end of the plug being slightly inserted into the perforation, the ball is put into the rifle or musket with either end foremost. When the explosion takes place, the plug is driven home into the lead, expanding the outer surface, and thus either filling the grooves of the rifle, or destroying the windage of the musket, as the case may be. The result of this experiment was beyond calculation; and for musketry, where the stupid regulations of the service require 3½ sizes of bore difference for windage, it is most excellent, as remedying this considerable drawback upon the usefulness of the arm; the facility of loading being as great, if not greater, than by the present practice.

Inventions, however, are of no use whilst kept in obscurity, and my first and natural course was to bring it under the notice of the parties for whose benefit it was intended. Accordingly, in July, 1836, a memorial was duly drawn up, and laid before the Master-General and Board of Ordnance, soliciting a trial. After overcoming some difficulties, a trial was ordered at the “cost of the inventor,” and in August, 1836, it took place at Tynemouth, in Northumberland, under the command of Major Walcot, of the Royal Horse Artillery, a party of the 60th Rifles being the firing party. The exact form of the memorial, and the points claimed by the inventor, are as follows:—

“To the Right Honourable the Master-General and Officers of His Majesty’s Board of Ordnance. The humble Memorial of William Greener, Gunmaker, of Newcastle-upon-Tyne, humbly sheweth—

“That your memorialist has, after considerable trouble and expense, discovered a method by which the facility of loading all rifles, muskets, and other small fire-arms will be much increased, as well as a considerable additional force or range of the projectile be obtained, even with a less quantity of powder than at present used. Your memorialist has frequently loaded one of his Majesty’s rifles by this method, as quickly as any soldier could load the plain musket, and the balls when fired have received the same or greater effect from the action of the grooves of the rifle. Your memorialist’s plan simply consists in the manufacture of a more ready kind of cartridge, which will answer for all fire-arms as at present constructed, and will also be a considerable saving to his Majesty.

“Your memorialist being aware, from former communications with your Honourable Board, that in no case is any sum of money allowed for travelling expenses, &c., and your memorialist being very far from rich, is unable to attend any committee, either at Woolwich or elsewhere, your memorialist, therefore, suggests that if it meet the approbation of your Honourable Board to issue an order to the officer commanding the depot of his Majesty’s 1st Brigade 60th Rifles, at present stationed in this town, or to any other regiment or detachment in the neighbourhood, to appoint a squad of men to fire 100 rounds of memorialist's and 100 rounds of the cartridges now in use, and to compare their respective merits, the whole to be provided at your memorialist's expense.

"And memorialist, as in duty bound, will ever pray.

"William Greener."

The success of the experiments far surpassed the expectations of the military men present; and that they fully established all the points claimed, will be evident from the following secret report made by Major Walcott to the Board of Ordnance:—

"I then examined Mr. Greener's ammunition, and found he had not made it up into complete cartridges, but that his ball was separate from his powder. I then examined the ball, which being less than the barrel of the rifle, went down very easily—indeed slided down, and is thus formed. The ball is cast with a hollow in it, to which a plug of the same metal is inserted, but not going home. The force of the charge is said by Mr. Greener so to act on this hollow ball as to expand it, filling up the whole barrel, preventing all windage, and so truly keeping its flight that the head of the plug first striking the object fired at, is then driven home; the ball becomes a solid, and as such is equal to the present mode, as well as having more force and with a less quantity of powder than at present used.

"A detachment of the 60th was then ordered to load with Mr. Greener's, and an equal number with his Majesty's practice ammunition. The first certainly had the advantage in quickness of loading, but this may be accounted for by Mr. Greener's ball being put in separate from the cartridge; for I am by no means certain (it being necessary that his plug should be exactly in the centre, either next the cartridge or from it) whether, when made into a complete form, should the plug have shifted from its position, it would not cost the soldier more time to place it right; neither am I certain whether the plug might not be liable to become jammed in the soldier's cartouch-box.

"After firing several rounds, at 200 yards, at the target, we succeeded in obtaining some of Mr. Greener's balls, one of which that had struck the target and did not go through I send (marked) as the most favourable specimen of the day's practice, the plug being driven hard into the ball, the others having lost their plugs. Mr. Greener, whose wishes I complied with in every way I could, then proposed firing a number of rounds into a sandbank, to show that the plugs did not quit the ball. A great many rounds were fired; in many the plugs were out, in many loosely fixed and easily removed, and in a part firm. Not having the advantage of the target I had desired him to bring, a number of rounds were fired at the rifle's extreme range, 350 yards, as the best means left of ascertaining the difference of range; the only result of which was, that it appeared invariably to me and others on the slightest resistance from the first the plug quitted the ball, and therefore must have lessened its force from loss of weight. The balls from both charges, Mr. Greener's and his Majesty's, went home to the target, but only one of the latter went through. I had then fired most of Mr. Greener's cartridges and balls, and fifty rounds of the practice ammunition of the 60th. I beg to submit with the greatest deference that in so great a change as this proposed, even should it be considered worthy any other trial, that the specimens I shall send up by the earliest opportunity may have competent examination—for, although the balls of Mr. Greener bear the impress of the grooves of the rifle, I am not able to state whether such may not equally well be produced by the action of being forced from the rifle as by the expansion Mr. Greener states to take place—should the Master-General deem it necessary that any further experiment be made by me and with cartridges properly made up."

The immediate result was a very pithy epistle from the Secretary to the Board, saying, that "in consequence of the bullet I had submitted being '*a compound*,' it was totally unfit for his Majesty's service, and no more trials could be allowed."

This, in 1836, was the universal mode of proceeding, as subsequent events clearly proved; whether from inability on the part of the constituted military science controllers, or from a fixed determination to reject all improvements from civilians, I knew not; but time explained it all, as the sequel will show.

The total destruction, in 1841, of the small arms department in the Tower of London, together with all the arms it contained, opened a vista to improvement both in the principle and mechanical construction of "Old Brown Bess." This opportunity was not lost. A series of letters, Nos. 1 to 6, appeared in the *Times* in November and December, 1841, urging the necessity of a radical change in the construction of military arms, if the nation was still to hold its high military prestige. The sensation created at this time was immense, and no doubt laid the foundation stone for that change which has rendered English arms superior to any in the world, instead of being, as they formerly were, inferior to any in Europe.

In one of those letters, which may still be found in the *Times* of December 25th, 1841, the following account is given of the progress I had made in the invention since 1836; and when the form and proportions of my expansive bullet of 1841 are contrasted with the present and the original form adopted by our Government from the French of Captain Minié in 1849, it must strike the reader as being so palpable a copy as to leave no ground for argument.

"One favourite suggestion of Hutton's has hitherto been strenuously rejected, even by those to whom his recommendations have, in other respects, been laws—viz., his plan of using 'oblong bullets.' Some years ago I laid before the Board of Ordnance a very simple plan of getting rid of all windage, yet of loading easily, and adding to the weight of the projectile (a favourite theory with the artillerists). This was effected by employing an oblong ball of lead '*a diameter and a half in length*,' having a perforation extending through two-thirds of it. An iron plug of a conical shape is slightly inserted into this perforation, and the gun loaded with it. When the explosion takes place, this plug is driven home into the lead, and, by expanding its outer surface, the projectile comes out of the gun fitting as tight as possible, and a line of flight is given to it of corresponding accuracy. The advantages of this arrangement are numerous, but, in naval warfare, of the most important nature, giving heavier metal with smaller rates, and from the composition and shape of the projectile combined, producing a corresponding destruction.

"But the authorities laid the plan upon the shelf, where it will rest until produced by some more important personage than myself. The poor inventor obtains but poor encouragement, while his more wealthy competitor is enabled to have every opportunity of trying schemes which, in most cases, are not worth the consideration of any, save the friends of the party."

In 1842, powerful influence being brought to bear, it was hoped that a trial of my invention would result; and in order to meet the strongly expressed public opinion, the Board of Ordnance ordered me to construct them model arms on my own principle. This was done, and the trial promised by the Master-General was demanded, but as obstinately refused by the Select Committee at Woolwich, whose power was superior to that of the Master-General; though he was fully pledged to afford me a trial.

Thus the progress of invention was delayed until 1848; sometimes enlivened, however, by the bursting of a shell of intelligence in the camp of military prejudice. Slashing letters appeared from time to time on military incapacity. Meanwhile Captain Delvigne and Captain Thierry continued their experiments, and on June 21st, 1842, a patent was obtained in France, which is thus described:—

"For having hollowed the base of my cylindro-conical bullet, not only for motives mentioned in the descriptive memoir given with my demand for a patent, but besides to obtain its expansion (son èpanouissement) by the effect of the gases produced through the ignition of the powder. By this means the effort of the powder itself, which formerly caused spherical bullets to deviate from the grooves, now contributes to force the bullets of my system more firmly into them."

In a paper published by M. Delvigne in the *Spectateur Militaire*, of August, 1843, we also find:—

"In order to avoid too great friction I grooved the cylindrical surface of the bullet; but, whilst I thus increased the windage of the body of the projectile, I reserved, at the two extremities of the cylindrical part, two circular rings of a diameter almost equal to that of the calibre. These two rings fixed accurately in the bore, secured the perfect position of the axis of the bullet, which the blow of the ramrod then forced tightly. In case of foulness, they easily gave way to the blows of the ramrod, and the axis of the bullet remained in the required position. The hollowing of the sides of the bullet gives besides the means of fixing on the cartridge without increasing the diameter of the calibre. But during these investigations, *I made an important discovery, which was, that the gas produced by the ignition of the powder, rushing into the vacuum formed at the base of the bullet, expanded it and forced it into the grooves*. I here give the idea, a new one, as I think, and recommend its application to such as occupy themselves with the effect of fire-arms and powder. The following, however, must be avoided: if the hollow is too deep, the expansion is too great, and the consequent friction enormous; sometimes even the gas will traverse the bullet, and consequently the projectile is deprived of a proportionary amount of velocity; if too small, the expansion does not take place."

In 1847 and 1848 Captain Minié makes his first appearance on the boards; and he proposed a hollow iron cup to fill up the cavity in Delvigne's bullet, and from this circumstance we get the name of Minié rifle.

The serious defects in our arms were now, however, becoming so glaring, and the disgrace of getting worsted in skirmishes with contemptible foes in the Cabul and Caffre wars, as well as nearer home in the Mediterranean, raised public indignation against the military arms department; and this indignation reached such a pitch that an immediate change was called for. The so-called invention of Captain Minié offered itself, and was immediately adopted, though the very same thing had previously, on two occasions, been rejected at my hands.

Thus the history of the rifle is brought up to the adoption by the Government of my principle, under the name of the Minié rifle; and the validity of the pleas on the part of the several claimants for a share in the invention has been succinctly stated.

During the succeeding years I several times made unsuccessful attempts to obtain from the English Government a recognition of my claim to the invention. True it is that insult was not added to injury, for they did not tell me I had no claim as an inventor, but they sheltered themselves under the political plea of "Oh, my dear sir, the injustice did not occur under our Administration, or we should be so happy to remedy it!"

Time went on, and war came at length, and brought with it proof that but for my invention we should have been ill prepared. "The queen of weapons saved the fight:" so said the Thunderer. "When war's wild din was done," the poor inventor was listened to.

The first step taken was through Mr. Scholefield, the member for Birmingham, who moved in the House of Commons for copies of the correspondence between myself and the Board of Ordnance in 1836, and the papers therewith connected. Thus an act of glaring injustice was exposed, and there was evidence of proceedings having been enacted over which I would rather draw a veil. The authorities were no doubt shocked at the injustice which the poor inventor had met with at the hands of the then Board of Ordnance.

Thus I obtained the Secret Report, which elevates so high the names of those who could designate a plan as "useless and chimerical,"[13] which was destined eventually to create greater changes in gunnery than it had undergone from its earliest invention.

[13] The Secret Report of the Select Committee.

Present:—Major-General Millar; Colonel Adye, C.B.; Colonel Tyer, C.B.; Colonel Drummond, C.B.; Sir Alex. Dickson, K.C.B.; Major Dundas.

"*Woolwich, 29th August, 1836.*

"Sir,—

"I have the honour to report that, in obedience to your minute, dated the 22nd inst., I assembled the Select Committee for the purpose of considering a new invented cartridge for rifles, made by Mr. William Greener, gunmaker, of Newcastle. Patterns of these cartridges, with a report from Major Walcott, Royal Horse Artillery, of a day's practice with them at Tynemouth. Several balls that have been discharged at and collected after that practice were submitted to the Committee, who, after an attentive consideration, is of opinion that the ends purposed by Mr. Greener have not been accomplished; that his plan *is useless and chimerical*. The Committee do not, therefore, recommend any further trial in the terms solicited by Mr. Greener in his memorial of the 6th inst.

"I have, &c.,

"William Millar, *Dep.-Adjut.-Gen.*"

I then disputed the fact of its being a French invention before the juries of the French Exposition in 1855; there, however, my evidence was inadmissible, from the fact of it not having been exhibited, and the invention not being a recent one. In spite of all this, I still persevered; and my next step was to submit the subject to royalty. I first submitted it to the Emperor Napoleon, who carefully investigated the facts of the case, and admitted the Englishman's priority. Eventually the British Government, after much trouble, also admitted the fact, (though not until after it had been submitted to the successors of the original select committee) and awarded me the sum of 1,000*l.* in the army estimates of 1857.

It is a fact, which all will acknowledge, that the principles involved in an invention should be best known to the inventor himself; and if he is unable to explain the very principles of such invention, then it is quite fair to presume that he was not the original inventor.

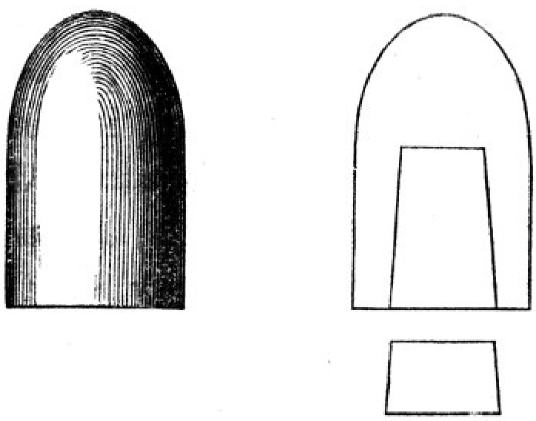
Now there is no evidence that either Delvigne or Minié had any profound knowledge of the science of gunnery, and their knowledge of the principles of the expansive rifle was so meagre as to justify the assumption, that their only connection with its production was that of copying from the *Times* newspaper, or from my works published in 1842 and 1846. My observations certainly appeared before any of theirs; and I believe that no straining of facts can in any way connect them with the invention, which was as perfect in 1841 as when they reproduced it in 1848 and 1849.

With these remarks, I pass on to what is of more importance, viz., the principle of the expansive rifle.

It had long been known that to give a spiral motion to a bullet in a direction coincident to its line of flight, was the standard of perfection in rifle projectiles; but this, until the invention of the expansive bullet, could never be attained with safety.

Spheres receiving this motion are not likely to retain it, because the periphery of the spherical bullet is, in all cases, subjected to much more friction than the rest of the sphere; a change would therefore certainly be induced, the axis of the spinning motion being changed from one coincident to the line of flight to that of one vertical to the same. The two grooved rifle was an illustration of this; for in all cases the projections on the bullet induced a change, the ring of the bullet revolving parallel to the horizontal line, as I predicted in 1841.

Enough has been said to point out the prejudicial action of any projections on projectiles, both as regards their accuracy and length of flight; perfect smoothness of surface being, in fact, absolutely necessary. Lengthened study and a series of experiments with bullets of a sphero-cylindrical shape having grooves and projections on their exterior identical with the grooving of the interior of the barrel, led me to consider the production of a bullet with a considerable cavity (equal, in fact, to two-thirds of its length) at the same time adopting as a standard one and a half diameters in the length of the bore of the gun; thus the thickness of the metal between the apex of the bullet and apex of the cavity was nearly one half of the diameter, as the following diagram will show.



This enabled me to insure two important principles, on which depended the success of the whole invention. 1st. The centre of gravity was in the head of the projectile. 2nd. "*The force was communicated directly to the centre of gravity during the explosion.*" This is a most important principle, which all writers presuming to give their version to the theory of the expansive system, have entirely overlooked.

If the arrow could receive the propelling force in the head, its motion would be even, and free from "hobbling," as Roger Ascham wishes it to be; but if, on the contrary, it is received at the opposite extremity, then there is a struggle between the head and the tail, as to which shall be first, and a "wobbling" motion is induced, enduring until an equilibrium of velocity is established.

It is essential to all future progress in the science of projectiles, that this point should be remembered, and its importance duly estimated; and it is possible to apply this principle to projectiles of any weight. If this point be attended to, where is the difficulty in extending the length of our projectiles to that of arrows? thus increasing their range indefinitely. There is, in fact, no law to limit the length of expansive bullets: the only limit to their length now is the tendency of lead to squash; but alloys of lead and other metals may yet be beneficially used for projectiles, and that to an extent of which at present we can form no conception.

The range of vision of the human eye being inferior to the range of the rifle will probably be the only limit to its use; and this range will not be difficult to attain: reduction in the size of bore enables us to elongate the bullet without diminishing its weight or the accuracy of its range; but without the existence of a cavity to insure the force being applied to the head of the bullet, this cannot possibly be done; whilst all other shapes are limited in their application, and an extension of range cannot be obtained with them.

Next to these two important points in the invention comes the question of expansion, whereby the grooves of the rifle are filled up with lead, and windage is as far as possible obviated. The expander I first employed consisted of a tapering piece of iron, similar in shape to the frustum of a cone, and this, when inserted into the cavity of the bullet, was flush with the bottom of the cylinder. The force generated by the ignition of the charge was exerted equally on the plug and on the leaden cylinder; the plug, however, moving more rapidly than the lead, is driven quicker into the bullet, the bullet expands, and thus the filling up of the grooves is accomplished. There can be no doubt that at the same time an upward force is exerted by the plug on the leaden bullet; and that, too, of a more elastic character than would be exerted by the gases themselves, if they were allowed to act directly with all their force upon the lead; for it is a fact beyond all dispute, that any force tending to set matter in motion gradually is more effective than that which is instantaneous in its action.

Many writers condemn *in toto* the Minié principle and its cup. Minié did not understand it; and the introduction of the cup by him was, I believe, an accident, or the best he could do by copying my mode of using it: it was not the production of his own brain.

It has been urged as an argument against the use of this cup, that sometimes expansion does not occur. This, however, may easily be accounted for by the fact that the cup is not tightly fitted into the cavity of the bullet; a space is left through which the elastic fluid penetrates the cavity, the cup then has as much pressure exerted upon it behind as in front, and hence it remains undisturbed.

Then the cup is sometimes driven in so violently that it becomes flattened against the flat surface of the upper portion of the cavity, cutting the lead so entirely as to leave the cylindrical portion of the bullet in the breech of the gun; this is well known to have been a frequent occurrence on the first introduction of this bullet. These defects are instanced, as evidence to show that Minié and others have no claim whatever to the production of the original idea—they cannot even now grasp it, but condemn it, because it is beyond the limits of their comprehension. True it is that, after blundering for several years, our Government have come back to my original idea, as the following quotation will show:—

"Colonel Hay," says Sir Howard Douglas, "has introduced an important improvement in the shape of the cup, and in the figure of the cavity into which it is forced on the firing of the charge. It will be perceived that the cavity in the Minié shot has the form of the frustum of a cone, while that of the cup is a hemisphere: now all who have examined the shot picked up after having struck an iron target or penetrated into the earth, find that the hemispherical cup is very liable to be canted or turned instead of being forced directly into the hollow space; the lead of the shot is not driven equally into the grooves of the rifle. For this evil Colonel Hay has proposed a remedy, in giving both to the cup and the cavity in the shot conoidal forms; by which means the former must, by the force of the powder, proceed directly forward in the hollow space, and thus uniformly expand the lower part of the shot in the bore."

If this is not conclusive evidence of the priority of my invention, then I cannot understand the English language.

The next object I sought to obtain in the invention was a reduction of opposing surface, and an increased momentum. The law of atmospheric resistance is as the area of displacement, and the velocity with which that displacement is effected. Thus, a spherical bullet of one ounce weight displaces a bulk of the atmosphere equal to the area of its hemisphere; whereas an elongated bullet of the same weight would have to displace so much less as is the difference between their diameters. These two bullets, started at equal velocities, are acted upon very differently by opposing forces; the velocity of the spherical is diminished much sooner than that of the elongated bullet, on account of its greater diameter: hence the increased range of the elongated bullet. Let us suppose an extreme case. Take a bullet produced from a description of hardened lead five diameters in length, and presenting to the atmosphere one-fifth the surface of a spherical bullet of equal weight; the reasonable assumption would be that this bullet would range a greater distance if projected at the same velocity, and if the same charge of gunpowder be used as with a spherical bullet.

The first series of experiments clearly established the fact that increased range could be obtained, and also with a vast reduction in the charge of gunpowder: with a saving, in fact, of nearly 50 per cent. Two drachms and a half were found equal to a range of fourteen hundred yards, whilst four drachms and a half on the old system would rarely reach half that distance. These important points were gradually developed, though not without many disappointments and much mental anxiety: the last discovery, to have rendered the task easy, should have been the first.

Extreme spiral curve in the rifle barrel is incompatible with the correct action of the expansive bullet. The old-established turns of one in four feet, one in three feet, and one in two feet nine inches, gave results in the order I have placed them; and it was not until the adoption of a spiral approximating to one turn in five and a half up to six feet, that I found the success of my experiments uniform: and this fact illustrates one great obstacle which my invention had to contend with before it was generally adopted.

The ordinary sporting rifles have invariably too much spiral; the amount of friction generated by an expansive bullet in a rifle of this construction is enormous, absorbing in many cases one half the power of the expellant. The result of this is most unsatisfactory: the bullet suddenly loosed from this immense friction, and freed from the column of air in the tube, rushes so wildly forward as entirely to destroy equilibrium in its flight; and hence the very loud complaints of disappointed experimenters.

The expansive principle now adopted combines such qualities that, however long and loudly it may be condemned, it will again assert its superiority, and hold undisputed the first place for generations to come. It is based on that law of nature which will always tell in mechanical productions; namely, minimum of friction, and hence maximum of propulsion or velocity; the greatest possible range with the least amount of expellant agency. The same law holds, even though the bullet should be elongated and made into an arrow. That which has been introduced to the world as an improvement on my invention, and modestly termed the “Pritchett bullet,” I rejected in 1841 as being inferior to the expansive bullet: any one who is curious, and wishes to be convinced of this fact, will find the following quotation in the *Naval and Military Gazette* for February, 1842:—“A great improvement may be effected by using plugs of a cylindrical shape, having the upper end round, and the part next the powder flat or concave; for rifles, to be of use, must be constructed for high velocity, and this can be done by a proportionate spiral and the use of a plug similar to that given above. In this case we may load with the greatest facility, and the bullet expanding, forces itself into the grooves of the rifle, and thus receives the modicum of spiral motion required.” A perusal of “Captain Jervis on the Musket Rifle” would lead one to infer that this was a great invention on the part of Mr. Pritchett, and that it would supersede to a certainty the more perfect expansive bullet; but Mr. Pritchett’s so-called invention has sunk into oblivion, from whence it will never emerge.

From practice I found that the most material defect in this bullet was its uncertainty of action: it was driven in upon itself, and thus its diameter was increased. A slight difference in the hardness of the lead, a bullet moulded when the metal was hot, and the reverse, would be such insuperable difficulties as to render their adoption quite impracticable; moreover, when rapid firing became necessary, the enormous friction created by the heat and hardness of the previous deposit from exploded powder, rendered the use of these bullets highly dangerous; as was proved in the Crimean war. I trust they are now for ever abandoned, for their adoption did not show great intelligence on the part of their advocates.

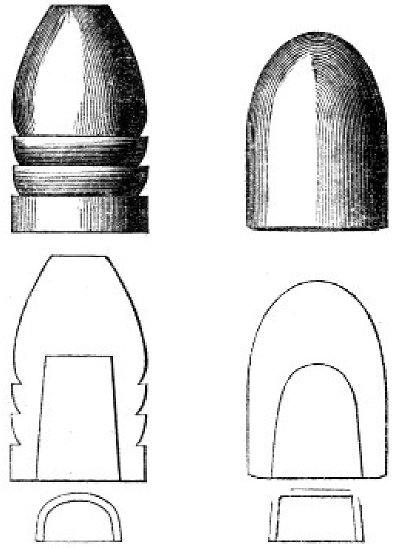
The expansive principle not being adopted in the armies of France and other Continental nations, may be justly attributed to the experimenters of the French school having been led astray; claiming, as they did, the entire merit of the invention. It is but fair that whilst endeavouring to establish my own claim to the invention, I should point out the discrepancies existing in the theory of my opponents.

That considerable imperfections exist in the expansive rifle used in France, is evident from the results of their experiments, and the time which has been wasted in discussing the principles necessary for correcting the flight of the bullet by “annular rings” being applied to its cylindrical part.

Captain Tamissier’s theory is “that an elongated bullet in passing through the air, describing the curve of the trajectory, maintained its axis parallel in its successive positions to the position it had at starting, and that the angle formed by this axis with the element of the trajectory—that is, the direction of the motion—changed every instant. The action of atmospheric resistance would also be altered by the surface presented by the projectile; as the point of application of this force would not always pass through the centre of gravity, but would establish a rotatory motion different from that with which the bullet was originally animated: in different words, the bullet, by preserving its original position, would after a time be pursuing its path with its broadside foremost; that is, with the point of its axis above the line of the trajectory and the near end below.

“To remedy this, and increase the precision of fire with these bullets, Captain Tamissier thought it was necessary to create resistances to the atmosphere as far as possible behind their centre of gravity, in order to bring the point of the bullet back to its original course. For this purpose he formed a number of circular grooves on the cylindrical part of the bullet, in imitation of the feathers of an arrow; which, he says, are placed at the hinder part to engender resistances.”

The folly of such a theory must be very apparent to a practical man. The engraving below of a bullet obtained direct from Captain Minié in December, 1855, and with which the troops were then experimenting at Vincennes, when compared with my bullet of 1843, renders any further argument unnecessary.

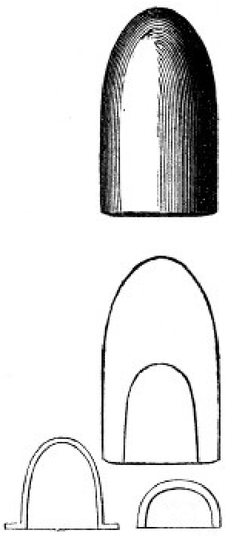


MINIE BULLET, 1855. GREENERIAN BULLET, 1843.

With this I contrast my bullet of 1841, at page 354, and a very slight inspection will be sufficient to satisfy any one of its superiority: every practical rifle-shooter knows that the smoother all the surfaces of the bullet, the more extensive and accurate is the range. That the French experiments should have given unsatisfactory results I am not at all surprised: the flat surface on the point of the bullet must offer a large space for the resistance of the atmosphere, during 1,000 yards of flight. Then to this must be added the effect produced by the rings around the bullet; and when the resistance of the atmosphere and that produced by the friction of the bullet are added together, we need not be surprised that the results of the experiments turned out very unsatisfactory. Surely, if the French school invented the bullet which produced this wonderful revolution in gunnery, they would have rendered it perfect, instead of producing it in a more rude state in 1848 than I had produced it in 1840.

Another point affording strong evidence that the whole was copied from my work of 1842, is this. In my original plan the bottom of the cavity of the bullet was flat, exactly as it now appears in Captain Minié’s annular ringed bullet. In 1843 this was changed into a hemispherical bottom; and this exists in all English expansive bullets, as the adjoining woodcut will show.

In 1852 I produced a new form of cup, intended to obviate the use of the heavier substance, or conical piece of iron. In addition to a cup of a parabolic spindle shape, it had a rim like that on a man’s hat, as the woodcut will show.



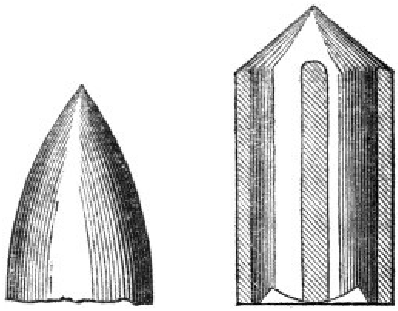
A great advantage is gained by this contrivance in effectually expanding the bullet, and thus closing up stray appendages, which are found to exert considerable influence on the ultimate direction of the bullet. A slight tail of cartridge-paper, a string, or an appendage of any description, exerts such an important influence on the bullet’s flight, as to cause it in some instances to describe a curve, the termination of which is very eccentric, and commences from the very base of its starting. It is evident, then, that great accuracy is necessary in order to produce a perfect expansive bullet. English bullets are pressed into shape by machinery, whilst in France they are formed in the ordinary mould; this, however, is at all times an uncertain mode of making them: a slight cavity in the head of the bullet would make it eccentric in its flight; and this is very difficult to avoid: a slight puncture, or an eruption on the surface, would, during a lengthened flight, be materially acted upon by the atmosphere, so as to influence in a great degree the direction of its flight.

The scientific world is deeply indebted to General Jacob, of the Scinde Horse, for the zeal and energy he has displayed in carrying out his principle of projectiles. He experimented on a scale never before attempted by any private individual; his explosive projectiles have created universal interest, and the great ranges he obtained will hand down the General’s name in the history of gunnery to all future generations.

Whilst ascribing all credit to General Jacob for the benefit he has bestowed on projectile science, it is not less my duty to point out how unfortunate for science, and for the General’s scientific reputation, were the defects which exist in the system of which he is so strenuous an advocate.

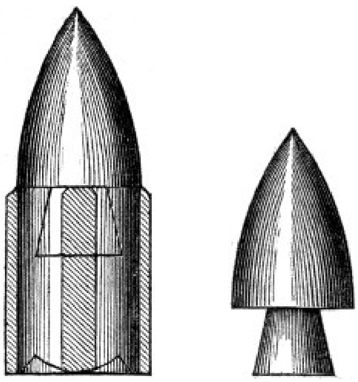
General Jacob’s principle differs from mine as widely as the poles are separated from each other. In mine there exists the least amount of friction, the minimum of spiral motion, and a most extensive range, with the smallest expenditure of expellant force.

In the General’s invention these points are exactly reversed: friction is at the highest point, the degree of spiral in the groove is more than double, and the charge, as a matter of course, is much greater. The range is greater, no doubt; as it ought to be, being obtained at treble cost. Cost, in all cases, is the key to success or failure; not cost in a monetary sense only, but cost of wear and tear. Destruction of the barrel, and the amount of buffeting by recoil, are points of cost; and the principle of General Jacob is so nearly allied to that of the “hexagonal” rifle, that many will think, and perhaps not without good reason, that the one has given rise to the production of the other. The great length of column, 2½ diameters in height, is so extreme, as to be evidence in itself of the very unsound principles on which this rifle is constructed. When bullets composed entirely of lead are used, the result is that the bullet is so driven in upon itself, as to upset the whole structure, “swaging” it whilst in the barrel into a long cylindrical tube of lead, as the wood-cut, exhibiting the bullet before and after firing, will sufficiently explain; whilst the friction and lateral pressure on the tube of the barrel, which must be necessary to effect the change in the bullet, require no further comment.



POINT OF BULLET BEFORE FIRING. WHOLE BULLET AFTER FIRING.

The experience gained by General Jacob induced him subsequently to adopt an iron or zinc-pointed bullet, as is depicted in the wood engraving.



COMPLETE BULLET. METAL POINT.

Thus departing from the true science of the question, instead of giving the centre of gravity to the head of the bullet, he tries to overcome the difficulties by which his system is beset, by increasing the spiral motion. As other writers take a similar view of the question, I insert the following quotation from a small work by Lieutenant Simons, Bengal Artillery, entitled “A Treatise on Fire-arms,” where we have the following appropriate remarks, strongly bearing on the peculiarities of this system:—

“Every point upon the surface of a projectile in motion, whether it be a rocket, javelin, ship, bullet, arrow, or any other description of projectile, is the end of a lever, the fulcrum of which is situated in the projectile's centre of gravity. The effect of the air to upset, *i. e.*, to force the light or pointed end of such projectile to the rear, or to unsteady, or cause to waver, the same, depends upon the lengths of the levers at the ends of which it acts, and upon the angles at which it presses against such levers, as determined by the positions of the points and by the shape of the projectile; it likewise depends upon the specific intensity of the pressure, which is doubtless greatest in the neighbourhood of those parts of the projectile which least easily allow the air to escape past them.

"An illustration in part of the truth of the foregoing proposition will present itself to the conceptions of those who have taken notice of the manner of the flight of rockets, or who have witnessed shells projected from mortars at night time. The light of the burning fuse, particularly during the first part of the flight of the shell, is seldom obscured from the sight of the beholders in the battery from which it is fired. The end of the fuse protruding beyond the general surface of the shell is the end of a lever whose fulcrum is the shell's centre of gravity. The pressure of the air against this lever as the shell moves forward, drives it to the rear, in which place it would remain steady, did the shell in its course describe a straight line; a curve, however, being the line actually described, it follows that the direction from which the resistance created by the shell's own motion comes, is ever varying; whereby the occurrence of an equilibrium is prevented, and the shell is caused to oscillate laterally as it were. If the size of the fuze end of it, however, be at all considerable, the shell will rarely topple over, and, in consequence, the light of the fuze, during the ascending curve, will generally be visible.

"The more rapidly a ball is made to reach its goal, the nearer will the line described by it approach to a straight one, and the less will it roll. It is possible that the old musket-ball did not roll much during the first fifty or hundred yards of its flight, and that the accuracy of shooting with it will have been less on this account. A ball which does not roll, may be said to be 'in position;' there is inherent in it a fixed tendency to deviate from the line in which it is projected. Now a shell which rolls much by reason of its comparatively slow motion, is ever tending to stray in different directions, and, therefore, a movement in the wrong direction, at one moment, being compensated for the next by a corresponding movement in the opposite direction, it may be by this means a recipient of an amount of accidental compensation to which, perhaps, the musket-ball is a stranger.

"Such being the manifest effect of projections upon the surface of a shell, it is not difficult to imagine what must be the unseen effect of projections on the surface of a rifle ball. One projection, placed without regard to effect upon such surface, would make the ball jog and oscillate much after the manner that has been described. Two or more of proper form and construction will, on the contrary, if properly placed upon a projectile, hold it steady, and so impart to it a fixed tendency to digress, thereby preparing it to be usefully operated upon by spiral motion.

"So much as has been said will, I think, suffice to disprove that not unfrequently entertained notion to the effect that the light end of a bullet is kept forward by the operation of the spiral motion imparted to it. I could cite more than one person and pamphlet (General Jacob), apparently under the influence of this belief, but which certainly does not accord with theory, and the practical incorrectness of which was thus manifested to me."

The Whitworth rifle, which was introduced to the world with a clarion flourish from the *Times*, has not made any very rapid progress toward perfection. It still drags out an existence, it is true, but its boasted superiority is all a myth; as time and experience will show.

Like the former, but more meritorious, invention of General Jacob, it is based on an unsound principle, an untenable theory, good only in seeming, which collapses when grasped by the hand of practical experience.

The peculiarity connected with this weapon is the extraordinary circumstances under which it first saw the light:—It was produced by the aid of Plutus, dragging in reputed science to fashion on the instant a weapon superior to the tardy results of three centuries; though during that period numbers of talented individuals had devoted their lives to the study of gunnery.

Wealth is generally believed to be able to remove all obstructions, and even to purchase capacity, if need be; though it can scarcely enable one individual to surpass the experience of ages, however talented that individual may be. The attempt thus to obtain such assistance was a slight by the Government of the day to the improvers of British fire-arms; they were passed over as of no value, and the country's wealth was thrown into the lap of a talented, but at the same time, not a practical man.

The Government of this country had on all previous occasions exacted from inventors their brains and their money, as an offering in exchange for patronage; on this occasion, however, they departed widely from their usual custom, for the "mountain came to the mouse." It would have been a grateful compliment if the Government had said to the inventor, "You have done something for the good of your country with your limited means, here are thousands of pounds at your command; do something better, for we need it." But nothing of the kind was done: a selection was made, justified by no antecedent qualifications. The first thing necessary was the acquirement in a very short time of a practical knowledge of gunnery, in order that a weapon should be produced superior to any other; but whether success has attended these efforts or not is still doubtful, and this is in itself a fit rebuff to the Minister, who expected, like the citizen's wife, that "gold would purchase capacity."

The great defect in the hexagonal-bored rifle is the extreme amount of friction, and the consequent useless expenditure of means.

The bullet is produced in the most accurate manner in a lathe, and is composed of an alloy of lead, tin, and manganese, so as to render it hard enough to resist the tendency to squash or swage; which is the case in General Jacob's principle. The angles on the bullet are cut with the greatest precision, in order to fit the groove of the barrel; constituting, in fact, a female screw of two turns in every thirty-nine inches of length.

As fair play has always been my motto, I am actuated by no other desire than that of enabling the reader to form a true conception of the intricate nature of projectile science; and though the eulogium bestowed on the inventor's own creation is rather egotistical, I give it entire, dissecting it afterwards in the manner I think most conducive to a correct knowledge of the real science of gunnery.

"THE WHITWORTH AND ENFIELD RIFLES.

"For the last few days a very interesting and important series of experiments has been in progress at the Government School of Musketry, Hythe, in order to test the comparative merits of these two rifles. The trial, which was of the most searching and impartial character, was conducted by Colonel Hay, the able head of the school, and has terminated in establishing beyond all doubt the great and decided superiority of Mr. Whitworth's invention. The Enfield rifle, which was considered so much better than any other as to justify the formation of a vast Government establishment for its special manufacture, has been completely beaten. In accuracy of fire, in penetration, and in range, its rival excels it to a degree which hardly leaves room for comparison.

"The following table gives the best results that have been obtained from 10 shots of each arm respectively, in the course of the experiments, which have extended over a week in time, and were brought to a close yesterday in the presence of Lord Panmure and of a number of military and scientific spectators:—

Rifle.	Range in yards.	Elevation.	Figure of Merit.
		Deg.	Feet.
Whitworth	500	1·15	0·37
Enfield		1·32	2·24
Whitworth	800	2·20	1·00
Enfield		2·45	4·11
Whitworth	1,100	3·45	2·41
Enfield		4·12	8·04
Whitworth	1,400	5·00	4·62
Enfield		6·20 to 7.	No hits
Whitworth	1,800	6·40	11·62
Enfield		—	—

It would appear from these figures that at 500 yards in 10 shots the Manchester rifle has a superior accuracy of 1·87 of a foot; at 800 yards 3·11; at 1,100 yards 5·63; and that at 1,400 yards and upwards the Enfield weapon ceases to afford any data for a comparison. In penetration the results obtained have been equally decisive; the Whitworth projectile, with the regulation charge of powder, going through 33 half-inch planks of elm, and being brought up by a solid oak bulk beyond, while the Enfield ball could not get past the 13th plank.

"The shooting on Tuesday was more to satisfy Lord Panmure and the other strangers present upon the comparative merits of the two weapons than to show the limit of what each could do under favourable circumstances. Still, the targets of every 10 shots on either side bore decisive evidence of the superiority of the new rifle, as a glance at the following table will prove:—

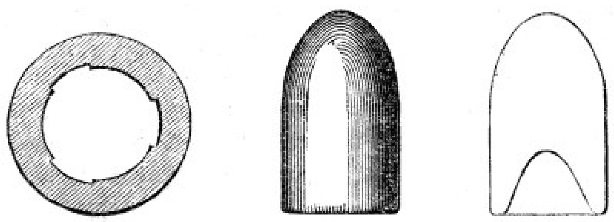
Rifle.	Range in yards.	Elevation.	Figure of Merit.
		Deg.	Feet.
Whitworth	800	2·22	1·41
Enfield		2·45	5·67
Whitworth	500	—	1·27
Enfield			3·30
Whitworth	500	—	1·33
Enfield			4·01

"The last entry in the table records the mean radial distance from a central point of 10 shots fired from a table-rest, by Colonel Hay and Mr. Gunner, the manager of the Enfield factory. Both are first-rate marksmen, yet at 500 yards the Manchester rifle in the hands of the former gives three times as good shooting as the latter can get out of the Government arm. All the other trials were made by firing from a beautifully-constructed machine rest, which placed both weapons on a footing of perfect equality as to the conditions under which they were tested. In addition to the foregoing experiments, there was one for showing that with cylindro-conoidal balls on the expansion principle of those used for the Enfield rifle, very superior shooting could be obtained from Whitworth's hexagonal bore. This was most satisfactorily established, the mean deviation on the target from the centre of the group of 10 hits being only ·85 of a foot at 500 yards' range. It will be observed that at 500 yards' range, at which the practice commenced, the shooting of Whitworth's rifle was so much better than the other that no greater distance was attempted. A reference to the first table of experiments will also demonstrate that the target made by the former weapon at 1,100 yards is nearly as good as that made by the latter at 500. These are great results to have achieved, and amply justify the forethought of the late Lord Hardinge in securing the services of so eminent a mechanic as Mr. Whitworth for the improvement of the rifle.

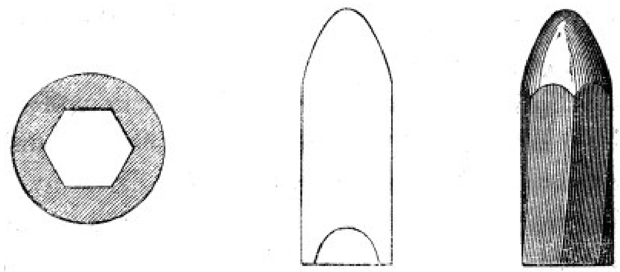
Until he took the subject in hand the proper principles for guidance in the construction of the weapon had not been accurately determined. The manufacture was still conducted by rule of thumb, and in a very hap-hazard way on the most important points. The use of grooves and an expansive projectile made it impossible to secure the requisite amount of pitch in the rifling and the indispensable hardness of metal in the bullet for penetration. Moreover, from the small amount of bearing, the wear and tear both in the barrel and in the projectile were enormous, and the length of the latter could not be increased without causing it to capsize in its flight. By the polygonal bore and rapid pitch to which the form of the bullet accurately conforms, Mr. Whitworth has rendered stripping impossible, and, his rifle when fired acting exactly like a male and female screw, the projectile must rotate with perfect steadiness and precision on its axis. He can increase its length so considerably as to secure space for converting it into a shell if necessary; and, being able to use metal of any degree of hardness, he can adapt its form and strength exactly to the work which it has to perform. Thus with a rifle 39 inches long and half-inch bore, having a turn in 20 inches, or two turns in its length, he finds no difficulty in penetrating a wrought-iron plate 6-10ths of an inch thick or cutting a core out of a piece of solid timber half a foot thick; and some idea may be formed of the extraordinary power of this arm when we mention that his projectiles in their flight rotate at the rate of 15,000 revolutions per minute. The question of driving holes in the 4-inch breast plates of floating batteries is at once solved by the application of these principles to artillery, the construction of which this new rifle proves must be completely revolutionized. A weapon which in expert hands will make good practice at 1,400 yards, and the range of which can be very easily helped by a telescope if necessary, gives the *coup de grace* to our present system of field batteries. At the Alma it would have silenced the Russian guns or driven them from their position, rendering the rush of the Light Division, with the heavy loss of life consequent thereon, unnecessary. Nor during the siege of Sebastopol would the rope mantlets of the Redan and the Malakhoff having given much protection to the men working behind the embrasures," &c., &c., &c.

So much for the praise bestowed by Mr. Whitworth on his own production. A beautiful experiment it has been, and one for which the scientific world is bound to be thankful; giving, as it does, perhaps a faint idea only of what is yet to be effected.

However, all is not gold that glitters: it is very well to do all this by straining every principle that can be brought to bear,—extra charge, bullets hardened and turned with mathematical precision, steel barrels, with a fineness of polish in the interior like that of a looking-glass—these are all great adjuncts in the trial against an ordinary unprepared gun, taken from a number promiscuously, and which perhaps might be the worst specimen in the possession of the party at Hythe. But these are trifles when compared with the two following facts. The diameter of the bore of Mr. Whitworth's is 500, or half-inch at the largest diameter, and 450 at the smallest, or a mean, taking the two extremes, of fifty bore; the Enfield is 577, or twenty-five bore, and the bullets on leaving the guns were the same weight exactly. The length of the Enfield bullet is ⅞ inch, that of the Whitworth is 1⅜ inch. But all this will be more fully seen from the woodcuts.



ENFIELD BARREL AND PRITCHETT BULLETS.



WHITWORTH BARREL AND BULLETS.

Thus it will be seen that the amount of resistance or displacement of atmospheric air by one bullet is nearly double that of the other, and this is a most important point in Mr. Whitworth's favour; but the quantity of gunpowder used in the one is precisely the same as that used in the other, though Mr. Whitworth's rifle is little more than half the size of bore, the pressure on the square inch being consequently nearly double; hence the circumstances are not sufficiently equal for Mr. Whitworth to claim for his rifle any great superiority: the gun may take the attention of the unwary, but its principles will not bear investigation.

Let me change the circumstances of the case, by retaining the principle of the Enfield, but changing the bore to the same as Mr. Whitworth's, increasing at the same time the length of projectile, and I will engage to beat it with a much reduced charge. The extreme degree of female screw or spiral, one turn in twenty inches, or two turns in the whole length of the barrel, creates, as must be familiar to the most obtuse mind, an enormous amount of friction, and in consequence of this an equal quantity of force is absorbed: in other words, there is a useless waste of force.

The Enfield barrel has but a proportion of turn, one in six feet six inches, or exactly half a spiral in the three feet three, generating 300 per cent. less friction than in the Whitworth rifle; so that on this score alone the saving would be very great, and in this trial the Whitworth would be inferior to the Enfield; the inventor, therefore, has unjustly laid claim to superiority, as the trial has been conducted on very unequal terms.

Mr. Whitworth says his bullet rotates at the rate of 15,000 revolutions in a minute; now the friction on the periphery of a bullet having this extreme spinning on an axis, must very much lessen its range. If we weigh force, and carefully calculate its expenditure in 2,000 yards, the periphery has made 4,000 revolutions. Now look at the shape of the hexagonal body depicted in the woodcut at page 377, and estimate the friction it will undergo. The Enfield in the same distance would rotate only 1,000 times, thus affording another gain of 300 per cent. The question, therefore, which arises is this: If all this can be done equally well with the Enfield, why not do it? And the answer is, because there is nothing to be gained by it. Great doubts now exist whether the bore 25 is not too great a reduction: in fact, you will find no military advocates for it. The faculty will tell you that small wounds are not so destructive as large ones: the human body is as much affected by the shock as by the penetration of a bullet. Many other reasons might be advanced in favour of increased size of bullet, and much more important reasons must be given, before the whole military system has to be re-changed, than a mere gain of 300 or 400 yards; whilst there can be little doubt that the ranges we now possess in the Enfield are more than equivalent to our wants. The human eye cannot define precisely at 900 or 1,000 yards, and yet greater accuracy is required to fire a ball at a distance of 2,000 yards; again, it is a question which has frequently arisen in my mind, in how many situations in England or on the Continent can we get a clear view of 2,000 yards. The effort, indeed, to increase range appears like seeking after a remedy for a disease which has never yet been discovered.

If ranges of 2,000 yards and upwards are required, rifled cannon will again take their proper place; for on investigating the tables of practice published by General Jacob, I find the average distance of shot from the centre of butt to be, at 2,000 yards, nearly 9 feet, with 13·7 degrees elevation; whilst the Whitworth is said to be 11½ feet, with about 8 degrees of elevation. I saw, some time ago, some practice at Shoeburyness with an 18-pounder rifle cannon, which gave a range of 3,650 yards, with an elevation of 0·10¾ degrees, and a breeze blowing across, a mean deflection of only 30 inches from the centre. This throws Jacob, Whitworth, and the Enfield all into the shade together; yet there can be no doubt that this can be excelled, when heavier guns are brought to the same state of perfection as this 18-pounder. The case therefore stands thus: the Jacob rifle has a greater range than the Enfield, at a cost of 100 per cent. more friction, and an expenditure of 50 per cent. more of projectile force; the Whitworth has also a greater range, but at a cost of 300 per cent. more friction, and 100 per cent. additional projectile force. With these observations I leave this subject in the hands of the public, being convinced that projectile power obtained at such a cost will never come into general use; though the production of the Whitworth rifle will always be looked upon as an experiment of very great interest.

There is but one other point relating to the use of guns on such a principle, and that is their safety; which is always of the greatest importance. It is a well-known fact that the first movement of projectiles depends very much on the amount of inertia in that projectile; and different forms of projectiles, though of the same weight, will offer very different amounts of resistance to motion. No one can doubt that two columns of lead, each of an ounce in weight, one being as high again as the other, will offer different amounts of resistance; first, from the law that the time occupied in overcoming inertia is in proportion to the length of that body; secondly, if these columns of metals are confined in tubes, then the friction on the one which is half an inch long will be much less than on the other, which is one inch in length: and this is, on the mildest terms, the relative position of the two. There can be no doubt that a much greater pressure is required to start the longer column of double the length; but when we consider that there are the facets of six angles, with a spiral inclination of one in nineteen, the difficulty of starting this bullet becomes still more apparent. Now suppose the gun has been loaded a few hours, and a certain amount of adhesion has been effected between the bullet and sides of the barrel, by the unctuous deposit from previous discharges, then the difficulty of starting the bullet instantaneously will be still more increased: supposing the breech end of a barrel, with the ordinary charge of the Enfield cartridge and bullet, has a force exerted upon it of 2,000 pounds in the square inch, then in the hexagonal not much less than double that strength will be requisite to meet the contingencies of dirty guns: in fact I know that a serious accident did occur very recently with a double rifle constructed on Whitworth’s principle, notwithstanding all the care bestowed upon it by a first-rate maker; and I believe that this gun, if it is to be used with safety, must have a barrel double the strength of other rifles.

The doubtful nature of Mr. Whitworth’s experiments must be apparent from the fact that they were made in a shed, from which strong currents of air were excluded: any bullet would range accurately in vacuo, or in atmosphere equally quiescent; deductions, therefore, drawn from such experiments must be worthless. Battles occur not under such favourable circumstances; protuberances on bullets tell most in high currents, and least in a quiet atmosphere; so that had the experiments been instituted in the open air, they would doubtless have yielded a different result. The hexagonal bullet of large size has been proved to be very eccentric indeed in its flight; hence a bullet of the smallest dimensions was used, for had it been larger, its great enemy, the atmosphere, would have rendered the chance of even partial success perfectly hopeless.

Now, observe what would be the effect of extension of length and decrease of diameter in the Greenerean expansive bullet. Harden it by alloys, as adopted in the Whitworth; use the same charge, and the probability is great, that, from the absence of extreme friction, it will excel in range, accuracy, and penetration the Whitworth, as much as that does now the Enfield.

If the Government can see any important advantage to be gained by extending the range we now possess; if anything is to be gained by reduction from 25 to 50 bore; if, indeed, there is any point which is advantageous in the Whitworth, I will pledge my reputation that this may be obtained in the expansive principle: and that, too, with a much less expenditure of expellant force.

The "hoodwinking" of the public by not disclosing the fact that the pressure of the gunpowder in the Whitworth was double, the bore being but one-half, is at best an attempt at concealment not creditable to the parties concerned. Knowledge of the principles which regulate projectile science is not so scanty as to allow the palm to be carried away from the profession, and worn by a gentleman who, on his own admission, is unpractised in the science of gunnery. The science to be effectually improved must be carried on at the cost of the nation, as Mr. Whitworth's experiments were. This fact certainly bears the appearance of a good precedent, and I hope it may be extended.

Mr. Whitworth, like General Jacob, has had to sacrifice scientific economy in order to obtain the points he required. I have already dilated upon the truism that all projectiles range with the greatest economy which have the centre of gravity in the head or fore part of the bullet. I have also pointed out the fact that the elongated projectiles which have not the centre of gravity in the head, turn over during their flight after leaving the muzzle of the gun; and this is also found to be the case in rifles having a greater degree of spiral than the Enfield, one turn in six feet 6 inches. To meet this difficulty, therefore, General Jacob adopts one turn of spiral in every three feet: thus his bullet in passing out has double the friction of the Enfield; and when we look at the fact that he is further compelled to increase the length of his bullet to 2½ diameters, a little reflection will point out the entire want of economy in his whole arrangement.

On turning to the Whitworth, we find that, in order to ensure his bullet keeping point foremost in its flight, he has to double the very great spiral adopted by Jacob: thus we have all its concomitant disadvantages, friction, expenditure of matter, and danger of bursting the gun. When we contemplate such arrangements as exist in these two guns, it must be evident that they are both self-destructive. No system of projectiles can be durable which is effected by straining all the acknowledged principles of mechanics; and this has been done in each of these cases.

The scientific world knows well that a much higher rate of speed can be attained in railway travelling than is daily practised; but they also know that it can only be obtained in the same way as Jacob and Whitworth obtained their range in gunnery: namely, by an excessive expenditure of fuel, and a wear of engine amounting to comparative destruction; whilst, at the same time, the danger is so much increased that it would be folly and recklessness to persist in such a course. The question, therefore, resolves itself into this; that in locomotion and in projectile science, if we would have them perfect, we must study the mode of obtaining the greatest results with the least expenditure of means.

Facility of loading must at all times be of great importance: the soldier cannot have the means of cleaning his rifle when in action, and yet if the hexagonal principle were to be adopted, it must be repeatedly cleaned, or it would be almost impossible to load it, and when discharged it would either burst or its fire would not be effective. During such a war as that in India, going on day and night, a soldier could not be expected to wash out his rifle after every half-dozen shots.

The field in which experiments are carried on is very different from that of a battle. Experiments, as detailed, sometimes turn out most fallacious when put to the use for which they are intended; and in no case is this more apparent than in breech-loading arms: thousands of rounds may be fired in a few days with great success; but extend that over twelve months, a certain number being fired every day, and the gun being cleaned after each day's practice, and long before thousands are fired, the gun displays weak points—points which could not be discovered in the lesser experiment. So it is in practice: a gun left dirty for hours is undergoing rapid destruction; the unctuous deposit from gunpowder has such an affinity for iron that minute galvanic cells are formed on its surface in a very short time: half an hour after a gun has been discharged in a damp atmosphere these operations may be seen to be going on with rapidity, and an old gun on the hexagonal principle (if one should last long enough to grow old) would not be a very desirable weapon, in point of safety.

The comparative cost of ammunition for the hexagonal rifle and the Enfield, is a point of no little importance. Calculation gives the former at something equivalent to 4½*d.* or 5*d.* at each discharge, while the latter cannot exceed 1¼*d.*, or at most 1½*d.*—a serious question for the Chancellor of the Exchequer.

That this sum may be lessened by the employment of machinery is not unlikely; but this can only be done to a limited extent, it being essential that mathematical nicety, as well as the right degree of hardness, should be strictly observed, otherwise the power of penetration will be sacrificed: and of this property a great deal has been made. There are few who do not know that a pound hammer will soon drive to the head a fine-pointed slender nail; whilst a short, thick, stumpy nail requires three times the force: again, if fine steel polished nails were constructed, a still smaller amount of force would suffice. If such effects are carefully studied, much may be done with very little means.

Very recently a statement appeared in the press that, owing to some ill-made cartridges being served out to the troops in India, the men found it almost impossible to load their Enfield rifles at all; having to call in the aid of trees and stones against which to butt the ramrod, in order to force the bullet home. The same account attributed this defect to the careless construction of these cartridges by the contractors. This, however, is unjust; all cartridges for the Enfield rifles being alone produced in the laboratory at Woolwich; and hence the defect is the more unpardonable. It is easy to conceive that in India, where the heat is intense, the grease on the cartridge might have disappeared; the unctuous deposit of gunpowder on the interior of the barrel is also rendered more adhesive, and necessarily offers greater obstruction to the ramming down of the bullet. The very slight difference between the diameter of the bullet and that of the bore, or windage, must necessarily add to the difficulty under such circumstances; but if half a size, or a few decimals of diameter, were taken from the sides of the bullet and added to its length, the difficulty would be effectually removed: with increased length, and increasing means of expansion, if necessary, such an occurrence could never take place.

The original expanding bullet was intended to fill up the difference of three sizes of gauge; surely, then, there can be no difficulty in expanding a much less diameter of bullet one half, or even full one size of gauge. Where would be the difficulty in having the bullet 26-bore, or even smaller, and expanding it to 25. The occurrence, indeed, of such a fact as that alluded to is to an intelligent mind quite incomprehensible; it could only arise from gross incompetency—some cobbling with the bullet’s cup in the pressing, or perhaps enlargement by wear, or more likely still from the pulp-made cartridge paper. That this difficulty has been experienced is obvious; and the inference is strong, that the official managers of these affairs are still in the midst of a long experiment: it is clear that they are not perfectly masters of the practice of gunnery, and it is almost time the people of this country had their work better done. It is more than probable that, instead of meeting this difficulty with the proper spirit of improvement, they will fly off at some other tangent, and adopt the nostrum of some “arrant quack;” thus effectually adding to the complication.

Each regiment ought to have moulds, and the means of making their cartridges on such emergencies; a body of provident officials ought to attend to this, that a repetition of it may be avoided.

An ordinary mind would have perceived that, in such lengthened operations as those our soldiers have been engaged in, the cleaning of their arms would be almost impossible; still the men are not instructed that in such a difficulty an oiled rag passed up and down the barrel would diminish it; neither is such a simple remedy provided: let us trust, however, that this misfortune will lead to improvement. If this difficulty is encountered in the Enfield, which is, comparatively speaking, a smooth bore, what would be the difficulty in the hexagonal bore with two turns in 39 inches! The possibility of loading the latter would be very remote indeed, if not quite impracticable, and a total bar to anything like its general adoption.

Pure lead is indispensable for all rifle bullets, but more especially for the expansive, which is in reality useless without it. A lubricating grease, of a given consistency for various climates, is also a desideratum yet to be accomplished; how desirable it would be, is shown by all the accounts of good shooting I have ever received or met with.

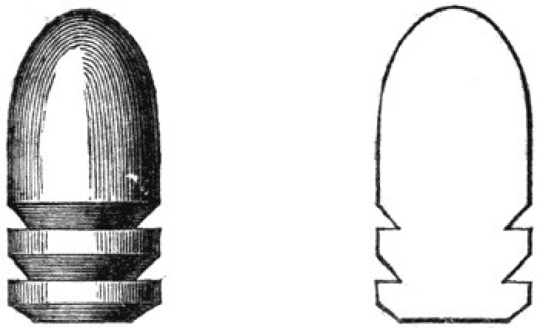
A vast number of projectiles have been produced, and strenuously advocated; but from the total want of scientific arrangement in their construction they have had but a very short existence. The vital principle in all elongated projectiles is to have the centre of gravity in the fore end; wanting that, an unnecessary spinning motion must be resorted to, at the cost of immense friction: for the tendency to change position can only be obviated by excessive spiral motion; whilst in a bullet having the centre of gravity in the head, much less spiral motion suffices: its scientific construction admits of no tendency to change; straight forward is its natural inclination, and to this inclination it adheres.

A late writer on projectiles has laboured hard to condemn the expansive principle and the cup; he has even aspired to lecture on it before Royalty, and as an improvement upon it, he recommends the following invention of his own:—

“In my endeavours to remedy the evils which have been so often and justly complained of, I attempted the construction of several bullets, particularly with the view of solving the question—can a cylindro-conoidal bullet be contrived, which will have a flat surface for its base, and the centre of gravity in the fore part? In my attempts from time to time I met with less or more success until I arrived at my last improvement, the principle of which has afforded me so much satisfaction, that I fancy I have only to describe it, to enable any intelligent marksman to perceive at once the utility of the contrivance.

“In the end of the bullet, which is a fair cylinder for half its length, I formed a cavity of a conical form, similar to the inside of a small thimble, which stretches forward somewhat more than half the length of the bullet, and which is wide enough to reduce sufficiently the weight of the hinder end, so as to throw the centre of gravity into the fore part, even after the explosion of the charge takes place. On the edge of the cavity I made an indentation, or shoulder, about a twelfth of an inch in depth, and upon this I placed an iron disc of the same thickness, which closes up the cavity even with the end of the bullet, making a flat surface of that part; so that it may be called a hollow flat-ended bullet, though to all appearance solid.”

The adoption of the disc, and the closing of the orifice at the bottom of the bullet, is merely the production of an elongated plug with weak sides, which must necessarily be driven in upon themselves, and thus shortened; and in so doing they expand. The disc prevents the possibility of the explosive gases acting upon the centre of gravity or the head, and thus the advantage of that being the primary motion is lost; and which ensures the absence of “wobbling,” a principle inherent in all plug bullets after leaving the muzzle: and a defect which it was the main object of my invention to avoid. The idea is evidently that of Captain Norton, as evinced in his rifle shell, and consequently is a plagiarism, either deliberate or accidental.



SWISS BULLET.

The Swiss bullet has obtained to some extent a reputation, admitting, like the Lancaster elliptical bullet, of being put into higher velocity. Its range, however, is limited, from the very great friction it undergoes in passing up the barrel: it is driven in upon itself until it becomes a mere plug of lead with a hemispherical head; and the centre of gravity being behind, ensures its flight frequently terminating by turning “topsy turvy.” Moreover, it cannot be used on a large scale, except by the addition of a hard metal point, as in General Jacob’s bullet.

The wisdom displayed in rifling barrels with the gathering or deepening groove may be doubted; it admits of serious consideration, whether or not it tends to increase the friction of the bullet passing outward. It is evident that did the bullet expand all at once it would do so; but as this is well known not to be the case, the question arises what is the advantage gained? for it is asserted on high authority that it improves the shooting. The mere deepening of the grooves at the breech end can have but little effect; and the question is, does the shallowing of the grooves as the bullet approaches the muzzle, produce the effect? We think it does. In the process of rifling these barrels, the rifling tool, by a very ingenious arrangement of screws, is caused gradually to cut deeper as it travels from the muzzle to the breech, so that when finished the depth of grooves at the muzzle is ·005 of an inch; half-way down the barrel it is ·010, and at the breech end ·015: thus gradually deepening $\frac{10}{1000}$ of an inch, whereas the usual method of rifling is to have one uniform depth of ·010 inches. From the contraction of the protuberances on the bullet from $\frac{1}{10}$ to $\frac{1}{5000}$ of an inch in passing up the barrel, results the apparent benefit: such a reduction would surely allow of the bullet continuing its flight with less friction on the atmosphere; for it cannot be too often repeated that perfect smoothness, even to a polished surface, is essential to the easy passage of all bullets through the air.

There are some rather curious deductions obtained by practice alone, which to ordinary minds appear of trifling importance; but they clearly show that correct rifle-shooting can only be obtained by the most perfect arrangement in the rifling and scientific construction of the barrels.

The Government have lately adopted a highly finished and costly rifle arm, with sword bayonet attached to the usual form of bar soldered to the end of the barrels on the right side. When these barrels were first constructed, they were made lighter than experience subsequently showed they ought to be; for it was found that the barrel not expanding equally with the other portions at this necessarily rigid point, influenced the shooting of the gun to a considerable extent; so that an increase of metal was found necessary.

The difficulty of obtaining good shooting with double rifles, one side of each barrel being held rigid whilst the other is yielding, explains the difficulty, and points to the remedy: an increase of metal, or, what would be more convenient, the adoption of the most perfect laminated steel for all double rifles; it being self-evident that soft barrels and correct rifle-shooting are to a certain extent incompatible.

Double rifles have nearly superseded single ones; for few who can afford the additional price will use the latter, when in the same weight he can have two useful weapons. The one great end generally sought in a rifle is sufficient weight to neutralise the force of the explosion or recoil; and the additional barrel answers this as effectually as additional thickness of iron in the single. But there is one objection which I have never been able to master in the construction of double rifle barrels, and I much doubt the possibility of effectually overcoming it—another proof that mathematical demonstrations are frequently wrong in practice, however correct in theory. Many hold it to be essential that double rifle barrels should be put together perfectly parallel. I followed this rule, and was at considerable cost in perfecting tools for the purpose; yet, strange to say, in trial I found invariably that the right barrel threw the ball slightly to the right, and the left to the left. This I have been at enormous trouble to ascertain, and am enabled positively to declare it is an indisputable fact. The cause of it is evidently the recoil not striking the stock in the centre, but on one side; which causes the gun to swerve to that side. However small or unapparent the recoil may be, still there is a recoil; and hence its effect. To remedy this it is necessary to incline the barrels in, towards the muzzle, to counteract that tendency; but in doing this another evil is created, for you can only do this to suit a given distance, either 100, 150, or 200 yards, as may be determined. Thus it will be perceived a deficiency must exist at all times;

and it shows clearly the necessity for motion being resisted centrically, if truth is to be maintained. This defect in the double rifle will always be a drawback to the “*most correct* shooting;” yet under ordinary circumstances it may not be a matter of vital importance, neither does there exist any means of sighting to overcome the difficulty. The only way to obtain a double rifle perfectly true—perfectly parallel, is to construct the barrels one above the other, as double pistols are now constructed. The only objection to them is the difficulty attending the arrangement of the locks, as one cock must strike the nipple the thickness of the barrel below the other, and is an unsightly matter at best. These facts lead to another, namely, the necessity of all rifles being stocked as straight as possible, avoiding in all cases any casting off in the butt; as it is evident that these matters have considerable influence on the correctness of shooting.

One great drawback to correct shooting is produced from the stock being thrown off at the butt end; and, in other cases, from imperfections in the stocking of the gun—all truth depending on the barrel or barrels being both stocked and held perfectly level in the act of using. It must be quite clear, that in case the right barrel of a pair be depressed but the 32nd part of an inch, the angle of the sight on the top, instead of giving elevation, will cause the line of flight of ball to be to the left, and “*vice versâ*.” Therefore, first of all be sure the gun is held square; and great advantage will be found in pointing the muzzle in all cases a few feet below the object, and raising it in a perfect line upwards to the bull’s eye. If this can be done well, in addition to the gun being held square, the better half of the difficulty is overcome; further practice will make perfect.

The point next in importance, is to take off the weight of the pull in the trigger, during the upward motion; overcoming the last atom of weight as the muzzle sight covers the bull’s eye. It must be done so gradually, that no jerk or pull can move the gun, be it ever so triflingly: in fact, all good shots fire thus while the gun is in motion. If the sight cannot be correctly obtained during the movement, always take the rifle down from the shoulder, and raise it again; for depend upon it, rifle shooting can never be acquired perfectly, where the habit is practised of holding the gun at the shoulder, “poking” the muzzle about and seeking the bull’s eye. All good shooting is produced from the shoulder; an absence of pulsation in the body which is induced by holding a weight. The shoulder rests are found to be the cause of vibration; resting one part of the body and straining another begets it instantly, and where rests are used they should be merely supports for the muzzle, and not for the centre of the gun. If the centre is placed upon it, the action of recoil is almost sure to jump the gun upwards. The best shooting can be accomplished from the shoulder, if the above instructions be carefully followed. Avoid in all cases gripping a rifle tightly, or you will most assuredly communicate the pulsation of the body to the rifle.

During the Crimean war many of the Enfield rifles expanded so much with the Pritchett plug bullet as not only to loosen all the bands on the stock, but also to produce a visible effect on the barrel; and to remedy this the Government adopted my expanding screw bands, which admit of being tightened by the screw when necessary.

The production of a perfect breech-loading small arm is as difficult as the production of a perfect breech-loading cannon, and that is so problematical as to amount, in my humble opinion, to nearly an impossibility. All experience teaches that a perfectly sound base of projection in the gun is indispensable, if good direction and velocity are required; without which there can be no good shooting. If this be a law, how can it be obtained where soundness is absent? Joints, slides, and their attendants, are all incompatible with soundness: the two cannot exist together; and hence no breech-loader can give the same results as a solid constructed gun barrel, unsoundness and absorption of power being always found to go hand in hand together.

I have had considerable experience in breech-loading guns, having obtained one or two patents; and very careful attention to the subject has satisfied me that the question was sufficiently ventilated soon after the adoption of gunnery, and that it was exhausted by many hundreds of inventors as ingenious as those of the present day; the result being in all cases a total failure.

One of the best breech-loading carbines of the present day is undoubtedly that of Mr. F. W. Prince, and those to whom they are unobjectionable will certainly find in this the simplest and a most effective weapon of the kind: Mr. Prince has certainly made the most of the practical knowledge he has brought to bear upon the invention.

Revolving rifles are, like revolving pistols, complicated weapons, useful only for certain purposes; requiring, as they do, very great care and cleanliness, to insure at best their limited services. Long barrels are useless, because all the velocity that can be given to the projectile has to be generated in the revolving chambers; all the superfluous force escaping at the joint of breeches and barrels. For any useful purpose, a nine-inch would be better than a longer barrel, allowing the bullet to leave the muzzle at a much higher velocity than it would do after passing through a barrel of thirty inches. It is evident, indeed, that a revolving pistol and a revolving rifle are possessed of power in inverse ratio to their lengths.

The French Government are making great efforts to improve their military system, in imparting to every soldier as much information relative to his weapons and the best method of using them, as is compatible with his limited education. Their institution of a normal-school for the instruction of the whole army in all that relates to guns, shooting, and natural “trigonometry,” is proof of this. A detachment from every infantry regiment in the service arrives at “Vincennes” early in the spring, and the men undergo a complete course of instruction during the whole of the summer and autumn months, or until by ability they acquire all that is to be taught. The first and a very essential part of the duty is to teach them to judge of distance; for this purpose a soldier takes a target, and runs straight ahead as far as he pleases. Having planted it, each man is called upon to judge the distance, which is recorded in a report of the day. This exercise is carried on to a great extent, until each becomes well able to judge correctly; then commences the instruction in shooting, each soldier using an elevation according to the distance he calculates he is from the target; and this is practised at all distances, from 500 to 1,000 paces. The greatest degree of perfection attained by the instructed is rewarded, by promotion or otherwise; and such skill in shooting is displayed by these various detachments as would truly astonish our military officers.

The accomplishment of a school of instruction for teachers of rifle shooting to the British army is now an established fact; the results, most flattering to the projectors, more than verifying their anticipations. The degree of perfection attained by some before leaving Hythe is so extraordinary, that I will leave the reality to be imagined or witnessed; and it will well repay the journey. The standing order lately issued, awarding substantial benefits to the adept in shooting, is sure to bear its fruits, and is only the first step to many others of no less importance.

Double rifled carbines can be constructed of so light a weight that their exclusive use for cavalry purposes is not far distant, 5½ pounds being sufficient weight to ensure perfect safety. A carbine of this description, from 18 to 20 inches in the barrel, could give a practical range of from 600 to 700 yards, with an extreme range of 1,000 to 1,100. A cavalry soldier armed with two of these would be equal to four of the present day, for they would be no greater encumbrance than the late carbine used by the Guards, which approaches 10 lbs. in weight; and a pair of double carbines could easily be carried at the saddle bow, their length being no obstacle.

Revolvers have not yet been, and I fear they never can be, made sufficiently durable to become a useful cavalry appendage. The fact may be concealed, but it is true, nevertheless, that their fragile nature, independently of their great cost, will always confine their use to an exclusive few: indeed, revolving and breech-loading weapons are among the doubtful class of arms, not fully developed as yet, even if they ever can be.

The adoption of double carbines will eventually throw all other small arms for cavalry purposes into the back ground; a range of 1,000 yards with a toy 5½ lbs. in weight is one of the greatest wonders of this wonderful age, showing the astonishing change which has been effected in gunnery: for a deadly power now exists in the most Lilliputian toy as well as in the Brobdignagian monster; and that, too, at immense distances. In proof of this, I will just quote a letter from that gallant officer, Lieutenant William A. Kerr, Southern Mahratta Irregular Horse.

"*Camp, Bejapore, May 29th, 1858.*

"Sir,

"I have received the Enfield carbine, and am much pleased with it in every respect. It cannot, I consider, be improved on, and is by far the best weapon for the mounted service I have ever handled. It is but due to you that I should mention, that your work, as put into the carbine, is far beyond what I expected at the money. I hope to be in a position, at no very distant date, to give you a heavy commission, and will certainly recommend you in every way I can. I have knocked over a deer at 400 yards with the carbine, and make very good practice up to 800 yards, by firing with two drachms of fine rifle powder. I have given it, and Prince's breech-loader, a fair trial; the latter cannot be compared to the former; it has not the same range, power of projection, or of shooting; it moreover fouls in the proportion of at least 3 to 1 more. Had I had such carbines at Kolapore, I would have destroyed the 27th Native Infantry in an hour.

"I am, sir, yours, &c.,
"William A. Kerr."

The weight of this single carbine is only 5¼ lbs., and it is 20 inches in the barrel. The great power of shooting would justify a reduction of length to 15 inches, thus reducing the weight to a little over 4¼ lbs.; and yet this carbine would be more certain in its effects at 600 yards, than old Brown Bess at 150. The complaint that carbines are found to be an encumbrance in the service is no longer valid: they may be made to form merely a portion of the saddle with the same facility of handling as a pistol, and with a hundredfold greater accuracy of range.

Mr. Greener's Model Carbine, 22 inches long in the barrel, .577 bore, 5¼ lbs. weight.

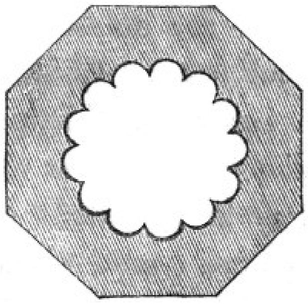
The hybrid affair, adopted by the Government, of a pistol made to serve as a carbine by the introduction of a loose butt, is of doubtful utility: if valuable as a carbine, it will never be used as a pistol; hence it had been much better to make it a carbine at once, thus rendering it at the same time more durable and less costly: even a double carbine might be constructed at about twice the price paid for the socket joint alone. But there is still a want in the Government establishment of "designers" of ability; all that has been effected by way of improvement has been done by feeling the way: a kind of progressional experiment, with a total absence of mind to grasp good ideas, and to hold them fast. The arms used by the corps of Guides who have distinguished themselves so much in India are now seven years old, and they will bear comparison with the best arms our Government are only just now producing: in fact, the irregular cavalry in India have always been armed with weapons in advance of those of the Government troops; and the explanation of this is very suggestive, they provide arms for themselves, and are more alive than the Government officials to the importance of having good ones.

The adoption of greased cartridges in India by some irregular corps, took place in carbines supplied by me eight or nine years ago; and the origin of the idea was this:—

The principal objection urged against the adoption of the rifle, is that of loading. I know not how quickly it is possible to load a musket; but with cartridges properly made, I think I could load and fire a rifle four times in a minute. But then it will be said, at the conclusion of so many shots, the rifle gets so foul, that it will be difficult to get the ball down. Not difficult at all. Have your cartridges made with a saturated cover, to surround the ball, and fit properly the grooves of the rifle.

It would clean the barrel so much, as to allow forty shots to be fired with as much ease as you now fire twenty. Or let a steel-wire brush be attached to the rifle; and by screwing it to the end of the rod, you can, by two or three times rubbing up and down, remove any accumulation of dirt from the powder. If, however, the covering I have mentioned were used with a weighty rod to the rifle, there would be no occasion for cleaning, short of fifty shots.

Experience leaves no room for doubt that a few grooves are better than many, in all expansive-principled rifles: the nearer the approach to a smooth surface the better, and the three divisions of grooves and projections adopted by the British Government is the best to meet all requirements. They will shoot as well as poly-grooved rifles; and if three grooves give the same result, more are unnecessary and useless. The advantage of the atmosphere acting to keep the bullet steady by its current down the grooving on the bullet seems to meet with no confirmation; improved shooting accruing by the grooves being reduced, as in the case of the gathering-grooved rifle experiments. In all cases of wild animal shooting at short distances with small charges, the many grooves will be an advantage: the same as those formerly adopted, and which are shown in the cut.



Expansive bullets may be effectually used; but in varying charges, incidental to game shooting, the same form of cavity in the bullet as is observed in the Enfield would not act, therefore a large cavity would be preferable to enable the less charge to act in expanding the lead into the grooving.

For other purposes than war, rifles will continue to be constructed on the poly-groove principle, and with spherical bullets. The perfect destruction of various animals is dependent generally on two causes: the penetration into the body, and the shock to the system during that act of penetration. No doubt exists that a spherical bullet would combine these two qualities best. The 25 bore, the 32 and 50 hexagonal bore would be, practically speaking, useless for the killing of elephants, tigers, &c. The effectual and instant killing of seals on ice is an illustration: failing to kill a seal dead, he will to a certainty reach his hole in the ice, and disappear, to the shooter’s serious disappointment. Small bore elongated bullets were very rapidly adopted, and as rapidly abandoned. “They did not kill dead;” the spherical bullet did this better. It would be wise to pause and consider whether a good military rifle is a good game-shooting rifle or not: whether the hole in the beast be wide enough. I am inclined to think the reduction to a bore of 25 too small for this purpose. In military muskets of smooth bore, the elongated bullet is not applicable: very little benefit is gained in using them in a smooth bore; and, although the original invention contemplated this, experience decided otherwise. The spherical bullet being thus indispensable, it follows that one size should be adopted which combines the greatest number of favourable points. Many years ago I made numberless experiments to ascertain this fact, and had it demonstrated beyond all doubt to be a bore of 18 and a bullet of 19; the difference in size admitting of the paper of the cartridge with a moderate degree of tightness. The ultimate range of such a musket with three drachms of gunpowder, would be equal to the range of the Enfield; but, of course, without one-tenth its accuracy. Yet for close quarters, line-firing, or quickness of loading, the musket will hold its place for centuries to come; and that this opinion is entertained by many officers, is proved by the fact that our Government is at this moment issuing contracts for 100,000 plain-bored muskets: 17 bore, 3 feet 3 inches long in the barrel. The near approximation of bore to my standard is suggestive of the influence my writings have had after many years, as the following extract from my book of 1842 shows:—

“Military rifles should never be shorter than three feet—say three feet three inches, with half-turn of spiral—the length of the musket. They should not be larger in the bore than a ball eighteen to the pound, as at that length a force, calculated to throw an extreme distance, might be generated. Whatever may be the arguments for heavy substances, they do not avail here, as it is impossible to throw them either with velocity or accuracy; for there never can be certainty, where so much elevation is required. The size of ball we have mentioned, can be thrown with great certainty, as far, if not farther, than any soldier in her Majesty's service can accurately survey a single object. For the purpose of annoying a dense body of men, such as a square column, such a rifle would be an invaluable gun; as the muskets now made will not throw a ball one-half the distance. As to the actual range of a rifle of this bore and length, I should think it would reach, effectively, the distance of 1,500 yards."

The experimental or competitive trials by the Royal Engineers at Chatham to prove the superiority of the elliptical bored rifle over the Enfield, is another of those occasional clap-traps with which the public are amused. The ordinary reader would judge and set it down for an established fact that the elliptical rifle was, as has generally been represented, an invention purely Lancasterian, gun and bullet; while the real facts are quite contrary: true, the barrel is rifled, slightly elliptical, and having "an increasing spiral;" but the ammunition is that of the Enfield—the "'Greenerian' expansive bullet with the centre of gravity in the head." The bullet that Lancaster adopted, as well known, had a leaden plug. I quote from the report of the select committee:—

"The plug bullet used by Mr. Lancaster does not appear suitable for military service, for when the plug is driven into the bullet by the ignition of the powder, it generally nips the paper of the cartridge between itself and the base of the bullet, and carries a portion of it away, as may be seen by the specimens sent to the committee; upon the amount of paper so carried away by the ball depends the accuracy or inaccuracy of its flight; and the plugs do not in all cases remain firmly attached to the bullet."

What then are these trials conducted to prove? It cannot be the superiority of Lancaster's bullet; for he has abandoned that, "*and uses the Enfield*." Is it the rifling?—if so, let us see what the same committee say of that:—

"The chief peculiarity of this rifle consists in the inner surface of the barrel being smooth, instead of cut into grooves, as in most rifled barrels. As a substitute for grooves, the interior of the barrel is cut into the form of an ellipse, whose major axis exceeds the minor by ·005 of an inch. The ball is rifled by being forced (when expanded by the explosion of the gunpowder) into the major axis of the ellipse, which thus fulfils the office of grooves in conducting the ball into the required degree of spiral motion.

"As Mr. Lancaster has adopted the American plan of a 'gaining-twist,' or 'increasing spiral,' and applied it to his smooth-bored barrels with *elongated* projectiles, it may be as well to consider the merits of this system.

"The advantages are supposed to be:

> "1st. Increased accuracy.
>
> "2nd. Less recoil.
>
> "3rd. An absence of the tendency a ball has, when starting with a rapid spiral, to twist the rifle over sideways to the right or left, according to the inclination of the grooves.
>
> "4th. A diminution of the tendency a ball has to 'strip' when first started.

"1st. The alleged increased accuracy has been by some attributed to the supposition that the revolutions of the bullet round its own axis increase in rapidity while passing through the air, in consequence of having acquired that motion when passing through the barrel, under the influence of the grooves; but it is difficult to imagine how a leaden bullet can carry within itself, after leaving the muzzle, any power of increasing its own rotatory or progressive motion.

"2nd. That there should be less recoil is natural, as the bullet meets with less opposition when first started from a state of rest; but the amount of recoil in all rifles now made for expanding projectiles is quite inconsiderable, and not worth noticing.

"3rd. The tendency of a bullet to twist the rifle on one side is now avoided by reducing the spirality of the grooves. Instead of being one turn in three or four feet as formerly, it is now one turn in six feet six inches, and sometimes only one turn in eight or nine feet.

"4th. The advocates of this system maintain that a bullet is less likely to 'strip,' or pass out of the barrel without rifling itself, when conducted gradually into the required degree of spirality. But the question is, whether in a well-constructed rifle, the bullet *does* strip? and if not, then a gaining-twist is unnecessary and objectionable, as it offers to the ball's progress a continually increasing opposition, while the ball itself is subjected to a continually increasing urging force from the inflamed gunpowder in the barrel, so that, as the velocity of the ball increases, so also does the resistance to its escape. A projectile is set in motion gradually, and is (or should be, if the quality and quantity of the powder, and the barrel, have a right proportion to each other) at its greatest velocity just before leaving the muzzle; consequently the tendency of a ball would be to yield to the increasing force of the powder and pass straight out of the barrel without following the grooves; and this more especially in a smooth bore, which has no clearly defined edges to hold and guide the ball to its proper degree of spirality, but where the lead may be compressed along the smooth surface so as to pass straight along the barrel."

So much for the gaining twist; it requires no further argument. The oval bore is not an invention of Mr. Lancaster: it is older than Captain Beaufoy's book, "Scloppetaria," published in 1808, for in it you will find a description how to rifle a smooth bore; and he gives drawings of the tools to do it with.

If these statements are facts—and I defy them being gainsaid—what connection has this gentleman with it at all? for what purpose is it pompously announced that the Lancaster elliptical bored rifle shoots superior to the Enfield, when there is *not such a thing*? The superior shooting of one man over another is more than sufficient explanation. The highly unscientific theory of putting a bullet into excessive spiral motion at the instant it has acquired a maximum of velocity is untenable, admitting of no lucid explanation. The Enfield rifle has evidently many enemies, who do not hesitate in injuring her reputation, nor hesitate about the means of doing it. All elliptical bores are but the two-grooved rifle in disguise: an idea fast exploding.

The truth of my opinion about the two-grooved or Brunswick rifle, introduced into the service in 1840, is now proved. Many of my readers will recollect that in my books of 1842 and 1846 I termed this “an abortion of science:” it has since died with that cognomen; though it was puffed up, as my readers will remember, by many high authorities, and amongst the rest by Dr. Ure, who said nearly as much for it as is now advanced in favour of the hexagonal rifle. On referring to the report of the Select Committee on Small Arms, published in 1852, I find the following account of it:—

“At all distances above 400 yards the shooting was so wild as to be unrecorded. The Brunswick rifle has shown itself to be much inferior in point of range to every other arm hitherto noticed.

“The loading of this rifle is so difficult that it is wonderful how the rifle regiments have continued to use it so long—the force required to ram down the ball being so great as to render any man’s hand unsteady for accurate shooting. Comment is unnecessary.”

The Prussian needle gun, too, has departed this life: another instance of the absurdity of adopting plans containing in themselves the reverse of scientific principles; for it may safely be accepted as an axiom that success at the present day can only arise to mechanical constructions which are based on those immutable foundations of mechanical science in accordance with great Nature’s laws.

That the principles of the expansive or “Greenerian” rifles are fast gaining the approbation of all scientific men qualified by their pursuits to judge, is evident from the fact that Birmingham has contributed, within the last twelve months, a considerable number of workmen to construct Enfield rifles in all the principal States of Europe. France, and Russia especially, are expending large amounts in manufacturing this arm; so that it is no stretch of imagination to suppose that in a few years the equilibrium of arms will be again established, all nations being armed with equally good weapons, to contrast with the contemptible ones of bygone times.

Before separating for the recess, a question was asked from the officials by an honourable member in the House of Commons:—“When a report would be given in as to the relative merits of the Enfield and Whitworth rifles as military weapons?” The answer given was evidently intended to mystify; for, from the most intimate inquiries I have made, I find that no experiments whatever are in progress. The last took place at Woolwich, in October, 1857, and terminated so very unsatisfactorily, that Mr. Whitworth wished to make some alterations in his rifles, in order to overcome the difficulties presented. Up to the present time the authorities inform me that no other rifles have been sent in for further trial.

The defects demonstrated in these experiments were precisely those pointed out in this chapter. On reversing their positions, “hard bullets *v.* soft,” the penetration of the Enfield was found to be equal to that of the Whitworth; the same number of elm deals being perforated. This proves what may be done by “mechanical dodges,” and how intimately acquainted those in charge of “gunnery experiments” ought to be with all its ramifications, or they, too, may be hoodwinked.

The difficulty of loading was here more strongly exemplified than at Hythe. The deposit from the “Government gunpowder” became so tenacious in the “hexagonal grooves,” that after a certain number of shots, loading became a very difficult matter indeed; so much so, that Mr. Whitworth considerately provided a very superior description of gunpowder, with which the hexagonal rifle worked a little better. The recoil, too, was of that severe kind as to leave strong recollections of its force on the minds of the reluctant operative shooters employed to carry out the experiment. The entire result may be summed up, in the mildest term, as “unsatisfactory.” The concealment of this result may be probably a considerate act on the part of the late Government; the parts acted by some of the members of it must be strong in the recollection of others; and letting *down quietly* this very highly inflated “wind-bag,” when it showed symptoms of collapse, was doubtless a judicious act.

CHAPTER X.

REVOLVING PISTOLS.

Revolving or repeating pistols have now become as necessary in war as the rifle. The peculiarity of the contests in various parts of America first showed the necessity of a weapon being constructed, the moral and destructive effects of which should be equal.

Colonel Colt was unquestionably the first to overcome the difficulties found to exist in the earliest productions, and when the introduction of the revolver into Europe became general, and the demands for it increased, the manufacturers were enabled, from the commencement, to avoid the defects which he had overcome in the course of his experience; and thus, their task was a lighter one than his. An immense number of revolving pistols have been constructed in a very short time; but, like all new creations in mechanical science, the production has been distinguished by quantity rather than quality. The general adoption of these arms has been greatly impeded by the very inferior quality produced. Revolving pistols may be had from 10*s.* upwards; but as to the utility of such cheap trash nothing can be said. The possession of one may have a moral effect on the courage of the bearer, and its appearance may act on the fears of the opponent, but the danger is greatest to him who fires. The complicated arrangement of all repeating fire-arms requires that they should be of the very best workmanship, if they are to be safe and efficient weapons. That they have been of the utmost use to the allied armies in the Crimea, and in that more desultory but treacherous struggle in the East, is certain. Many and valuable lives have been saved by their ready application. The moral effect of the revolver was amply demonstrated where one noble young soldier held his post at “Rewah” by the dread of his revolver alone; the mutineers knowing well that six of them must fall before they could reach him, and feeling that each might be one of the six, he held his own until relief came.

Again, a tale is told of another gallant officer who shot five in succession, reserving the sixth for that arch-miscreant Nana Sahib; but unfortunately that sixth barrel missed fire. How many thousands of lives that shot might have saved had it been successfully fired! With all good, however, comes a certain amount of evil: no perfect weapon has ever yet been constructed; but this shows how desirable it is that a perfect revolver should be invented, if possible.

There are but few manufacturers of revolvers who have reached any degree of eminence: Colt, Dean, Adams, Tranter, and Webley, comprise nearly all the distinguished men in this country. There are a multitude of second-rate makers in England, France, and Belgium; but the most celebrated makers in Europe are those I have enumerated; and in order to guide the reader as far as my knowledge will serve, I will impartially point out the advantages and defects belonging to each production.

The construction of Colonel Colt’s repeating pistol is, according to his own description, a motion got by cocking the lock and rotating the cylinders; as described in the following quotation:—

“They differ from those formerly made, principally in the greater simplicity and the better proportions of the parts of the lock and the framework. Important additions and improvements have been made in the loading lever and rammer for forcing the balls firmly into the cylinder, the employment of the helical or spiral groove on the arbor on which the cylinder turns, whose sharp edges are intended to prevent fouling by scraping off any smoke or dirt accumulating in the cylinder from the lateral fire entering the centre opening, and the inclined plane leading to the recesses on the periphery of the cylinder, to direct the bolt below the opposite shoulder in the recesses; thus preventing the cylinder from being accidentally thrown too far by the sudden action of cocking. The lock is now composed of five working parts, instead of seventeen, as formerly; and it is obvious that if the several parts of the machinery are made proportionally strong for the work they have to do, so is the arm rendered more efficient by the greater simplicity of the general construction.

“In all arms having a moveable breech it is desirable to bring the barrel and cylinder as nearly in contact as possible, in order to prevent the escape of lateral fire, and yet to leave freedom for motion, without friction: this is now effected by the base pin, on which the cylinder turns, entering a corresponding opening in the under part of the barrel, being there held in place by a key passing through and bearing against the back end of the slot in the barrel, and the fore end of the slot in the base pin, which is thus drawn up to the bottom of the hole, and yet the barrel is prevented from being brought too close upon, or in absolute contact with, the cylinder, whilst its end is still held in its proper position with respect to the cylinder. In the event of any abrasion of the end of the cylinder or of the barrel, by deepening the cavity, or filing the end of the base pin, the key can be driven further in, and the proper distance for the readjustment of those parts be maintained, whilst the essential rigidity of structure is secured.

“In loading the present arm, it is necessary to draw back the hammer to the half notch, to allow the cylinder to be rotated freely by hand; a charge of powder is then placed in each chamber, and the balls, without wadding or patch, are put one at a time upon the mouths of the chambers, turned under the rammer and forced down, by the lever, below the mouth of the chamber. This is repeated until all the chambers are loaded. Percussion caps are then placed on the nipples, when, by drawing back the hammer to the full catch, the click or lever is brought into contact with one of the ratchet teeth, on the base of the cylinder, bringing the nipple into the precise position to receive the blow of the hammer: the arm is then in a condition for being discharged by simply pulling the trigger; and a repetition of the same portion produces the like results, until all the chambers are discharged through the barrel.

“The movements of the revolving chamber and hammer are admirably provided for. The breach, containing six cylindrical cells for holding the powder and ball, moves one-sixth of a revolution at a time; it can, therefore, only be fired when the chamber and the barrel are in a direct line. The base of the cylindrical breech being cut externally into a circular ratchet of six teeth (the lever which moves the ratchet being attached to the hammer), as the hammer is raised in the act of cocking, the cylinder is made to revolve, and to revolve in one direction only. While the hammer is falling, the chamber is firmly held in its position by a lever fitted for the purpose; when the hammer is raised, the lever is removed and the chamber released.

"So long as the hammer remains at half-cock the chamber is free, and can be loaded at pleasure. The rapidity with which these arms can be loaded is one of their great recommendations, the powder being merely poured into each receptacle in succession, and the balls being then dropped in upon it, without any wadding, and driven home by the ramrod, which of course is never required to enter the barrel.

"While carried in the pocket, or belt, there is no possibility of an accidental discharge of these pistols. Whenever it is required to clean the barrel and chamber, they can be taken to pieces in a moment, wiped out, oiled, and replaced.

"The hammer at full-cock forms the sight by which aim is taken. The pistol is readily cocked by the thumb of the right hand, a plan in every way far superior to the arrangement whereby the hammer is raised by a pull on the trigger: this is in every respect most objectionable, the pull materially interfering with the correctness of aim; and the sear-spring having the duty of the main-spring to perform as well, is apt constantly to be getting out of order.

"The ramrod attached to these pistols consists of a very clever but simple compound lever, which, forcing the ball effectually home, hermetically seals the chamber containing the powder, and by the application of a small quantity of wax to the nipple before capping, the pistol may be immersed for hours in water without the chance of a miss-fire."

The great disadvantage said to be existing in this revolver is the necessity of cocking and half-cocking at every discharge; which double action is difficult in certain positions where revolvers are of the greatest use, as in a melée surrounded by many enemies, where the cocking and firing by one pulling motion, as in Tranter's and Dean's, is more expeditious: in fact, certificates are published by officers who, at the battle of Inkermann, would have been cut down had the slightest delay been necessary for cocking the pistol. On the other hand, it is said, that no certain aim can be taken where the pulling up and sudden liberation of the mainspring discharges the pistol; the act of discharging it destroying the aim. These two points have their advocates and their objectors, as has always been the case with new plans.

The mechanical construction of Colt's pistol is effected entirely by machinery, and on this account superiority is claimed for it; in my opinion, however, the boasted benefits of machinery have never yet been realised. The manufacture of guns without machinery is difficult, but the entire use of it is unnecessary. Certain portions of pistol-making can never be done as they should be by machinery; and I have not yet been able to discover anything in Colt's manufacture to make me advocate the use of machinery. I should not consider a pistol made by hand, and equal to the best of Colt's, as well made; a hand-made pistol ought to be much better in all respects.

Dean and Adams were the first makers of note who contested the palm with Colt. They thus describe their pistol:—

"The barrel, the lock-frame, and top-bar were all forged out of one piece of iron: the chamber to contain five charges, revolved on a centre pin, which could be either drawn entirely, or partially out, as was required and was held in its position by a side spring; the toothed ratchet was secured to the base of the chamber by two screws, so as to admit of its being renewed, when it was abraded by use, and motion was given to it by a ratchet pall, connected with the hammer, which was lifted by pulling the trigger. The hammer moved on a transverse pin, and was pressed down on the nipple by a back spring in the stock, being connected with it by a swivel link; the trigger was kept in position by a horizontal bent spring, and had attached to it the hammer-lifter and the ratchet pall; the point of the former fell into a notch in the base of the hammer, so that as the trigger was pulled, the hammer was raised, until the rounded portion of the base, acting as a cam, forced the lifter out of the notch, and allowed the hammer to descend on the nipple and to explode the percussion-cap. On withdrawing the finger from the trigger, the lifter and ratchet pall descended and again slipped into the notches of the hammer and the chamber, in readiness for repeating the operation of firing. The lifter was retained in contact with the hammer, by a small flat spring, the upper end of which was attached to the pall, while the lower end acted upon the lifter, which, in turning on its centre, brought the lower prolongation against the spring, below the centre, so as to press the upper end in the proper direction, in order that its action might be certain.

"The rotation of the chambers was obtained by a ratchet pall, acting on a tooth each time the trigger was pulled, thus causing the chambers to revolve, so far as to bring a nipple into the proper position for receiving the blow of the hammer, and in that situation it was held by a projecting stop on the back of the trigger.

"In order to load the chambers it was necessary that they should revolve free of the stop: this was effected by pressing inwards another stop, attached to a spring on the side of the lock, which engaged the point of the hammer and prevented it from descending on the nipple, until the chambers were loaded, when, on the trigger being pulled, the side spring stop was released and resumed its original position, leaving the weapon ready for action.

"The bullets were cast with a small 'tang' on them, which served to fix a wad on each; thus no ramrod was required in loading, the bullets being merely pressed in with the finger. The aperture of the barrel was slightly expanded at the lower end to admit of the bullets entering more readily in firing. The rifling of the barrel was the reverse of the ordinary system, as it consisted of three projecting 'feathers,' or ridges, extending the length of the tube, leaving very wide grooves between them.

"It would be observed, that the cocking and firing were performed by the same action of the trigger; therefore the rapidity of firing was proportionally great; the arm was very light, its construction simple, and its action certain."

The defect of cocking and firing by the same action of the trigger must have been important; for new patents were, I believe, taken to cover both plans, and they now manufacture what is termed a double-action pistol, which acts either by cocking with the finger, or by the trigger, as of old. The important improvement in the durability and soundness of Dean and Adams's pistol over Colt's is, that the barrel, the lock-frame, and top bar, are all forged out of one piece of iron; thus, the cylinders revolve in a frame which cannot undergo any displacement.

In Colt's, the barrel is supported by a crooked elbow, rising from the centre, or revolving pin; its principal support consequently is some distance below the tube of the barrel, but parallel to it: the effect of long firing is to bend this elbow, causing the barrel to fall or droop downward, instead of continuing in a straight line with the chambers; thus, an opening between the chambers and the barrel is established, increasing the space for lateral escape.

Next, though certainly not least, is Tranter's pistol, of three different modes of construction. The name of this manufacturer has risen higher than that of his London competitors; owing, no doubt, in a great measure, to the generally entertained opinion that all essential improvements in the English revolving pistols have arisen from the skill and untiring industry of Mr. William Tranter. Whether the opinion that he originated all the improvements claimed for Dean and Adams's pistol is well founded or not, I cannot say: I only reiterate the opinion; and I believe, from the very great attention Mr. Tranter has paid to the subject, and from his great mechanical skill, that he is quite capable of effecting these improvements. Any admirer of beautiful arrangements in gunnery has only to examine one of his double-trigger revolving pistols, to be struck with the elaborate nature of his improvements. I give a wood-cut of it on the next page, and some quotations from his own description of its quality:—

"W. Tranter's patents for a double trigger, a safety-hammer spring, an elongated socket for the chamber, a loading lever, and a lubricating bullet for revolving arms, increase the value and efficiency of these arms as defensive weapons.

Half size of the medium 54 gauge double-trigger Revolver.

"By means of the patent double-trigger the pistol can be held more firmly in the hand while being fired, and only one hand is required to raise the hammer and fire the pistol. A perfectly accurate and quicker aim can be taken, and the pistol discharged at the instant desired; the hammer can be raised again without lowering or removing the pistol from the object till the whole of the chambers are fired off. The chamber is held firmly opposite the front barrel before the hammer begins to fall, and also at the moment it is discharged; the chamber cannot be turned away from the front barrel by the hammer at the moment it is discharged. In cases of emergency the pistol can be fired with the greatest rapidity by pulling both triggers together. The exploded caps do not get into the works and render the pistol useless till removed. But little practice is required to enable a person to shoot with accuracy.

"The patent safety hammer spring always acts with the hammer and trigger; should anything accidentally lift the hammer, the safety-spring instantly falls under it and prevents it falling upon the cap, thereby preventing an accidental discharge. The safety-spring also facilitates the loading, by allowing the hammer to rest upon it while the chambers are being charged, and at the same time acting as a safety-spring during the operation of loading. The pistol can be carried with perfect safety when loaded, either in the pocket or holster, by allowing the hammer to rest upon the safety-spring.

"By means of the patent elongating socket, the chamber can be properly and readily adjusted to the frame of the pistol; and as the chamber with use becomes too free, and the strength of the shooting depreciated, the elongating socket enables it to be readjusted as perfectly as when first made—an important consideration with these arms.

"The patent loading lever enables the pistol to be loaded with greater facility, and fits the lubricating bullet to the chamber so exactly that the powder cannot fail to bend up the flange of the bullet and distribute the lubrication all over the inner surface of the chamber and barrel; it also fixes the bullet so firmly in its place in the chamber that it does not fall out with being carried in the pocket or holster, neither does it project forward with the firing of the pistol.

"The patent lubricating bullet, with the lubricating composition, effectually lubricates the inner surface of the chamber as far as the bullet enters, also the face of the chamber where it comes in contact with the front barrel, and the whole of the inner surface of the front barrel; thereby preventing any deposit of lead or powder that may deform the bullet, enabling the pistol to be loaded with the greatest ease after firing a number of shots, and facilitating the passage of the bullet through the front barrel. The accurate fitting of the bullet and the repellent properties of the lubrication completely protect the powder from exposure to wet or damp, and effectually prevent one chamber igniting the powder in the other while being fired. The pistol has been fired five hundred times in succession with the lubricating bullets without being cleaned or getting out of order, the last fifty shots being fired with as much accuracy as the first; the pistol could then be loaded and fired with the greatest facility, there being no deposit which interfered either with the loading or firing.

“W. Tranter has taken out another patent for improvements in fire-arms, and having combined with those improvements some of the improvements comprised in his former patents, recommends the above as possessing every requisite for a double-action cocking revolver.”

These revolvers will be found to possess the following advantages:—

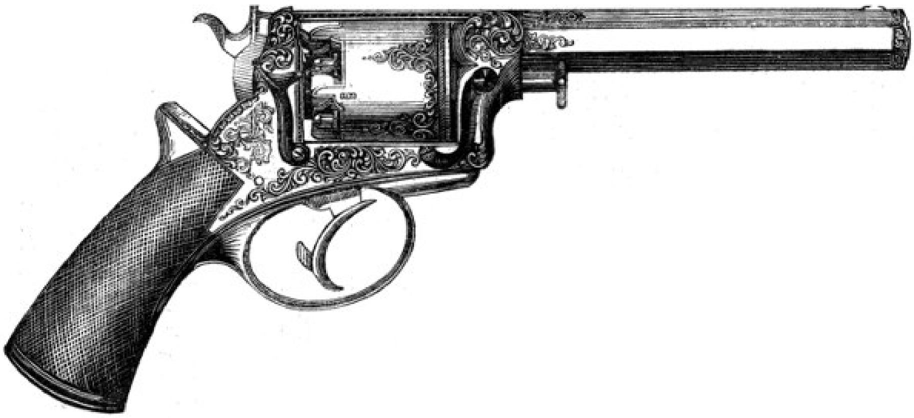
“The pistol can be used with one hand, and fired with the greatest rapidity and facility by pulling the trigger with the fore finger only.

“The hammer can be raised and the pistol fired as an ordinary fowling-piece.

“The spring lock for locking the chambers enables the pistol to be carried safely, and can be released when required by the thumb of the right hand.

“The lock of the pistol is simple, and not liable to derangement. It can be easily taken to pieces when required, and as easily put together again.

“The patent elongating socket is combined with this revolver in the same manner as with the patent double-trigger revolver, and with the same advantages.



Tranter’s double-action Revolver.

“The new patent loading lever is attached to this revolver in the same manner and with the same advantages as to the patent double-trigger revolver.”

Webley’s patent revolving pistol is an improvement upon Colt’s best pistol, the cylinder rotating by the cocking of the lock. The advantages obtained are, an exceedingly simple construction in the rotating movement, enabling the patentee to manufacture them at a lower price than any of the preceding makers, and thus to produce, what is a great desideratum, a good and reasonable priced pistol.

Webley’s Revolver.

“Keep your powder dry” was the old watchword: “Take care of your ammunition” ought to be the watchword of the present day.

Facility of loading is no doubt to a certain extent an advantage, but doubts exist whether breech-loading guns, if brought to such a state of perfection as to come into general use, would not, from their very facility of loading, become a serious evil.

The difficulty which Commanding Officers have to contend with in war is in restraining their men from firing too rapidly, using two shots where one would suffice; but the process of loading inculcates care of it, takes considerable trouble, and hence men husband their fire the more.

The two different principles of revolvers illustrate this. The self-acting one is apt to be fired more than once; a man in a state of excitement may pull twice before he pauses, and two shots are expended where one would have sufficed. The cocking-lock pistol, in addition to the less pull required in firing, gives time for observation, as the necessity for cocking every time creates a pause, and is an admonition to coolness: this is often very advantageous in shooting game, in which, as in the more serious affair of shooting men, deliberate coolness is required.

Therefore, excepting only the chance—the very remote chance, that may arise, requiring you to fire six shots as rapidly as possible—so rapidly that the cocking pistol would be too slow, I would myself prefer the cocking pistol; from the fact of being able to take much better aim with it, and there being less chance of missing, through the heavy pull necessary to raise the cock and fire the pistol on the self-acting principle. The almost general adoption, in the present day, of the cocking-lock, and its application in both Adams's and Tranter's self-acting principles, is proof of the general bias towards the same opinion.

The tendency of all revolving pistols, and of course revolving rifles also, to foul in the barrel after a few shots, is a very serious drawback to their efficiency in use. The following quotation from Lieutenant Symons' work is one opinion which I select from a number in my possession:—

"Revolving pistols only ought now-a-days, in my opinion, to be made breech-loading; and of these the pistol of Colonel Colt is a very good specimen. I can generally hit a target the size of a man with this pistol at a distance of 150 yards when clean, *i. e.*, with the first shot; and I on one occasion put five out of the six shots into the target successively. When foul, however, the bullets will not fly steadily and on their points. I one day, for the purpose of experiment, fired 60 rounds without cleaning, at planks placed a few yards off only, when latterly the bullets, instead of cutting the circular holes they had been doing, commenced to make marks in the planks as if nails an inch long had struck them sideways. On taking off the barrel to ascertain the cause, I found that it was nearly choked up with lead. The barrel of this pistol rapidly fouls, though the chambers do not."

It also furnishes a complete answer to the absurd proposition of imparting spiral motion to a bullet, by means of an increasing spiral, after it is put into high velocity. The fouling of the barrel by lead to an extent (as I have seen) of a considerable portion of the bore, is absolute proof that the bullet does not follow the course of the grooving: in its passage through the directing barrel it passes straight out, with the velocity imparted to it in the chamber.

The experience of this fact induced Mr. Tranter to invent his lubricating bullet, the only form of pistol with which many shots can be fired without cleaning. There are, in reality, many defects to be overcome (though it is very doubtful whether they will ever be) before revolvers can in any degree be relied upon for constant operations. I know for a fact that at this moment Government have in store many thousands, disabled for all useful purposes, though by the most trivial circumstances; fouling with lead being one of the most prominent defects, or some trifling disarrangement of the rotating machinery, such as it might be supposed could be repaired: but they are returned to store as hopeless, in the usual course, and thus their fate is sealed as a military weapon.

The double-barrelled under-and-over pistol was entirely discarded for the new toy; but hopes are entertained that the former will soon be restored to the lost preference of all who value their own safety, and would rather depend on two certainly destructive shots than six uncertain ones. For my own personal use in any scene of combat, my reliance would be on a pair of double-barrelled pistols; or what is of more use still, on double carbines. The Emperor of the French, however, is arming his sailors with revolving pistols; and lately, in India, a squadron of Dragoons used the revolver with deadly effect on a body of rebel Sepoys.

CHAPTER XI.

ENFIELD MACHINE-MADE RIFLES.

Enfield, the seat of the Government manufacture of small arms, will become a celebrated place in future history; its productions being now one of the wonders of the present age. The term “Enfield Rifle” does not denote any one improvement, but a series of improvements; Enfield being merely the name of the place where the manufactory is situated.

The Enfield rifle differs from the original rifled musket (better known as the Minié musket) in the fact of the bore having been reduced to ·577, and the weight of the arm to 9 lbs. The regulation Minié musket was 10 lbs. 8¾ oz. in weight, so that a saving of 1½ lbs. has been effected by the adoption of the present gun. The size of the bore was ·702, and the weight of the bullet 680 grains, whilst the present regulation musket is only ·577 bore, the bullet being 520 grains in weight.

The model arms ordered by Lord Hardinge, the Commander-in-Chief, in 1852, of Messrs. Greener, Purday, Richards, Lancaster, and Wilkinson, formed the base from which the Enfield was constructed. The “Sight” was Westley Richards’ invention. The Expanding Bands for securing the stock and barrels (without which a machine-made musket would always be an uncertainty) are an invention of mine; several other points were also adopted on my recommendation: as, for instance, the furniture being case-hardened, as in the rifle-corps gun, and the fastenings of the bayonet. These points, however, being merely suggested improvements, and not, strictly speaking, inventions, conferred no benefit on me beyond the compliment involved in their adoption.

It is well known that, but for my evidence before a committee of the House of Commons in 1848, the swivel-lock would not have been so soon adopted as it was. Thus it is evident that much of the outer form, as well as the principle, of the present arm is due to my exertions. Much surprise was shown by the Select Committee in 1852 that I did not give in for trial some improvement upon my own principle (which, by the by, they had not at that time admitted); but prudence taught me otherwise: to have done so would have affected the soundness of my claims.

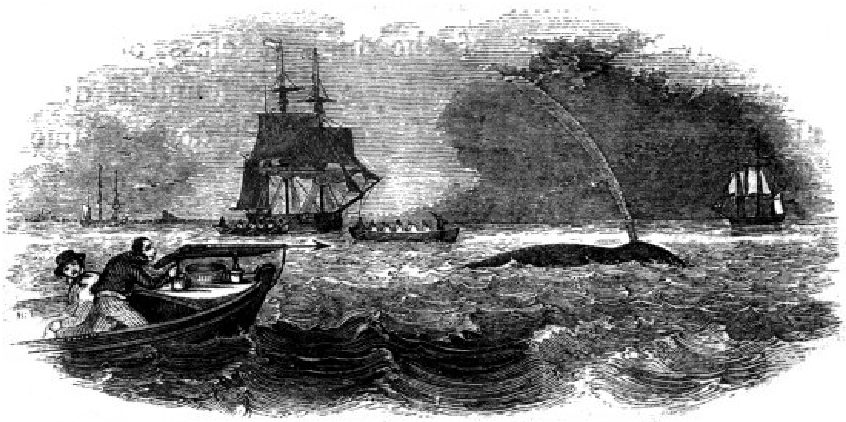
About the year 1851 it was determined to adopt some portion of the American system of manufacturing guns by the aid of machinery. A commission was appointed and sent out to the United States in order to inspect the operations of their mechanism, and to ascertain the advisability of adopting the whole, or a portion, of their machinery in England. To the selection of the members of that commission, and to their judgment, may be ascribed whatever is ill or good in the system; the majority being military men connected with military matters, and the others machinists, the bias was no doubt in favour of machinery. The Enfield manufactory, at its starting, was intended to be a moderate affair, I believe; but now it has expanded into such gigantic proportions that, if it continues in action, the manufacture of military arms must partially cease to be the trade of Birmingham: for all large establishments of machinery must be employed, to protect them from decay; and whatever may be the cost of production, machinery must go on, or be entirely given up.

The extent of the Enfield manufactory may be estimated from the fact that it now produces weekly 1,100 stand of arms complete, and employs men and boys to the number of 1,300. At this rate of production, a very few years will suffice to place such a stock of arms at the command of the Government as will render the employment of foreign artisans unnecessary. Enfield machine-made arms are undoubtedly specimens of the highest class of that description; but whether they will be found as durable as hand-made arms I very much doubt: time alone can decide this.

CHAPTER XII.

THE HARPOON GUN.

Whale shooting has now become a great fact; no other means being used to capture this monster of the deep but the harpoon gun, when it is possible to obtain it. Although little doubt remains but that whales, like "grouse," are becoming scarce, and that in a short time they will become almost extinct, yet their great value when captured will always stimulate hardy and daring seamen to pursue them even into their remotest haunts. The following cut represents the boat and gun now in use.



Experience has proved the value of this invention; and every ship that goes to the fishing has now a full complement of six harpoon guns. Nine-tenths of the fish got within the last few years have been shot. From a calculation I made after the conclusion of a late season, the result must have been very satisfactory and profitable to the owners of the ships, and also to the gun-makers. I have every reason to know that the amount of money realised by these harpoon guns amounted to little short of 100,000*l.*; and this from guns of my manufacture alone: for I, like most inventors, have competitors, who manufacture upon my model and at less than my price.

Harpoon guns are similar to small swivel guns; they are of 1½ inch bore and 3 feet long in the barrel, which when stocked and complete weighs 75 lbs. The construction of the lock is very simple, being upon the principle of a saddle pistol lock; the caps, the nipples, and lock, are completely and effectually covered, and protected from damp, or spray from the sea. The lock is also securely bolted until the moment it is wanted; when by the removal of a pin, the trigger string is pulled, which fires the gun. The harpoon is projected with considerable accuracy to any distance under eighty-four yards; that being the greatest range ever obtained with this description of gun. The charge is very small to project 40 lbs. weight; for the harpoon itself is 10½ lbs., with an increasing weight of three-inch line from the gun to the extreme range, in all weighing full 40 lbs. This immense improvement is the result of calculations, deduced from the nature of gunpowder. The charge is short of an ounce of powder; but is, or ought to be, good powder, of the largest grain; fine powder will not do it, but, on the contrary, would jump up the end of the harpoon, or bend it, so that it would be of no further use until repaired.

CHAPTER XIII.

ON SHOT, CAPS, AND WADDING.

Patent shot being still produced as at the time of publishing previous editions of my works, I have no important improvement to record.

The manufacture is very simple: the lead is first tempered by the aid of arsenic, in the proportions required by the slag (a technical term) for the kind used; some lead taking more and some less. The melted metal is then poured into a perforated pan placed over the mouth of the pit, or tower (whichever may be in use.) Messrs. Walkers, Parkers, and Co. have towers in their various factories where they make shot; the cut represents the one in Newcastle. Messrs. Locke, Blackett, and Co. cast down the shaft of a pit, and by this means obtain a greater fall. The fluid metal takes a globular shape in falling, and the concentric motion of each particle round its axis keeps it in this form until its passage through the air has extracted the heat, and before it reaches the body of water placed to receive it. The only difficulty is in casting very large sizes; for if the distance the drops fall be not sufficiently great, and they reach the water in a semi-fluid state, the resistance of the water misshapes them. About three different sizes come out through one pan. These are separated by the aid of riddles, or tabled, as the process is termed. A quantity of the shot is placed on a slight incline, when those that do not run off are rejected. The whole are then polished in a machine termed a drum, with a mixture of black lead. This gives to the shot that beautiful polish which captivates the eye, but which injures the shooting of the gun, as the black lead adheres to the interior of the tube. All shot should be used unpolished; and the addition of hardness is unquestionably another advantage. Slag-lead is lighter than other lead, but it is much harder, and thus more suitable for shot. I regret the disuse of shot made with quicksilver, as it is unquestionably much superior, though more costly. A considerable improvement is yet to be introduced in the manipulation of shot-making; and I shall commence a round of experiments with that object at the earliest opportunity.

Copper caps are now a misnomer: very few are to be met with. Brass caps boiled to the colour of copper are the rule, the former the exception. Good caps are made in Birmingham, if a remunerative price is paid for them; and I have the pleasure to name several makers: Messrs. E. and A. Ludlow, Messrs. Pursall and Philips, and Mr. Cox. It must be borne in mind that cheapness means inferiority: every article is made according to price.

The mixture of fulminating mercury composition is:

Fulminating mercury	3	grains or ounces.
Chlorate of potash	5	do.
Sulphur	1	do.
Powdered glass	1	do.

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The List of Plates shows (slightly) different texts from the captions in the plates themselves.

The List of Illustrations is incomplete, and not all illustrations have the captions listed in the List of Illustrations. In some cases the hyperlink will point to the first of a number of illustrations listed under a single name.

The sometimes slight difference in wording between the Table of Contents and the actual chapter headings has been retained.

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Textual remarks

Page 12, snaphaunce is not a Dutch word; it is derived from the Dutch snaphaan.

Page 64, footnote: the original does not show the footnote anchor; the footnote has been included without its anchor. Possibly the footnote refers to the Point Blank Range data for the 10-inch and 8-inch howitzers.

Page 239, price calculations: the total for single guns should be 19*s.* 9*d.* The other amounts given in the text do not correspond with the table; this has not been changed.

Page 240, price calculations: the totals for double and single guns should be 16*s.* 3*d.* and 9*s.* 9*d.*, respectively.

Page 13 (first set of advertisements), amount of shooting is possibly an error for account of shooting.

French accents have not been corrected or added (Andrê, Minie, èpanouissement, etc.), Latin accents have been retained, unless mentioned below.

Changes made to the text

Footnotes and illustrations have been moved; some illustrations have been rotated 90°

Some missing/incorrect punctuation has been added or corrected silently

Page vii: Polygroove changed to Poly-groove as elsewhere

Page ix: Firelock changed to Fire-lock as in the the text

Page xi: Badajoz changed to Badajos; Mallett changed to Mallet (2x) as in the text

Page xvi: manufactury changed to manufactory as in the text

Page 5: a cubic distance changed to a cubit distance

Page 8: likwise changed to likewise

Page 23: suphuretted changed to sulphuretted

Page 27 (table): 9.90 changed to 9·90

Page 42: horizonal changed to horizontal

Page 63: almost from a class changed to almost form a class

Page 91: enginering changed to engineering

Page 131: impres changed to impress

Page 139: fusees changed to fuses

Page 140: wthin changed to within

Page 154: furnance changed to furnace

Page 159: is is changed to is

Page 160: exhibibits changed to exhibits

Page 166: Ther changed to There

Page 169: 1·40265 changed to 1·40625

Page 211: fustrum changed to frustum

Page 219: Weimer changed to Weimar

Page 229: artizan changed to artisan

Page 239: Wedgebury changed to Wednesbury as elsewhere

Page 249: twent changed to twenty

Page 271: answert hat changed to answer that

Page 301: expansive powder changed to expansive power
Page 303: impossibity changed to impossibility
Page 317: filed changed to filled
Page 356: frustrum changed to frustum
Page 358: frustrum changed to frustum
Page 436: to to changed to to
Page 5 (first set of advertisements): STEEET changed to STREET
Page 8 (first set of advertisements): BRMINGHAM changed to BIRMINGHAM
Page 3 (second set of advertisements): Gobe changed to Globe
Page 5 (second set of advertisements): Bouchier changed to Bourchier

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