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Addendum to "Breech- Loaders for the Army:" Being Remarks on the Result of the Agitation of the Breech-Loader Question, And Concerning the Introduction of Gun- Cotton Into Modern Warfare

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***ADDENDUM TO "BREECH-LOADERS FOR THE ARMY,"
BEING REMARKS ON THE RESULT OF THE AGITATION
OF THE BREECH-LOADER QUESTION, AND CONCERNING
THE INTRODUCTION OF GUN-COTTON INTO MODERN
WARFARE.**

By ARTHUR WALKER, Esq., Lieutenant 79th Highlanders; Lieutenant
Instructor School of Musketry, Fleetwood.

IN these days of railways and electricity, which seem to lend to modern men a reflex of their promptitude, celerity, and decision in all their doings, events succeed each other so thick and fast, that even the steam printing machine can hardly keep pace with their rapid march. The foregoing paper, and the remarks it elicited at the Royal United Service Institution, had scarcely been consigned to the press and given to the public, when the arguments therein contained received a flattering endorsement from the military authorities, the theoretical conviction on their part having been followed by a prompt determination to give it effect in practice.

In fact, so much had transpired in a variety of ways on the subject of breech-loaders, during the last year or two, that the feelings of the country were becoming fairly roused, and the public mind was fast approaching the point of demanding that the army should have the benefit of the undoubted superiority of breech-loaders over muzzle-loaders, when, with prescient sagacity and meritorious promptitude, Lord de Grey and Ripon forestalled any such pressure from without by taking action in the matter himself.

He decided to submit the question in its integrity to the thorough investigation of a competent military tribunal, composed of seven officers,† whose high standing and varied experience on the subject afforded an excellent guarantee for the soundness of their judgment and the propriety of their decision.

This committee assembled on four occasions, and after examining a number of witnesses, it arrived at the unanimous conclusion that it was advisable to arm the whole of our infantry with breech-loading rifles.

Beyond this emphatic recommendation nothing was done in the

* Contributed in September, 1864.—Ed.

† The following are the officers of the Committee referred to:—Major-General David Russell, C.B., President; Colonel Thomas Steele, C.B., late of the Coldstream Guards; Colonel The Earl of Longford, K.C.B.; Colonel Clarke Kennedy, C.B., Commandant of the Military Train; Colonel Parke, C.B., Commandant at the Fleetwood School of Musketry; Colonel Adye, C.B., Royal Artillery; and Colonel Walker, C.B., formerly of the 2nd Dragoon Guards, and now Assistant Quarter-Master-General of the South-Eastern District.

way of detail, except that attention was directed—in the event of the decision of the committee being adopted—to the necessity of a more efficient service for the transport of the first reserve of ammunition; and of such importance was this considered by the authorities, that another special committee has since been appointed, with the view of examining the suggestion made on this head by the former.

The first reserve of ammunition should, obviously, be made to accompany soldiers whithersoever they may have to go—whether along the path of a mountain-defile, or in making a flanking detour across a river by a bridge of planks or boats. To convey this supply, pack-mules or horses (but the former are much to be preferred) should be substituted for the present system of cartage on service; or perhaps some description of handcart, or tumbril, on wheels, could be devised, so light and portable as to permit of its being easily moved along by one or more men, and capable, on occasions, even of being transported on their shoulders. A certain number of extra men would have to be told off for these tumbrils and to supply the pouches from them. At present each brigade carries its own ammunition, but with a breech-loader, that can be fired five or six times as often as a muzzle-loader, it will be absolutely necessary that every *company* in a *regiment* should have its proper quota of ammunition transport attached to it, just as it now has its quota of pioneers and buglers, the reserve ammunition for the *brigade* and the *division* being kept quite distinct.

Some such provision is absolutely necessary; but we are inclined to think that even more attention and consideration in this matter should be given to the soldier himself, with respect to the load of ammunition which he has to carry. It is generally becoming evident that the day has gone by for heavy-weighted soldiers; and the prevailing opinion is that a kit of over 50lbs. weight is rather too much for our modern soldier, or rather rifleman-sharpshooter, whose salient characteristic must be the utmost agility, promoted in every way by convenient equipment, in order to meet the sudden requirements which will be necessitated in future warfare, wherein if anything be certain, it is that victory will depend upon the accurate *coup d'ail* of the leader in deciding upon action, and the promptitude with which his soldiers can carry out his object.

Heavy, massive, unwieldy regiments are as obsolete as Frederick William's Patagonian Grenadiers: the days of old when battalions leisurely advanced, till they could distinguish the whites of their enemy's eyes before opening fire, are now long past; the deadly missile begins to pour in at a distance at which even the sound of its discharge is inaudible, and the foe himself appears little more than a thin dark line upon the landscape. To advance now "very slowly," (*fort lentement*), as Todleben, the hero of the Crimea, describes our troops to have done at the Alma, towards an enemy's breast-works, in the face of rifled guns and troops provided with breech-loaders, would only be equivalent to advancing "into the jaws of death."

We must apply the Banting-system, as it were, to our heavy-booted, over-fed, and over-clad Grenadiers, for depend upon it, it is your light-footed, clear-eyed youth, breech-loader in hand, with open collar and

no 50lb. knapsack to drag him to the earth—like a race-horse over handicapped—who will turn the tide of future battles.

Let us imitate the “loose order” and rapid concentration of the battle of Solferino, rather than perpetuate that tardiness of movement which cost us so much in the Crimea, both in men and reputation.

Obviously, therefore, the strength of the soldier must no longer be wasted in doing the work of a travelling packman, or rather a pack-horse, but, on the contrary, husbanded for the work for which he is specially intended. With this view, the weight of his kit should be reduced, and his dress modified, so as to permit him to carry some thirty or forty rounds more of ammunition.* After victory plenty of kit haberdashery can be got for the mere seeking; but ammunition is to be procured only from one shop, and that may be very far away.

The Prussians have already adopted this system; they carry *in front* two ammunition pouches, capable of holding some thirty rounds each, whilst they carry another thirty rounds by way of reserve in their knapsacks.

It seems strange that the present lumbering cartouch-box, misnamed a “pouch,” with its awkward position *in rear* of the back, is still retained to hamper and incommode the modern soldier, whose work will be very different to that which was performed by those that used it in the last and preceding century.

Another Committee has likewise been appointed to *give effect* to the recommendation of the first, as to the adoption in our army of breech-loaders, or, in other words, to determine the very important and difficult question—WHICH BREECH-LOADER shall be put into the hands of the British soldier?

Pending, however, the decision,—which it will obviously require some time to make, and still longer to give effect to in the shape of a new armament,—it appears that Lord De Grey contemplates the “conversion,” or, as the French call it, the “transformation” of a number of Enfield rifles into breech-loaders; and has actually advertised for the best means of doing so, under the condition that the cost per rifle should not exceed £1, and that the shooting of the transformed weapon should not be inferior to that of the unaltered arm, awarding at the same time to each competitor £20 as compensation for the cost of pattern, together with one thousand rounds of ammunition suited for the arm so converted. No doubt this can be done; indeed the problem has in a manner been already solved in the Mont-

* In a letter to the “Times” (28th December, 1860), on “Military Organization,” the author pointed out this necessity, and suggested means by which the necessary reform could be effected without increasing the *impedimenta* of an army to any material extent.

A letter by an Englishman in the service of the Confederate States appeared the other day (in the “Times”), in which the writer, after cleverly expatiating on the advantages of breech-loaders, and the fact that the Confederates, as fast as they captured rifles in the field, converted them into breech-loaders, states his opinion that the 60th Rifles, if armed with breech-loaders, could destroy the brigade of Guards in fifteen minutes, little knowing that as at present constituted, and armed with the Whitworth rifle, the 60th actually carry more weight, man for man, than either a Guardsman or a Linesman. So much for our *heavy* (pseudo) “Light” Infantry.

Storm rifle (the great objection to which, we may remark parenthetically, consists in having the hinge of the breech-piece *in front* of the charge, vide Figs. 21—23), and there are, we believe, some dozen other known designs for the desired conversion.

In thus attempting to utilize the rifle we have, Lord de Grey is doubtless actuated, first, by reasons of an economical kind, and, secondly, by his desire to supply the army *at once* with a breech-loader, even though in the shape of a makeshift, pending the discovery of a more perfect form of breech-loading rifle. But while doing full justice to his motives in taking such a step, we are inclined to doubt its wisdom. Makeshifts are bad at the best, as sportsmen and rifle-men well know; and a makeshift on which the prestige and safety of the empire may depend would be worse than all.

There are numerous serious objections to it. The expense of the conversion will of course ultimately have to be added to the cost of new breech-loaders for the army, so that in this sense it may be said to be "penny wise and pound foolish." Again, even at the best, an Enfield Rifle does not last longer than ten years; but in reality its life as a *rifle* is much shorter: so that in seeking to adapt a breech-loading system to it may be said to be "throwing good money after bad." The weapon has been condemned by an Ordnance Select Committee, and to all intents and purposes it cannot bear comparison, as a military weapon, with others with which it was tested by the Committee in question. Its day is gone; its glass is run; let it rest in peace; having done what it could in one stage of its existence, let us not vainly torture it into a metamorphosis, to which all the heathen gods together could not give congruity. "New wine in old bottles" would be nothing to the idea of turning the present condemned Enfield into the Enfield of the future.

Again, it will be a difficult matter, at the rate per rifle stipulated, so to alter the rifle as to dispense with the percussion-cap system, on the manifold disadvantages of which we have enlarged; and, finally, by retaining the Enfield-bore we sacrifice one of the great gains secured by the breech-loading rifle, namely, that a very small bore may be used, with its concomitant advantages of increased range, penetration, and accuracy, *without* any of the disadvantages which the use of a smaller calibre than .50 in. involves in a muzzle-loader in the shape of difficulty in loading and accumulation of fouling, &c.

This is a point which appears to have been entirely lost sight of by Major-General Boileau in his remarks at page 406, as to the applicability of the Whitworth or Lancaster small-bore to a military breech-loader. Indeed what he there doubts as feasible has actually been accomplished; for, as everybody knows, the Westley Richards' breech-loader has a barrel on the Whitworth principle; indeed it is patented as such.

It is not a little mortifying to our national pride to hear on all occasions of this kind the reiterated remark that they manage these matters differently and better across the Channel; but better this than that we should delude ourselves into a vain notion of superiority in such matters. For several years past experimental breech-loaders

have been tried and tested at the great school of musketry at Vincennes; and in the weapon and ammunition recently served out to the Cent Gardes, the French Emperor appears to have found a breech-loader with which he is satisfied, and so we find that the other morning an imperial order made its appearance, in which it is decreed that *the whole* of the army of France will henceforward be furnished with a small-bore breech-loader (·30, we understand, is the calibre), the cartridge to contain its own ignition.

There is no compromise here—no half-measure. France has had enough of musket—"transformation," and found it a very sorry make-shift; and so the chances are now that the greater portion of the French army will be supplied with breech-loading rifles of surprising efficiency, before we have even commenced the transformation of what the volunteers—perhaps too disparagingly—term "a gas-pipe."

Would it not be well for us to follow so good an example, and instead of tinkering up our old barrels with new breech-pieces, rather at once discontinue the further manufacture of the muzzle-loading Enfield (at present going on as fast as ever), and direct at once our energies and resources to the construction of a good breech-loader, to be served out gradually to the army as the present arm wears out, or as fast as the new arm is ready to relegate the old one to the ranks of the Militia or Volunteer forces?

Be this as it may, however, the momentous question for our service still remains to be answered—*which breech-loader* shall we adopt?

The elucidation of this matter will doubtless occupy the Ordnance Committee for many months (*query*, years?) to come, unless, indeed, the National Rifle Association come to their assistance and settle the matter off-hand.

We may be permitted in the meanwhile to say, that we cannot see why the Association should at all continue the custom of having a competition for *muzzle-loading rifles*—as it proposes, we observe, for November next—under the present circumstances of the universally admitted breech-loading superiority, and since the British army is to be furnished with breech-loaders. It appears to us that the Association might just as well endeavour to elicit the best *long bow* as the best muzzle-loader now, for all purposes of practical utility.

In this breathless age it seems almost like plunging into antiquity to recall the late Wimbledon gathering, yet we must refer here, however briefly, to what undoubtedly formed the most important portion of the programme at that meeting, we mean of course the competition for the prize of £100, given by the Marquis of Tweeddale, for military rifles carrying ·550 ammunition. With a view of attracting the best weapons in either class the money offered was divided as follows:—£50 open to muzzle-loaders, and £50 open to breech-loaders. The conditions under which the contest took place were well calculated to test the qualification of the respective rifles, the stipulation being that each competitor was to fire 100 rounds continuously on four successive days, at 500 yards, until 400 rounds should be expended,—at the termination of each day's shooting the rifle being locked up without having been cleaned, so as to test its shooting under all circumstances

—not merely when fresh from the factory, with every advantage in its favour—thus to demonstrate whether it would bear up against the disadvantages of active service with equal efficiency.

The prize for muzzle-loaders was won by a short large-bore Whitworth, which accomplished the following surprising and marvellous results:—Out of the 400 shots fired on four different days, 1,162 marks were scored, or only 38 marks less than an average of centres. The time occupied in making this splendid practice was 103 minutes, or within a fraction of 4 shots per minute. As this striking and insurmountable evidence of what can be done with a muzzle-loader is certain to be adduced in argument whenever the comparative merits of muzzle and breech-loaders are discussed in future, it is right to state that in the handling of Mr. Whitworth's rifle, the time occupied in loading was reduced to a *minimum* by the use of cartridges specially prepared. These were of a similar description to those patented for use with his small-bore rifle, save that they were made of the regulation size. A paper cylinder contains both the powder and bullet in the order in which these are to descend into the barrel. The bullet acts as a plug at one end of the cylinder; at the other the powder is confined by a little calico and pasteboard slide, which can be pulled away the moment the cartridge case is placed on the top of the barrel. A single downward motion of the ramrod through the cylinder sends the bullet home after the powder; the cartridge case then slips off over the head of the ramrod, and this there is never any occasion to turn, because the point, hollowed slightly into the shape of a cup, gives all the force that is necessary to the charge in ramming home, and immediately that the rod is withdrawn from the barrel it is in the right position to be thrust into the stock.

Mr. Whitworth was also fortunate in his representative Mr. Leece, whose steadiness, quickness, and confidence of aim were very remarkable. This explanation does not involve any disparagement of Mr. Whitworth's rifle. On the contrary, it shows, that having made up his mind to forward what he believed to be the best weapon, he took care to surround it with the best appliances; it proved the great practical utility of such competitions, and elicited the fact that we had much to learn even as to muzzle-loaders. However, their *rivals* and successors *in case* are what most concerns us on the present occasion, and we therefore turn to the results of the *breech-loading* competition.

The rifle that won that prize was made by Mr. Henry, gunmaker, of Edinburgh. Its mechanism may be briefly described as follows: the breech (upper part) acts as a plunger, the back part of it having a double eccentric lever, whilst the front part has a peculiarly inclined face, formed out of the solid steel, which *rights* the position of the cartridge, carries it into the chamber of the barrel, and also extracts the empty cartridge-case on being opened again, and draws it out altogether.

The actual result of its practice on this occasion may be summed up as follows:—In the 400 rounds fired, 1,080 marks or points were made in 68 minutes 32 seconds, giving a value to each shot of 2·7

points, and a rate per minute of 5·84, or nearly 6 shots, which is half the rapidity of the long-bow of our ancient British archers.

THE HENRY BREECH-LOADER.

In awarding the prize to Mr. Henry, the Council took occasion to remark that they did not, however, consider that this breech-loader met all the requirements of a military arm, and this is their reason for initiating with liberal foresight another contest for arms on this principle, the best arm to have £100, the competition to take place next February.

The breech-loader which came next to Henry's in point of merit, appears to have been one called the Snider rifle, closely resembling in principle the Prussian needle-gun. It exceeded the Henry rifle in rapidity of loading, but fell far short of it in point of accuracy.

In conclusion, we have only to remark that the only real difficulty remaining to be overcome in the development of a thoroughly efficient breech-loader for military purposes is in the cartridge itself, the best ammunition being almost a harder problem than the best arm. Those who use breech-loaders over the stubble, or in the forest, have, of course, over and over again congratulated themselves on having at length obtained a cartridge which entirely does away with the "bother of caps." Hitherto, as we have already mentioned, the authorities have studiously (for prudential reasons, no doubt) set their face against the use in the army of a cartridge which shall combine such elements of danger as the presence of the percussion powder, as well as that of the villainous saltpetre. It is obvious that the brass pin which stands out at the right angles of the cartridge (in the Henry breech-loader and in the cartridge for breech-loading fowling-pieces in general), and the blow on which causes the ignition of the fulminating powder, would be extremely likely to be bent from its position, or forced out altogether in the rough handling to which it would be subjected in a campaign.

In the American invention, to which we have referred at page 405, it seems this obstacle of facile derangement is completely obviated. The cartridge is to all appearance similar to that in ordinary use (with sporting breech-loaders), save that it is without the "pin." But a slight beading runs round the circumference of the copper capsule,

which forms the base of the cartridge, and the inside of this rim or periphery is lined with a paste of the fulminating powder, and thus the hammer especially formed for the purpose, striking it through the aperture in the barrel where the pin would have otherwise protruded, on any portion of its surface, will ignite the charge. The likelihood of the derangement referred to above is thus remedied, and there is a minor difficulty (but still a difficulty) also superseded—that of its being necessary to insert the cartridge into the barrel with the pin accurately fitting the groove prepared for it. There is also another advantage claimed for this cartridge. It is asserted that nothing but the peculiar action of the hammer will ignite it. A number of them have been shaken violently together, struck, and thrown down with force on stones, and generally subjected to an elaborate course of rough treatment, with the determined intention of accomplishing their explosion, but all to no purpose. The inventors explain that to do so requires a squeeze as well as a sharp blow, and that, unless the cartridges be inserted in a close-fitting barrel, their elasticity preserves them from the combination of the two.

They are professedly water-tight, and impervious to fire. I have certainly seen some, round which gunpowder has been exploded, apparently quite uninjured.

Mr. Westley Richards, who, by the way, did not enter into the competition for the Marquis of Tweeddale's prize, is engaged, at the request of the Government, in making a breech-loading arm, with a cartridge to contain its own ignition, although he does not appear to be very sanguine as to the result, on account of the expense of the copper case, and the difficulty of extracting such a cartridge after firing from the *small-bore* rifle.

For our own part, we are inclined to believe that this difficulty will eventually find its solution in that wonderful material gun-cotton, 1 drachm of which is capable of effecting as much as 3 drachms of gunpowder, and that too with far less recoil, and a perfect immunity from smoke and fouling.

Experiments made by the Austrian committee proved that 100 rounds could be fired with gun-cotton, against 30 rounds of gunpowder. From the low temperature produced by gun-cotton, the gun does not heat. Experiments showed that 100 rounds were fired with a 6-pounder in 34 minutes, and the gun was raised by gun-cotton to only 122° Fahrenheit, whilst 100 rounds with gunpowder took 100 minutes, and raised the temperature to such a degree that water was instantly evaporated, therefore considerably above the boiling point, or 212°. The firing with the gunpowder was, therefore, discontinued; but the rapid firing with the gun-cotton was continued up to 180 rounds, without any inconvenience. The absence of fouling allows all the mechanism of a gun to have much more exactness than where allowance must be made for fouling. The absence of smoke promotes rapid firing and correct aim. There are no poisonous gases, and the men suffer less inconvenience from firing in casemates, under hatches, or in closed chambers. The fact of smaller recoil from a gun charged with gun-cotton is established by direct experi-

ment; its value is *two-thirds* of the recoil from gunpowder—projectile effect being equal. To understand this may not be easy, unless it results from the greater rapidity of its entire ignition; whilst that of gunpowder, strictly speaking, takes time, the ignition of gun-cotton is instantaneous throughout the mass, and the known causes of recoil with gunpowder are modified accordingly.

The great fact of the instantaneous ignition of gun-cotton, and the generation of all the gas, *before motion commences*, are, it seems, sufficient to account for diminished recoil in the piece.

The comparative advantages of gun-cotton and gunpowder for producing high velocities are shown in the following experiment with a Krupp's cast-steel gun, a 6-pounder. With the ordinary charge, 80 ounces of powder produced 1,338 feet per second. With the charge of $13\frac{1}{2}$ ounces, gun-cotton produced 1,563 feet. The gun may be made shorter; less weight, therefore, to drag, and less difficulty in the working. As to the advantage in weight of gun, the fact of the recoil being less in the ratio of 2 to 3, enables a less weight of gun to be employed, as well as a shorter gun, without the disadvantage to practice arising from lightness of gun.

As regards durance of gun, bronze and cast-iron guns have been fired 1,000 rounds without in the least affecting the endurance of the gun.

As regards conveyance and storage of gun-cotton, it results from the fact that 1lb. of gun-cotton produces an effect exceeding 3lbs. of gunpowder in artillery, that the difficulty of transport will be diminished, and much less room will be required for ammunition. This is an immense advantage, whether it is carried by men, by horses, or in waggons.

It may be placed in store, and preserved with great safety. The danger from explosion does not arise until it is actually *confined* in the requisite space.

It may become damp, and even perfectly wet without injury, and may be dried by mere exposure to the air. This is of great value in ships of war—in case of danger from fire, the magazine may actually be submerged, without permanent injury to the ammunition.

Gun-cotton positively keeps the gun clean, and requires less windage, and therefore performs better in continuous firing. In gunpowder there is 68 per cent. of refuse, or the well-known matter of fouling. In gun-cotton there is no residuum, and therefore no fouling, so that the present elaborate instruction in "cleaning arms" will be at once reduced to a *minimum*, if not annihilated so far as the rifle-barrel is concerned.

Each gun and each kind of projectile requires a certain density of cartridge. Practically, gun-cotton is most effective in guns when used as one-fourth to one-fifth of gunpowder, and occupying a space of $1\frac{1}{6}$ of the length of the powder cartridge.

The mechanical structure of the cartridge is of importance as affecting ignition. The cartridge is formed of a mechanical arrangement of spun cords, and the distribution of these, the place and manner of ignition, the form and proportion of the cartridge, all affect the time of complete ignition. As a cartridge, gun-cotton has to be enclosed in

a manner to prevent its compression, and give it a certain amount of space to do its work. Indeed its gradual instead of instantaneous combustion is altogether dependent on this point being attended to, for whereas the running down or compression within certain limits of gunpowder is essential to its effective action, any such process is fatal to that of gun-cotton, in other words gun-cotton must be simply transferred to the breech of the gun, so as to retain its normal formation or natural degree of textile expansion.

For this purpose, the cartridge, or muzzle-loaders, can either be made up in a strong, hard pasteboard tube, so as to prevent its compression; or the simple cotton-yarn may be wound round a thin-hollow wooden tube like thread on a bobbin, with a sufficient cylindrical thickness to fill the chamber of the gun.

The drawback to this is, as was found during experiments with gun-cotton at Hythe, that the charred remnant of the wood or paper is apt to remain in the barrel, to the detriment and danger of subsequent firing.

The necessity for maintaining the gun-cotton spread out or expanded to the full room it requires, which acts so awkwardly and disadvantageously in a muzzle-loader, becomes of little or no consequence in a breech-loader, in which the chamber intended for the reception of the charge can be so arranged as to permit the gun-cotton to be placed quietly in its appropriate receptacle, without being further interfered with till the moment of final discharge. It is by the complete mastery he has gained over all these minute points, that General von Lenk is enabled to give to the action of gun-cotton on the projectile, any law of force he pleases.

Finally, its cost of production is considerably less than that of gunpowder, the price of quantities which will produce equal effects being compared.

Having thus stated some of the mechanical properties of gun-cotton as an explosive agent, we cannot do better, in conclusion, than answer the question which will not unnaturally present itself to some readers, viz., what *is* gun-cotton, considered chemically?

Gun-cotton, or pyroxilin (*pyr*, fire, and *xylon*, wood) as it is generically termed, was invented in 1846 by the German chemist Schönbein; and although the announcement produced considerable sensation at the time, it had, until recently, ceased to occupy the minds of those whom the invention chiefly concerned—the military profession. “Punch,” indeed, gave significance to it by figuring a meeting between Guy-Fawkes and Schönbein on Westminster Bridge; the former regretting that the latter had not been his contemporary with his invention. Certainly there might have been no “joke” in the matter, at the present day, about “the Plot,” had gun-cotton been at the disposal of the arch-conspirator.

The “report,” like all other reports, died away; and gun-cotton, far from being generally applied even to mining operations, was merely made the substance of a thick mucilage, dissolved in ether, to serve by way of sticking plaster. Subsequently, however, photography took it in hand, and found its ethereal solution a perfect means of

presenting to light the sensitive surface for the production of it beautiful pictures; for the collodion of the photographers is merely gun-cotton dissolved in sulphuric ether, and mixed with an iodide which by being immersed in a bath of nitrate of silver, becomes iodide of silver, the most sensitive to light of all substances as yet discovered.

The recent Austrian Commission, and the conclusive investigations of Baron von Lenk, have completely restored to this giant of the chemist's laboratory its "proud eminence;" and, like gunpowder of old, after having been used for every purpose but the right one, in our *professional* point of view, it now finds itself exalted to the position of the most available agent for the purposes of warfare.

The manufacture of gun-cotton is one of the simplest manipulations of the laboratory. First, make a mixture of equal measures of strong nitric acid (sp. gr. 1.5), and sulphuric acid (sp. gr. 1.845). Then take one part—say 1 oz.—of finely carded cotton-wool, and immerse it in 15 parts of the above mixture. Instantly great heat is generated by the chemical action which ensues, and therefore this is the ticklish point of the manufacture. The cotton must be at once completely immersed in the mixture, otherwise it becomes so hot as to undergo immediate decomposition.

After a few minutes' immersion, the cotton must be taken out and plunged into a large volume of cold water, and then carefully washed in other water, until the mass ceases to show the slightest acid re-action when touched by litmus paper or placed upon it. It must then be carefully dried. Of course it will dry of itself in the air; but at all events, if artificial heat be used for the purpose, it must not exceed 170°.

Such is gun-cotton; and it is evident to the reader that it contains all the elements of gunpowder; the *nitre* of the nitric acid, the *sulphur* of the sulphuric acid, and the *carbon* (or "charcoal") of the cotton; its explosive or detonating property can therefore be readily conceived.

Tow, linen, paper, nay, even *saw-dust*, may be used instead of cotton; and in the last case it is evident that gun-cotton might be made to assume the form of *powder*, and so perhaps become more convenient for military purposes. The wood best suited for the manufacture of gunpowder might be treated in this way with the view of testing the feasibility of the suggestion, which we submit to the manufacturers.

The chemical change develops new properties in the substance; the cotton fibre increases more than 80 per cent. in weight; although differing very little in appearance from unchanged cotton, it may be distinguished from it by its harshness to the touch, by the crepitating sound which it yields when pressed by the hand, and by its *electric* condition. The only certain means, however, of distinguishing the explosive substance from ordinary cotton, is by the chemical action of iodine dissolved in a solution of iodide of potassium. When the former is moistened with this iodine solution, and a little sulphuric acid is subsequently added (one part of acid to four of water), a *yellow*

colour is evolved; whilst ordinary cotton, when similarly treated, assumes a *blue* colour.

In the open air gun-cotton burns with a flash, but without smoke or report; and a temperature of somewhat less than 400° is sufficient to ignite it, being 200° less than that required to ignite gunpowder. Authorities, however, differ very much as to the required temperature, which seems to vary with the mode in which the gun-cotton is prepared. Some specimens have exploded when being dried at a temperature of not more than 132° .

Up to the publication of the Austrian Report, the real properties and effects of gun-cotton were little understood. It can be exploded in any quantity instantaneously. This was considered its great fault; but it was only a fault when we were ignorant of the means to make that velocity anything we pleased. General von Lenk has discovered the means of giving gun-cotton any velocity of explosion that is required, by the mere mechanical arrangements under which it is used. In his hands, gun-cotton has any speed of explosion; from one foot per second, to one foot in the *one-thousandth* of a second, or to instantaneity.

The instantaneous explosion of a large quantity of gun-cotton is made use of when it is required to produce destructive effects on the surrounding material. The slow combustion is used when it is required to produce manageable power, as in the case of gunnery.

It is plain, therefore, that if we can explode a large mass instantaneously, we get out of the gases so exploded the greatest possible power, because all the gas is generated *before motion commences*; and this is known to be the condition for maximum effect. The great waste of gunpowder is almost ridiculous; it is positively 68 per cent. of its own weight, and only 32 per cent. is useful. Moreover, this 68 per cent. is not only waste in itself, but it wastes the power of the remaining 32 per cent. It wastes it mechanically, by using up a large portion of the mechanical force of the useful gases. The waste of gunpowder issues from the gun with much greater velocity than the projectile; and if it be remembered that in 100lbs. of useful gunpowder, this is 68lbs., it will appear that the gas of 32lbs. of useful gunpowder is wasted in impelling a 68lb. shot; the power resulting merely from the refuse of gunpowder!

It is found that the condition necessary in gun-cotton to produce instantaneous and complete explosion, is the absolute perfection of closeness in the chamber containing the material. The reason of it is, that the first-ignited gases must penetrate the whole mass of the cotton; and this they certainly do, and effect complete ignition throughout, only *under pressure*. This pressure need not be great. For example, a barrel of gun-cotton will produce little effect, and very slow combustion, when out of the barrel, but instantaneous and powerful explosion when shut up within it.

On the other hand, if we desire gun-cotton to produce mechanical work, and not the destruction of materials, we must provide for its slower combustion. It must be distributed and opened out mechanically, so as to occupy a larger space, and in this state it can be made to act

even more slowly than gunpowder, and the exact limit for purposes of artillery General von Lenk has discovered by critical experiments. In general it is found that the proportion of 11lbs. of gun-cotton, occupying one cubic foot of space, produces a greater force than gunpowder, of which from 50 to 60lbs. occupies the same space, and a force of the nature required for ordinary artillery.

For artillery, gun-cotton is used in the form of thread or spun-yarn. In this simple form it conducts combustion slowly in the open air, at a rate of not more than one foot per second. This thread is woven into a texture or circular web. The webs are made of various diameters, and it is out of these webs that common rifle cartridges are made, merely by cutting them into proper lengths, and inclosing them in stiff cylinders of pasteboard, which form the cartridges. In this shape its combustion takes place at the speed of 10 feet per second.

In these cylindrical webs it is also used to fill explosive shells, as it can be conveniently employed in this shape to pass through the neck of the shell.

Gun-cotton thread is spun into ropes in the usual way up to two inches in diameter, hollow in the centre. This is the form used for blasting and mining purposes; it combines great density with speedy explosion.

The gun-cotton yarn is used directly to form cartridges for large guns by being wound round a bobbin so as to form a spindle, like that used in spinning-mills. The bobbin is a hollow tube of paper or wood. The object of the wooden tube is to secure in all cases the necessary length of chamber in the gun required for the most effective explosion. The gun-cotton circular web is inclosed in close tubes of india-rubber cloth, to form a match line, in which form it is most convenient, and travels with speed and certainty. In large quantities, for the explosion of mines, it is used in the form of rope, and in this form it is conveniently coiled in casks, or stowed in boxes.

As regards the practical application of gun-cotton to the destructive explosion of shells, it appears that, from a difference in the law of expansion, arising probably from the pressure of water in intensely heated steam, there is an extraordinary difference of result, namely, that the same shell is exploded by the same volume of gas into more than double the number of pieces. This is to be accounted for by the greater velocity of explosion when gun-cotton is confined very closely in very small spaces. It is also a peculiarity that the stronger the shell the smaller the fragments into which it is broken.

In mining operations, the fact that the action of gun-cotton is violent and rapid in exact proportion to the resistance it encounters, tells us the secret of its far higher efficacy in mining than gunpowder. The stronger the rock, the less gun-cotton, comparatively with gunpowder, is necessary for the effect; so much so, that while gun-cotton is stronger than powder as 3 to 1 in artillery, as before stated, it is stronger in the proportion of 6.274 to 1 in a strong and solid rock—weight for weight. It is the hollow rope form that is used for blasting. Its power of splitting up the material is regulated exactly as wished.

With respect to military and submarine explosion, it is a well-

known fact that a bag of gunpowder nailed on the gates of a city will blow them open. In this case gun-cotton would certainly fail; a bag of gun-cotton exploded in the same way is powerless. If one ounce of gunpowder is exploded in scales, the balance is thrown down; with an equal force from gun-cotton nothing happens. But to blow up the gates of a city a very few pounds of gun-cotton, carried in the *hand of a single man*, will be sufficient, only he must know its nature. In a bag it is harmless; exploded in a box it will shatter the gates to atoms. Against the palisades of a fortification a small square box, containing 25 lbs., merely flung down close to it, will open a passage for troops. In actual experiment on palisades, 1 foot in diameter, and 8 ft. high, piled in the ground, backed by a second row of 8 inches diameter, a box of 25 lbs. of gun-cotton cut a clean opening 9 ft. wide. In this case three times the weight of gunpowder produced no effect whatever, except to blacken the piles.

Against bridges it is equally formidable. A strong bridge of oak, 24 feet span, was shattered to atoms by a small box of 25 lbs., laid on its centre. The bridge was not broken, it was literally shivered.

The effects of gun-cotton under water are not less striking and conclusive in its favour, as compared with gunpowder. In the case of two tiers of piles, in water 13 feet deep, 10 inches apart, with stones between them, a barrel of 100 lbs. of gun-cotton, placed 3 feet from the face, and 8 feet under water, made a clean sweep through a radius of 15 feet, and raised the water 200 feet. In Venice, a barrel of 400 lbs., placed near a sloop in 10 feet water, at 18 feet distance, flung it in atoms to a height of 400 feet!

All the experiments made by the Austrian Artillery Commission or Committee were conducted on a grand scale, 36 batteries, 6 and 12-pounders (for gun-cotton) having been constructed and practised with that material. The reports of the Commissioners are all based on trials with ordnance, from 6-pounders to 48-pounders, smooth bore and rifled cannon.

Such then are the properties and effects of gun-cotton. We are aware that exceptions may be taken as to certain parts elicited and claimed as advantages in the new material as an agent in warfare, such as the diminished heat of the gas and the shorter gun required.

Thus we learn in a recent investigation, conducted at the French Academy of Science by M. Pelouze, one of the chemists who wrote a report against gun-cotton in 1849, in conjunction with a M. Maurey, with the view of testing the value of General Lenk's process of manufacturing gun-cotton compared with that in France, that while admitting a difference of chemical composition between the two varieties, they affirm that all their specimens of his cotton exploded at a temperature of 180° Fah., and that at temperatures as low as 99 Fah., decomposition ensued with equal certainty, but only in the course of a few hours, and in one case they even obtained an explosion at 83°, which induced them to "suspect" that it may even be decomposed at the ordinary temperature.* Yet in the face of such a

* This spontaneous decomposition passes through four different stages. At first it contracts slowly without losing its primitive form and texture, so that its volume

conclusion, they admit that General Lenk had been able to fire 1,000 rounds in quick succession from a piece of ordnance without spoiling the bore of the gun, or without any apparent tendency in the gun-cotton to ignite spontaneously from the high temperature to which the gun-metal assuredly must have been raised after so many quick successive discharges. Facts are stubborn things, and if such as have here been quoted can be established by the Austrian Commission, it will be futile to "reason" them away, for, as Galileo says, "when we have the decrees of nature, authority goes for nothing." Preconceived, scientific inductions, based on the action of gunpowder gas, cannot be quoted in opposition to the facts established on gun-cotton.

The expansive and motive force of gunpowder is doubtless materially connected with its heat, but facts seem to prove that this is not a condition so essential in gun-cotton; and the learned objectors should rather try and find out the reason for the apparent anomaly, than preach it as an impossibility, from a text recorded under a different dispensation.

The same remark applies to the shortness of gun required for gun-cotton. Beyond a certain limit, it is certain that length of gun is a disadvantage; and accepting the facts of the Austrian Commission, we do not see that the objection opens any other question than the adequate length of gun for maximum effect.

It is satisfactory to know that at their last meeting (1863) the British Association passed a resolution urging the Government to appoint a commission, by means of which a more complete investigation—and such as the subject unquestionably deserves—may be made and practically applied. This recommendation has not been without its effect, and we rejoice to find that the War Office has appointed a committee on gun-cotton, with the President of the Royal Society as chairman, and that they have instituted a number of experiments, which are to demonstrate the superiority of gun-cotton over gun-

becomes ten times less than its original one. A few days later it becomes soft, and is transformed into a sort of gummy matter which adheres strongly to the fingers, and has no longer any appearance of texture or organization whatever, even when viewed through the microscope. When this mass has become quite homogeneous, its volume is again reduced by one-half. The third stage, which occurs some considerable time after, instead of producing any further contraction, causes an expansion, so that the substance, reduced as it is to one-nineteenth of its original volume, swells up to the full extent of the latter. In this state it is still gummy, but the mass is porous, and full of cavities like a sponge. During these three stages there is a constant evolution of nitrous vapours, which become much more abundant during the third stage. This evolution of gas gradually diminishes during the fourth stage; the substance slowly loses its gummy quality and yellowish colour, and becomes so friable as to admit of being crushed into powder between one's fingers; it then becomes as white as sugar. It takes at least five months to see all these stages passed through. The sugary substance is very acid, nearly entirely soluble in water, and is composed of glucose, gummy substances, oxalic acid, a little formic acid, and another which M. de Luca thinks is new, and with which for the present he has obtained salts of lead and silver. The glucose contained in this last transformation of gun-cotton has the taste and even the flavour of honey; it quickly reduces the tartrate of copper and potash, and ferments in contact with yeast, producing carbonic acid and alcohol. It appears from M. de Luca's experiments that gun-cotton will keep indefinitely *in vacuo*.

powder, not only for war, but for industrial purposes. The cotton has been tried in one of the mining districts of Wales, and is now undergoing trial in the lead-mines of Allenheads, in Northumberland; while the gun-cotton factory at Stowmarket is kept busy with the manufacture.

Whatever has been done up to this time, it is to be hoped that England will not remain behind-hand in a matter of such great and national importance, for we have no hesitation in maintaining that the introduction of gun-cotton into warfare will effect as great a revolution as that produced by gunpowder of old.

Compared with the latter, in its beginning, gun-cotton is a *perfect* thing, of which we have become possessed—completely meeting all our present difficulties, supplying all our wants, and giving the last perfection to the soldier's weapon. Surely, the high exaltation predicted by Robins of old to "the state that shall thoroughly comprehend the nature and advantages of rifled barrel-pieces, and having facilitated and completed their construction, shall introduce into its service their general use, with a dexterity in the management of them"—is even more applicable to this wonderful invention, which is now offered by science and art to warfare, in order to make it sharp, short, and decisive.

And then? Well, then possibly "the goal of yesterday will be the starting point of to-morrow." The ordinary breech-loader may eventually have to make way for a breech-loading *revolver* (or what the Yankees term "repeater"*) with an indestructible steel rifled-barrel, capable of letting one man do what it before required many more times that number to accomplish, in accordance with the universal tendency of our age to substitute mechanical means for manual.

But for a time, at least, a good breech-loader, with gun-cotton, will be, if not perfection in the fire-arm, the nearest approximation to it we can hope at present to attain. Imagine the future battle-field unclouded with smoke—clear as the hand-to-hand encounters of the ancient warriors, who never lost sight of their enemy. Then, indeed, our tactics will have to be modified, if we are to play our part successfully on the battle-fields of Europe or America—battle-fields which will probably become more bloody than ever.

But we must not permit these facts and hopes held forth by this new agent of destruction to produce any present stagnation in our efforts for advancement; but rather, content with the materials thus far practically placed within our reach,

"Forward! forward let us range!"

* In accounts recently brought from America, it is distinctly stated that some Federal cavalry regiments are armed with *sixteen-shooter* rifles! (equivalent to a sixteen-chambered revolver); and, on the other hand, we learn that the Confederates have introduced a self-feeding rifle, the cartridges (containing their own ignition) being first placed in a receptacle hollowed out for them in the stock, and supplied in rapid succession to the barrel by the mere action of full cocking the piece. With such means of destruction, the American war must surely, ere long, bear some analogy to that waged by the Kilkenny Cats.—A.W.

DESCRIPTION OF BREECH-LOADERS ON PLATE XXXI.

WESTLEY RICHARDS'.

Fig. 8 represents cartridge inserted and breech closed.

Fig. 9 shows breech open to receive cartridge.

Fig. 10, appearance of rifle, with breech closed.

TERRY'S.

Fig. 11, side elevation of musket, with breech apparatus.

Fig. 12, breech apparatus, with cartridge inserted in barrel.

Fig. 13, breech apparatus detached, closed up to breech.

Fig. 14, enlarged view of breech apparatus.

GREEN'S.

Fig. 15, side view partly in section, showing breech apparatus.

Fig. 16, piston or bolt, and the cover of the breech chamber.

Fig. 17, transverse section of the cover of the breech chamber and piston, or bolt.

Fig. 18, end view of ditto.

Fig. 19, breech-plug loose in breech plate, which partly turns round in plate.

Fig. 20, side view, with breech closed, and ready for capping.

MONT-STORM'S.

Fig. 21, side elevation of Enfield rifle fitted with Mont-Storm's breech-loading chamber.

Fig. 22, breech raised, showing cartridge in chamber.

Fig. 23, side view, partly in section, showing position of breech at the moment of firing.

 LIEUT.-COLONEL DAVIDSON'S PATENT TELESCOPIC RIFLE SIGHT.*

THE telescopic sight for military and long range rifles patented by me may be described as follows:—

The telescope is contained in a strong steel tube, and is attached to the side of the rifle, so as to meet the eye in presenting; and is capable of being depressed to any required angle, according to the range.

A reference to the diagrams Figures 1 to 8 (Plate XXXII), which are on the scale of one-half, will explain how it is attached to the rifle, with its eye-piece pulled out to focus, and the telescope set for two degrees of elevation.

A and B are collars firmly fitted to the telescope, A at the object end, and B a few inches from the eye end. The front collar A is furnished with an arc C, divided from zero to 12 degrees of elevation. The exact shape of this collar will be seen from the other three views

* A paper contributed by Lieutenant-Colonel D. Davidson, 1st City Edinburgh Rifle Vols., and late H. M. Bombay Army.—Ed.