



## Gun-Cotton Cartridges—Prentice's System

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question is to measure, to judge, and to estimate the intervening angles, that is an angle between the four points and the end on or between four points and any greater angle. For that reason the proportion of height is necessary; because if the proportion varied, the angle between the lights when seen obliquely would be very different. For instance if one ship adhered to this proportion, she would show her lights, at two points, in the position shown in the diagram; whereas, if another vessel showed her bright light at a lower level, she would show it at a different angle, and thereby represent herself as steering a different course. For that reason proportion is necessary, and for no other. But the particular proportion of the equilateral triangle is not essential, the principle being that a proportion be fixed and universal.

Mr. ROTHERY: Quite so. Captain Craufurd's principal remark was about the necessity of a good look-out and a good eye. I believe it cannot be disputed, that with the best eyes and the best look-out, you cannot tell a ship's course. That is the case. I do not think I have made any mistake in that diagram (No. 1). The green light there shows nothing; you may keep as good a look-out as you can, and yet the green light will show you nothing except that the starboard side of the vessel is presented towards you, from a line very nearly ahead to ten points round the compass. It is no guide to the course of the ship; and it is necessary to know the course of a ship to avoid collision.

Mr. HARPER: One remark. With respect to the height, it seems to me that the lower the light, the more distinct it would be.

Captain HEATHCOTE: That is what I say. I believe the equilateral triangle is not the best. The better proportion is when the height of the mast-head light is equal to half the distance between the side lights. You will observe that with this proportion the angles are more easily read than with the equilateral triangle. But a possible objection to that occurs to me, that the white light, at that height above the level of the side lights, might in small vessels be too low.

The CHAIRMAN: I must confine myself to very brief observations. I feel perfectly certain that we have not had sufficient time to discuss the subject on hand, for we have only partially entered into it. I trust it will be resumed another evening this session. I would only say at the present moment, with respect to the difficulty of placing the red and white lights before the foremast, I see a difficulty in trimming them when you get into a sea. That is a difficulty which, as a practical seaman, I am afraid of. I will not detain you any longer, except to ask you to join me in a vote of thanks to Captain Heathcote, for the able manner in which he has brought this matter forward.

## GUN-COTTON CARTRIDGES—PRENTICE'S SYSTEM.

By MR. JOHN LATHAM, 27, Pall Mall.

In bringing before you this evening a short description of the new gun-cotton cartridges which have been lately introduced for breech-loading arms, and which are undoubtedly the first successful application of this material for sporting purposes, I feel that a few words are necessary to explain what may appear to be presumption on my part in undertaking a subject on which you have had so much previous information. In Mr. Abel's admirable lecture delivered in this Institution two years since, you have the fullest account of the chemistry of the subject, and into this I do not propose to enter, except as far as may be necessary to explain the reason of the mechanical arrange-

ments adopted. In short, I can only profess to give you my own experience as that of a practical gunmaker who has taken great interest in the application of this material to small arms; leaving aside the questions of its employment for artillery and blasting purposes, as well as the chemistry and philosophy of the subject, which have already been brought before you by gentlemen better qualified than myself to deal with these points.

You will remember the excitement with which the news of Professor Schönbein's discovery was hailed when it was first made known in 1846. The superior power, the cleanliness, and many other advantages of the new material, and the ease with which it could be manufactured in small quantities, set all the world experimenting with it, and nothing less than the speedy abolition of gunpowder was expected. Under the direction of Mr. Henry Wilkinson, I was one of the number who entered eagerly into a course of experiments, and soon became aware that the management of this new projectile force was by no means the easy matter which at first it appeared to be. On two occasions the cotton I produced exploded in the process of drying in a water-bath, at a heat considerably below 200°. Some other specimens, prepared with the same manipulation, could hardly be induced to explode at all. Even when an apparently definite product had been obtained, its behaviour as a projectile force was extremely capricious. At one time 15 grains of cotton would send a 30 guage bullet through three inch deal planks, giving as much projectile force as 50 grains of gunpowder, and the very next shot with the same weight of the same cotton would hardly have strength enough to indent the wood. But the advantages of the new material, when it could be induced to do its work properly, were so great that an attempt was at once made to introduce it commercially, and the patent was purchased by Messrs. Hall, the well-known gunpowder manufacturers at Faversham, who established a large factory for its production. I have here specimens of gun-cotton procured from them in 1846, which, after the lapse of 20 years, have lost none of their original qualities. These specimens are all of cotton wool, which was the only form of the material then employed, and one of them, as you will see, is coloured blue, a plan which was proposed to avoid the chance of accident from the resemblance of the explosive cotton to the ordinary material. The charges employed for sporting arms consisted of 20 grains by weight of this cotton wool, slightly compressed, so as to form a ball, and glued to a wad which fitted the gun. This charge was used with one ounce of shot in a 16-bore muzzle-loader, and made very good shooting, though too irregular to be depended upon. Gun-cotton was also employed for blasting purposes, but some lamentable accidents which occurred in the filling and "tamping" of the holes brought it into discredit, and finally the explosion of Messrs. Hall's factory, with the loss of several lives, caused the manufacture to be abandoned. About the same time experiments in France and Germany were brought to a close for similar reasons. Spontaneous combustion was suspected or feared. I am not aware that it was ever definitely proved, but the idea of gun-cotton as a practical agent was given up, and it was only

brought forward in lectures on gunpowder as a type of all that was most to be avoided as a projectile force.

In short, having become aware that gun-cotton, when used in the same way as gunpowder, was too dangerous and uncertain to be employed, the question was left, in England at least, without further investigation for nearly fifteen years. In the meantime, Mons. Montigny, the well-known gunmaker of Brussels, introduced a breech-loading rifle on the needle principle, in which he enclosed a small charge of gun-cotton in the body of the projectile, and the thrust of the needle piercing through this body of cotton ignited a small pellet of fulminating powder in front. We can now see by the light of our present experience that he could not possibly have devised an arrangement better calculated for bursting the rifle in which such a cartridge was fired, and this was actually the case in so many instances that this plan was soon abandoned. The only other attempt that I am aware of to revive the employment of gun-cotton was made in 1855 by Captain Norton, to whose fertile invention we owe the first indications of so many of our modern improvements in gunnery. I have here a specimen of Captain Norton's cartridge; the charge of gun-cotton rolled into a ball is enclosed in a covering of paper with netting outside, the arrangement bearing a considerable resemblance to the plan at present adopted for sporting cartridges.

It must not be supposed, however, that because gun-cotton was abandoned for projectile purposes its manufacture was discontinued. Its employment in photography as the base of the well-known collodion caused a constant demand for it; but it was found at first as capricious and uncertain a servant for artistic as for military purposes. Some spoke of a "solution of gun-cotton in ether," whilst others found their gun-cotton obstinately refusing to dissolve in that substance. Other extraordinary anomalies in its action were found, and the whole subject was obscure until the publication in the *Journal of the Chemical Society* of an elaborate series of researches by Mr. Hadow, of Bristol, which were conducted in the laboratory of King's College, London. He first showed us the true chemical constitution of pyroxyline, and established the fact of there being at least four varieties produced by the usually received process—the differences being caused by variations in the strength of the acid used, the temperature of immersion, &c. He designated those varieties by the letters A, B, C, D. Of these the first compound A is the most explosive, containing the largest amount of peroxide of nitrogen, and is insoluble in ether. This is produced by the strongest acid which can be employed, and this compound which Mr. Hadow holds up to the avoidance of all good photographers is the only one with which we are interested in gunnery. But the value of his researches is this, that it is precisely the presence of the lower compounds B, C, and D, which, however valuable they may be in photography, have given rise to many of the defects of the old gun-cotton. These explode at a very low temperature, and are liable to spontaneous decomposition, if not combustion, by keeping. It was, therefore, a great advance when we learnt from Mr. Hadow how to avoid these in our gun-cotton.

But our difficulty with regard to the capriciousness of the force produced still remained; we could hardly tell when we ignited a charge of gun-cotton what the result would be, and as one, at least, among the possibilities was the bursting of the gun, it is not surprising that the experimentalists were few. In short our knowledge of gun-cotton up to 1862 may be summed up in the words of a German writer of that date, of which the following is a translation:—

“Gun-cotton,” he says, “is an ideal force, a non plus ultra force. Incapable of any modification, he is a stubborn ‘*mauvais sujet*’ of noble family, who, wherever he makes his appearance, behaves with terrific violence, and won’t accommodate himself in the least to existing arrangements, conducting himself like an autocrat or a revolutionist of the first order, he demands that everything shall consult his convenience, that the whole edifice (of our fire-arms) raised upon the basis of centuries shall be overturned because, forsooth, he has appeared on the scene.”

About 1862 it became known in England that gun-cotton had been in use in Austria for some years, and that certain modifications introduced by Baron von Lenk, a general officer in the Austrian army, had proved so successful that the whole of the artillery service had been adapted for its employment under the direction of that officer, who published in 1862 a work under the title of “*Das gezogene Schieszwollfeld-und Gebirgsgeschütz*” (nach Lenk’s System).

As this showed that considerable progress had really been made, Mr. Abel, Chemist to the War Department at Woolwich, was commissioned by the English Government to examine into the subject, and that gentlemen has himself laid before you the results of his investigation. Without entering into the chemistry of the subject, I may briefly state the principal points in which we are indebted to General von Lenk for an advance upon our previous knowledge.

If the process given by the original inventor, and detailed in the patent taken out in England by John Taylor, in October, 1846, be strictly followed, the resulting compound is undoubtedly the most explosive form of gun-cotton, and the specimens I have shown you prove sufficiently that this substance is permanent and unaltered after a lapse of twenty years. But the substance then employed—loose carded cotton, or cotton wool as it is generally termed—cannot be sufficiently modified in its mechanical arrangement to produce the result we want in a projectile force, viz., a gradual combustion or evolution of gas, as distinguished from instantaneous combustion or explosion.

General von Lenk obtains the controlling power required by the simple expedient of employing cotton in the form of loose yarn or thread which is afterwards woven into cord, thread, or hollow braid, according to the rapidity of combustion which he requires. By this means he effects for gun-cotton an improvement similar in kind, but even more extensive in effect than the improvement which is effected in gunpowder by the process of granulation, and he is enabled to modify the rate at which the gun-cotton will burn from the most violent detonation down to simple combustion. Another and very curious

point which he established was this—that the explosion of gun-cotton is materially affected by the manner in which it is lighted. Thus if lighted with a large flame or great body of heat, the combustion is vivid and intense; but if only a small spark be applied the result is apparently a rapid smouldering of the material without any flame. You will see how this peculiarity affects its use in fire-arms, since a copper cap of double the usual strength may start the combustion of this material so rapidly as to render it uncontrollable, whilst a cap that hangs fire from damp or other causes may cause the charge to lose much of its force.

For cannon and small-arm cartridges Baron von Lenk employed gun-cotton yarn twisted tightly round a hollow cylinder or spindle of wood, so that the combustion proceeded from the exterior surface towards the interior of the cartridge. For quick-match and bursting charges for shells he employed hollow braid, in which the burning gases, traversing the interior of the material, cause a more rapid and intense combustion such as you have seen in the previous experiments.

In 1863 a short account of General von Lenk's discoveries was read at the meeting of the British Association, at which Mr. Prentice, of the firm of Messrs. T. Prentice and Co. of Stowmarket, in Suffolk, was present. Messrs. Prentice have for years been largely engaged in the manufacture of artificial manures, and employ great quantities of nitric and sulphuric acids in their business. Mr. Prentice entertained the idea of establishing a manufactory of gun-cotton at his works, and no small portion of the success which has been achieved in England is owing to this fortunate circumstance, whereby the manufacture has been undertaken by a gentleman already thoroughly conversant with the chemical properties of the substances employed, and who has been thus enabled not only to reduce the necessary dangers of the manufacture, but to introduce important improvements in the application of gun-cotton. The works extend over nearly an acre and a half of ground, traversed by a stream of running water, which is employed for washing the cotton and for filling the magazines, for the stock of this material is kept constantly under water from the time of its manufacture until it is required for actual use. You have here specimens of the cotton as it is received at the works in the form of coarse loosely-spun yarn and fine thread. These are first freed from dirt and grease by dipping in a hot solution of potash, and thoroughly washed and dried before transferring them to the bath of the mixed acids, in which they remain for forty-eight hours, being kept cool during the process by the immersion of the jars in a stream of running water. The omission of this precaution was one great cause of the uncertain quality of the old gun-cotton, as, if the temperature be allowed to rise above 60°, there will be great danger of the formation of some of the lower and unstable forms of gun-cotton. On removal from the acid-bath the cotton is placed in a centrifugal drying-machine, which removes the surplus acid in the same way that a mop is dried by trundling it; the cotton is then thrown under a fall of water, and finally laid in running water for fourteen days to complete the washing. After a very dilute alkaline-bath it is finally immersed in a hot solution

of soluble glass, of which it takes up a very small quantity. It is on the advisability of this process that our English chemists are at variance with General von Lenk, who recommends it, but as the only objection that can be urged is that it is probably useless, we may pass it over without further comment. After a final washing the cotton, which we ought now to designate by the formidable name of trinitro-cellulose, is in a fit state to be manufactured into cartridges. Every stage of the manufacture is carefully tested from day to day, and no precaution is spared to ensure the perfection of the results. The thread, whilst still wet, is woven into solid or hollow braid, and stowed under water until required.

These specimens will give you a clear idea of the mechanical means by which the combustion may be modified to any speed of explosion required, and you will remember that to produce a propelling as distinct from a shattering force, we require the slowest form of combustion. But there is one point more which requires attention, and without it we shall still be unable to get regularity of shooting. You may remember that in speaking of the earlier experiments with gun-cotton I mentioned the extraordinary variation in the results produced with equal charges of this material. The principal cause of this irregularity is so simple that it is only remarkable how it escaped attention for so long. I will explode a few grains of gun-cotton and an equal quantity of gunpowder, and you will notice the difference of the thin invisible gas produced by the one and the thick black smoke of the other. But in all the early experiments we were using the same wadding to confine both, and the consequence was that the thin gases of the gun-cotton often escaped past the wad without exerting any projectile force on the charge. To obtain the maximum effect with gun-cotton, it is necessary that the chamber in which it is exploded should be closed as perfectly as possible, and it is only when a very tightly-fitting and hard wad is used that regularity of shooting can be obtained. These conditions render it especially difficult to employ gun-cotton for muzzle-loading arms. The necessary tightness of the wadding requires greater force to ram it down the barrel, and if rammed in the least degree too hard, the mechanical arrangement of the cotton may be disturbed, and its rate of combustion altered. But in breech-loading cartridges these difficulties do not exist; and it is satisfactory to note that the improvements in our projectile forces keep equal step with the improvements in projectile arms, each assisting and supplementing the other.

The material employed in small-arm cartridges is the closely woven braid, but the rate of combustion in this is still too rapid. It is therefore enclosed in a small cylinder of waxed paper or cardboard (Fig. 2), and subjected to hydraulic pressure until it is compressed into two-thirds of its original bulk. This small cylinder performs two very important offices—first, by compressing the material it retards and regulates the rate of combustion, and it also directs the force of the gases upon the shot, and prevents, to a certain extent, the strain upon the sides of the barrel. If I light one of these cylinders you will see the steady regular flame with which it burns. But in the gun it burns at double

this rate because it is ignited at both ends, and to effect this, it is enveloped in a small piece of gun-cotton muslin, which communicates the flash of the cap instantaneously around it (Fig. 1). It is this combination of quick and slow combustion which is found necessary to produce the best results, and this arrangement is one of the improvements introduced by Messrs. Prentice on Baron von Lenk's system.

FIG. 1.

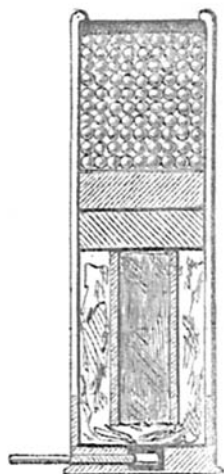
Gun-cotton Cartridge.  
(Section.)

FIG. 2.

Pasteboard Case containing  
Compressed Gun-cotton.

These cartridges which have only been introduced during the past season for sporting purposes, have achieved a success which already great, will no doubt increase as they become generally known. Their advantages as compared with gunpowder are the lessened report, diminished recoil, and absence of fouling and heating of the gun. An animated discussion has taken place on the question of their safety, and I ought perhaps to say a few words on this. When used with the ordinary Lefauchaux double-grip action, and in a pair of good Damascus barrels, they are perfectly safe, but in some of the guns made in the present day with very light barrels, and especially if these are of any of the varieties of so-called "steel," greater caution will be necessary. For the new central fire breech-loaders, the cartridge must be specially constructed. In short, as you may judge from the extent and variety of the circumstances which affect the combustion of gun-cotton, it is very dangerous for any, but the most experienced to make experiments with it.

It is obvious that the arrangement of these cartridges is open to some objection on the score of complication. It is not possible to vary the charge, since the addition of a few grains of gun-cotton unless all the other parts of the cartridge were modified to suit it, would throw



out the action of the whole. And this is at present one of the greatest obstacles to its general adoption. If the cylinder containing the compressed charge, and the ruslin envelope could be dispensed with, and the combustion of the simple rope of cotton so controlled that all chance of the development of a shattering force be avoided, this rope could be safely supplied in length from which sportsmen could charge their own cartridges by simply cutting off the portion required, we should have overcome the greatest obstacle to the general employment of gun-cotton. I am happy to be able to state that there is every prospect of this desideratum being very speedily accomplished. A modification of the manufacturing process has just been patented by Messrs. Prentice, which, if it prove as successful as the first experiments indicate, will be the greatest step in advance which has yet been made in the employment of gun-cotton. All these complicated contrivances for regulating the combustion will be dispensed with, and all fear of a shattering explosion will be obviated. The cotton will be supplied in the form of a simple rope, which can be used with as much simplicity and certainty as the measuring of a charge of gunpowder. This improvement consists in weaving raw or unconverted cotton with the explosive material in sufficient quantities to moderate the combustion to the degree required.

By permission of the Council the case of specimens now on the table will be deposited for a short time in the Museum of the Institution. I have also a specimen of the new gunpowder, or rather gun-sawdust, lately invented by Captain Schulze, at Potsdam, in Prussia. As this has only just been received, I am unable to give you any information as to its projectile force in comparison with gunpowder or gun-cotton, but if I ignite a small charge of it you will notice the beautiful white flame with which it burns, almost rivalling magnesium in brilliancy, and the small quantity of residue left after combustion.

**THE CHAIRMAN:** I am sure that I express the feelings of this meeting in giving our best thanks to Mr. Latham for the interesting paper he has laid before us.

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Monday Evening, June 18th, 1866.

**VICE-ADMIRAL J. II. CODRINGTON, C.B.,** in the Chair.

**ADJOURNED DISCUSSION ON CAPTAIN HEATHCOTE'S PAPER.**

**THE CHAIRMAN:** Captain Heathcote has been kind enough to come here this evening with the view of a further discussion taking place on the subject which he introduced to us at a former meeting, and the reading of the paper on which subject, has given us much pleasure and a great deal of information; and also in the hope that other officers may make suggestions on the subject, so that we may all of us be able to form opinions as to the best system for preventing collisions at sea at night. I think it would be desirable, if Captain Heathcote would be good enough, to give a short statement of what took place the other evening.