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IN ~~PERIODICALS~~ STORE

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description of cotton were successively submitted for equal periods (forty-eight hours) to treatment with one and the same quantity of the mixed acids. The specific gravity of the latter, at the commencement of the experiment, was 1·82. The acid was separated from each quantity of the cotton at the expiration of the above period, by means of a small centrifugal machine. After two quantities of cotton had been immersed in the acid, its specific gravity was reduced to 1·81. The original mixed acids were examined by means of a standard solution of carbonate of soda; a known quantity of the mixture neutralized 148·3 measures of the solution. After immersion of the first quantity of cotton, 147·5 measures were neutralized by an equal quantity of the acid, and 146·3 measures after immersion of the second quantity of cotton. The reduction in the strength of the acid appeared therefore to be very uniform. The four products successively obtained were carefully purified and dried. The volumes of gas which they furnished upon ignition corresponded very closely with each other and with that obtained from a specimen of the Austrian gun-cotton.

In a second similar experiment, five different quantities of cotton were submitted successively to treatment for forty-eight hours with one and the same mixture of acids. The first three products furnished, upon comparative examination by the exploding method, almost identical results; the fourth and fifth afforded indications of less complete conversion. Examined synthetically, there was a difference of not quite 1 per cent. between the amount of recovered cotton obtained from the first and the fifth products.

The results of these experiments indicated, therefore, that products corresponding closely in composition can be obtained by the treatment of even more than two quantities of cotton successively with the same acid. It should be observed, however, that the above results were obtained with cotton in the unspun condition, and that the proportion borne by the mixed acids to the cotton was higher than that prescribed in the Austrian system of manufacture.

Experiments instituted upon a manufacturing scale at the Royal Gunpowder Works, Waltham Abbey.

(10) Very considerable difficulties were experienced in procuring the small quantity of cotton (two to three cwts.) required for these experiments, in a condition resembling sufficiently closely that employed at Hirtenberg, as its production in the form of the thick and the thin loose rovings, or yarn, necessitated some deviation from the ordinary method of spinning, which it was difficult to induce manufacturers to attempt without the promise of an extensive order. Eventually I succeeded, through the kind assistance of Mr. Whitworth, in obtaining the requisite quantity of coarse and fine yarn or roving, resembling closely in character, and quality of cotton, the specimens obtained from Hirtenberg, though in the subsequent operations with the coarse or thicker kind no inconsiderable proportion of it was found to be in a much less compact or more lightly twisted form than the Austrian samples. The comparatively open condition of this portion, and the impossibility of placing it under a sufficient strain to wind it compactly into cartridges, in consequence of the weakness of the yarn, must exert considerable influence upon the rapidity of its combustion in its employment in ordnance (as a few rough experiments at Waltham Abbey have indeed already shown); the gun-cotton prepared from these portions will therefore be carefully separated from the remainder, and will doubtless furnish instructive comparative re-

sults in the preliminary artillery experiments to be instituted with the gun-cotton.

The acids of the prescribed specific gravities were readily obtained at moderate prices—the sulphuric acid having a specific gravity of 1·84, and that of the nitric acid (a light amber-coloured acid) being 1·52.

The apparatus and implements employed, and the modes of conducting the various operations, were, as closely as practicable, in accordance with those in use at Hirtenberg—a slight deviation only, in the form or material of some of the implements, being adopted where it was decidedly advantageous and could not in any way influence the nature of the results. The following is an account of the details of manufacture:—

(11) a. *Preparation of the Cotton.*—The cotton was made up into skeins, those of the stout yarn weighing from four to six ounces each, and those of fine yarn from three to four ounces. It was then boiled for about fifteen minutes in a dilute solution of carbonate of potassa (of specific gravity 1·02, containing one pound of the salt to three gallons of water), and transferred thence to a centrifugal machine, which was maintained for about five minutes at a speed of 500 to 600 revolutions per minute. The alkaline liquid was thus very effectually separated from the cotton, which was then washed thoroughly, first by hand in a large tank, and afterwards by submersion in a stream for forty-eight hours. At the expiration of that period, the water was separated from the skeins by the aid of the centrifugal machine, and the purified cotton was then dried. Although the cotton was of good quality and very fairly cleaned from seed (being quite equal in these respects to the Austrian samples), it was found to sustain a loss of about 5 per cent. by the treatment with alkali and washing. The potassa solution in which it was boiled acquired a coffee colour. Portions of seed were still retained by the purified cotton, which were subsequently dissolved out perfectly by the acids.

(12) b. *Preparation of the Acids.*—The proportions of acids (three parts by weight, or 2·45 by volume, of sulphuric acid to one part of nitric acid) were weighed off and transferred to stoneware barrel-shaped vessels provided with taps, two of these receiving the sulphuric acid and a third the nitric acid. The barrels were so arranged upon a suitable table that the acids could be delivered from the taps into a deep and very capacious stoneware vessel, fitted with an iron lid with suitable apertures and a tap; this vessel was raised from the ground sufficiently to allow of the acids being transferred from it to well-stoppered stoneware bottles. While the acids were flowing slowly and uniformly from the barrels into the covered mixing-vessel, the resulting mixture was kept continuously stirred by means of a large iron paddle, and after they had been entirely transferred (which occupied about ten minutes), the stirring was continued for about twenty minutes before the mixture was drawn off into the bottles. The product of this operation had a specific gravity of 1·82. The elevation of temperature resulting from the mixture of the acids was considerable; in one observation the temperature of the acids before mixture was found to be 20° C., while that of the mixture, when complete, was 38° C. The acid thus prepared was set aside in a cool place, and never employed until at least twenty-four hours after the mixture had been made.

The mixing process and all the other operations with the acids were conducted in the open air, the workmen selecting their positions with reference to the direction of the wind. Thus no injurious effects, nor even inconvenience, were experienced by those employed.

(13) c. *Treatment of the Cotton with the mixed Acids.*—About twelve hours before immersion in the acids, the skeins to be operated upon at one time

(which had previously been dried in the air) were suspended in a capacious and well-ventilated drying-chamber, the temperature of which was maintained, for the above period, at not less than 49° C. They were then transferred, while in the chamber, to stoneware jars with tightly closing lids (the same as were used for keeping the cotton immersed in acid), and were allowed to become perfectly cold in these before submission to treatment with acid.

The vessels which were found most suitable for use in treating the cotton with the acid were large and rather deep stoneware pans: one, provided with an iron lid, contained the quantity of mixed acids required for the treatment of a certain number of skeins; a second, which was fitted with a perforated ledge of iron, and was surrounded by cold water, served for the treatment of the cotton, which was conducted as follows:—a proportion of the acid having been transferred to the second pan, two skeins were thoroughly immersed in it, and stirred about for two or three minutes; when saturated with acid they were raised upon the shelf and pressed together with the paddle, so as to allow the superfluous acid to flow off; the quantity of acid absorbed by these skeins was replaced in the pan by an addition of fresh acid, and further skeins were immersed, those which had drained being transferred to a jar while the freshly immersed ones were soaking. In this way the operation of immersion was continued until the whole of the skeins to be treated at one time had been transferred to the jars, six of the large yarn or nine of the fine being introduced into one of these.

The skeins were pressed down in the jars by means of the paddle, and sufficient acid was added just to cover the cotton completely. The jars were then closed and placed into vessels containing water, in a cool building, where they remained for forty-eight hours.

It was found an important precaution to keep the vessel in which the cotton was first immersed surrounded with water, especially in the warm season during which these experiments have been conducted, as the evolution of heat during the first action of the acids upon the cotton is considerable. The contents of the jars to which the gun-cotton was transferred were not found to become heated to any important extent, even when not surrounded by water. The proportion of acid to cotton said to be contained in the jars, as the process is carried out at Hirtenberg, is that of ten to one; but it was found necessary, in order to cover the cotton completely as directed, to employ at least fifteen parts of acid to one of cotton. This proportion would doubtless be much diminished if means were employed for compressing the cotton in the jars more highly than was the case in these experiments.

The precaution of adding a fresh supply of the acids to that which remains in the immersing-vessel after the withdrawal of each quantity of cotton treated, was proved by experiment to be of the greatest importance in securing the uniformity of the product. In one of the first operations, no fresh quantity of acid was added before immersing the skeins treated last. In other respects these skeins were submitted to precisely the same treatment as the remainder (*i. e.* an additional quantity of acid was added to them in the jar, they were allowed to remain for forty-eight hours, &c.). When examined synthetically, they furnished at least one-half per cent. more cotton than the skeins first treated in the same operation; and when fired in the proof-mortar, a decidedly lower range was obtained with the cotton last treated.

(14) d. *Purification of the Gun-cotton.*—At the expiration of forty-eight hours the jars were conveyed to a centrifugal machine, by which the principal quantity of acid was separated from the cotton. The machine employed at Hirtenberg for this purpose is made of copper, the one used by me was constructed entirely of iron, the sides of the revolving cylinder consisting of coarse iron-wire gauze, rendered sufficiently rigid by an iron framework. After each operation the machine was washed out with an abundant supply of water, and thus the corrosive action of the acids upon it has really been very trifling. The oxide dissolved by the acid when the skeins were placed in the machine was sufficient to colour the liquid, and also to stain the cotton in places, but these stains disappeared entirely in the first washing which the product received. The skeins were rapidly transferred, by means of an iron hook, to the machine, and the latter was then set in motion, at first slowly, and ultimately at a speed of 800 revolutions per minute. Within ten minutes the acid was so far separated from the cotton that the skeins were only damp.

Some precautions were necessary in effecting the first transfer to water of the skeins, with acid still clinging to them. If they were simply thrown into water so that the latter would penetrate them only gradually, the heat resulting from the union of the free acids and the water immediately established a violent action of the nitric acid upon the cotton, quantities of nitrous vapours being disengaged. At Hirtenberg the gun-cotton, when taken from the machine, is quickly placed under a small cascade, where its saturation with water is effected with very great rapidity. As this arrangement was not attainable at Waltham Abbey, the skeins, directly they were removed from the machine, were plunged singly, as rapidly as possible, and moved about violently, in a large body of water. They were then washed by hand in a stream until no acid taste whatever was perceptible in the cotton, and were afterwards immersed in the stream for a period of not less than forty-eight hours. For this purpose they were arranged in rows upon poles fixed in frames, which were so placed in the water that the skeins were in a vertical position, the water circulating among them freely. The current of the stream used at Waltham Abbey (at the only available place for these experiments) was not so rapid as could have been desired, and the dryness of the season had rendered it unusually sluggish; still it was sufficient to afford a continual change of the water surrounding the cotton. The character of this water is by no means such as to render it specially fitted for the purification of the gun-cotton. The bed of the stream is always thickly covered with luxuriant vegetable growth, and the water itself is consequently so highly charged with vegetable matter, that, although light was excluded as far as possible from the cotton during its immersion, the skeins became covered in many places, within a few days, by vegetable growth, which in time attached itself so firmly to the cotton as to be very difficult of removal by hand-washing.

The system of purification, as carried on at Hirtenberg, differs very considerably from that described in General Lenk's process as patented in this country: At the above-named establishment, the gun-cotton is in the first instance left in the stream for three weeks and upwards; it is afterwards washed in a dilute solution of carbonate of potassa, again washed in water, dried, and then treated with a solution of soluble glass. After this treatment it is dried, washed for six hours in the stream, and finally by hand.

In the patented process, it is directed that the gun-cotton in the first instance should be immersed in running water for *forty-eight* hours and up-

wards; it is not submitted to any treatment with carbonate of potassa, but is boiled, after the first washing, in a weak solution of soluble glass, and on its removal from this, without any intermediate desiccation, it is immersed in the stream for about six days.

The process of purification which I adopted differed from that in use at Hirtenberg only in the postponement of the long-continued washing until after treatment of the gun-cotton with alkali. At the expiration of forty-eight hours the skeins were removed from the stream, the water was separated from them in the centrifugal machine, and they were then boiled for a few minutes in a solution of carbonate of potassa of spec. grav. 1·02. Having been returned to the centrifugal machine, for the separation of the alkaline liquor, they were again placed in the washing-frames and left in the stream for a period of fourteen to eighteen days. On subsequent removal from the stream, each skein was washed by hand, to separate mechanical impurities, and one-half of each quantity of gun-cotton prepared was finally left in soak in distilled water for some hours. I found that, in consequence of the very large quantity of salts of lime in the river-water, the proportion of mineral matter in the gun-cotton was notably increased (it varied from 1 to 1·5 per cent.); this final washing was consequently adopted (there being a good supply of distilled water at hand) for the purpose of reducing the proportion of mineral matter added to the gun-cotton by the long-continued immersion in the stream. The gun-cotton thus finally purified was dried in the open air.

(15) c. *The treatment of the purified Gun-Cotton with Soluble Glass*, which forms one of the features of the Austrian system of manufacture, was stated by the officials at Hirtenberg to effect two important objects,—first, a retardation of the combustion of the gun-cotton; and secondly, its protection from atmospheric influences, by the formation of a coating upon the fibres of the cotton. In my account of the results of examination of the specimens of Austrian gun-cotton, I have entered fully into the reasons and facts which lead me to the conclusion that the treatment with soluble glass, the subsequent desiccation, and the final washing of the gun-cotton for five or six hours do not practically exert any effect upon the properties of the material, the only result being the addition to the mineral constituents of a small proportion of silicate of lime.

In General Lenk's process, as described in the English patent, the soluble glass is applied, as already stated, to the gun-cotton which, after the removal from the acids, has undergone no further treatment than an immersion in running water for forty-eight hours or thereabouts; when removed from the bath of silicate, the gun-cotton is not dried, but at once immersed for a period of six days in running water. It is at once obvious that this treatment cannot exert any effect upon the cotton, beyond possibly the neutralization of a minute trace of free acid still retained by it after the first washing. That the treatment with soluble glass is not intended to exert any other than a purifying effect upon the gun-cotton, appears also to have been understood by Professors Redtenbacher, Schrötter, and Schneider, in their inquiry into Baron Lenk's system of manufacture; for the only allusion which in their joint report they make to this point, is as follows, "the treatment with soluble glass has no influence on Baron Lenk's gun-cotton, it being previously free from acids."

In order to test, as nearly as possible in its integrity, the system of manufacture as carried on at Hirtenberg, it was determined to submit one-half of each quantity of gun-cotton produced in one operation to the treatment with

soluble glass, the other half being dried, as a finished product, after the immersion in distilled water above-mentioned.

The purified skeins to be treated with silicate of soda were first exposed to air until moderately dry, and then soaked for one hour in a boiling solution of the silicate, containing ten per cent. of that substance. When the excess of the liquid had been subsequently removed by means of the centrifugal machine, the gun-cotton still retained about 80 per cent. of the solution, which, by evaporation, left therefore about 8 per cent. of soluble glass in the material. The skeins were thoroughly dried in air, and then immersed in the stream for about forty-eight hours. A longer period of immersion was adopted than in use at Hirtenberg, on account of the comparatively sluggish current of the river. The skeins were finally washed by hand and dried, this operation completing the manufacture of the gun-cotton. A comparative examination of the ash of a "silicated" product with that of gun-cotton prepared at the same time, which had not undergone this treatment, exhibited a difference amounting to about one-fourth of the ash existing in the gun-cotton not treated: the latter furnished 1·45 per cent., the silicated left 1·85 per cent. of ash. The proportion of silica left in the gun-cotton was decidedly greater than that found in the Austrian specimens; but the portion not treated with soluble glass also contained a very notable amount of silica, derived from suspended matter in the water. A portion of gun-cotton treated with soluble glass has been washed for a few hours only, for comparative experiment.

(16) Artificial heat was not employed in drying any portion of the purified gun-cotton. This operation was accomplished by suspending the skeins during the day upon lines in the open air, or in a well-ventilated shed in wet weather and at night.

Miscellaneous Memoranda.

(17) 1. Samples of the products of manufacture obtained at Waltham Abbey have been submitted to synthetical examination, and furnished results as uniform as could have been anticipated, and corresponding to those demanded by the formula

$$C_{36}\left\{\begin{matrix}H_{21}\\9NO_4\end{matrix}\right\}O_{30}.$$

In the course of the manufacture the increase of weight actually sustained by the cotton has been directly determined, and it has been found that 100 lbs. of cotton, purified by the treatment with alkali, furnished about 177 pounds of gun-cotton (not silicated). The amount which theoretically 100 lbs. of cotton should furnish, of gun-cotton of the above composition, is 183·3 lbs. The discrepancy between these numbers is certainly not great when allowance is made for mechanical loss in the various washings, and for the foreign matters dissolved out of the cotton by the acids.

(18) 2. Several experiments have been instituted for the purpose of examining the characters of the product resulting from the treatment of cotton with the mixed acids which have already been used once. The quantities of cotton treated at one time, and the various steps in the manufacture, did not differ in any way from those adopted in the regular system in use. The product obtained from the coarse yarn, by means of the once-used acid, has been examined synthetically, and found to correspond very nearly in composition to gun-cotton of the formula

$$C_{36}\left\{\begin{matrix}H_{22}\\8NO_4\end{matrix}\right\}O_{30},$$

or the next lowest substitution-product to that obtained in the ordinary pro-

cess of manufacture. It was found, moreover, that the cotton yarn obtained in this experiment was very decidedly weaker (*i. e.* could sustain only considerably less strain) than the ordinary product—a result which must be ascribed to the greater predominance of sulphuric acid in the mixture which has been once used.

Experiments with this mixture and the *finer* yarn, furnished a different result to the foregoing. The products corresponded closely in composition to the theoretical result attained by the original or first employment of the acids. The rotting or weakening effect noticed above was much less apparent in these products than in the case of coarse yarn.

It would appear from these results that the mechanical condition of the cotton (*i. e.* the thickness of the yarn) exerts an important influence upon the nature of the product furnished by the once-used acid. Further operations are in progress in which this acid is employed; and the explosive effects of the resulting products will be carefully compared with those of the material obtained in the ordinary way.

(19) 3. No systematic artillery experiments or others illustrative of the explosive effects of gun-cotton prepared at Waltham Abbey have as yet been instituted, beyond a few trials of small charges in the mortar employed at the Gunpowder Works for purposes of proof. Even these results, however, as far as they go, are possessed of considerable interest, as demonstrating some of the most important points of difference between gun-cotton and gunpowder, when used in cannon, and as illustrating to some extent the value of the simple mechanical means devised by Baron Lenk for regulating the explosive action of the gun-cotton.

A quantity of the coarse roving, corresponding in weight to one-third of the proof-charge of gunpowder, was wound round a conical wooden plug, with the application only of a slight strain (equal to two ounces). The range obtained by this charge, or cartridge, was fully equal to that furnished by a full-proof charge of Enfield-rifle powder. The same weight of gun-cotton, wound upon a cone of the same dimensions, but kept during the winding under a strain of one pound, gave a range which was materially shorter than that furnished by the loosely wound charge, but quite equal to the average proof range (or three times the weight) of ordinary cannon-powder. Results agreeing with the above, and in very good accordance with each other, were obtained in frequent repetitions of those experiments.

The variation in composition of exceptional or special products, such as have been referred to in the preceding, manifested themselves in a corresponding variation in the range obtained with them, when tried under the same conditions as the ordinary products. Thus the skeins which in one particular operation had, as above described, been immersed finally, without addition of fresh acid, and which furnished synthetically a somewhat high proportion of cotton, did not yield so long a range as the ordinary products, nor as the first skeins obtained in the same operation. Again, the coarse yarn which had been treated with acid already once used, when wound into cartridges with a strain of two ounces on the yarn, did not furnish as long ranges as the ordinary products wound under a strain of one pound; and when made into cartridges under the latter conditions, the ranges it furnished were very considerably below the average results obtained with the ordinary product.

The absence of any appreciable residue in the mortar, and of any but the most trifling amount of smoke, only noticeable if watched for, were, it is hardly necessary to say, novel and important features in these few proof experiments.

(20) 4. Some observations made during the drying, and in the preservation

in store, of the finished gun-cotton, can hardly be passed over altogether without notice in this communication, though the precise nature and cause of the result which has manifested itself are still undetermined.

By far the larger proportion of the gun-cotton prepared at Waltham Abbey was dried in the open air, being exposed to strong daylight, and very frequently to powerful sunlight. When dry, it was packed into ammunition-boxes—large wooden cases containing an internal casing of tinned copper and with very tightly closing double lids. In opening some of these boxes containing gun-cotton, a faint but peculiar odour was accidentally observed, which was more distinct in some boxes than others. This observation led to the introduction of some pieces of litmus-paper among the skeins in different boxes, and these were found in some instances to change, after the lapse of time, to rose-colour, some merely at the edges, others more or less perfectly throughout. The change of colour was like that produced by carbonic acid upon litmus; and if the boxes were left open for some time, the paper gradually regained its original colour. If they were again closed for twenty-four hours or longer, the reaction upon the litmus-paper was again observed in those instances in which it had first been decidedly manifest, but it has been noticed to become gradually weaker. It was subsequently found that the gun-cotton, after it had been for some time exposed to strong daylight, and particularly to sunlight, in the open air, exhibited the same slight acidity, and that the reaction noticed in the boxes was always more marked in those which contained the gun-cotton most recently exposed for drying.

As above stated, no satisfactory explanation can as yet be afforded of the occasional exhibition of this slight acidity in the thoroughly purified gun-cotton under the circumstances described; to whatever causes it may be due, it appears evident, on a perusal of the report of Drs. Redtenbacher, Schrötter, and Schneider upon Baron Lenk's gun-cotton, that those chemists have noticed a similar occasional acidity as occurring in the Hirtenberg cotton, and, indeed, that this acidity has been dwelt upon as a cause for alarm by persons who have feared the spontaneous decomposition of the gun-cotton. The surmises as to its possible origin, put forward in the report above referred to, are, it must be confessed, not very satisfactory; neither, in the face of the extraordinary precautions adopted for effecting the complete purification of the gun-cotton, is the force of the following concluding paragraph of that part of the report which refers to this subject, very apparent:—"These acid traces should the less evoke surprise when we bear in mind that the gun-cotton in process of manufacture had been exposed for forty-eight hours to a strong acid bath; moreover, if the subject of comparison, viz. gunpowder, be tested with equal severity, similar evidence of chemical action will be forthcoming." It is in a material in which, in the first instance, the most delicate tests fail to detect the slightest evidence of free acid, that this slight acidity occasionally becomes evident. That exposure to light will, after some time, induce decomposition in the most carefully purified gun-cotton, is beyond dispute: as the latest of many proofs, which I myself have had of this, I may mention that some litmus-paper which has been for a few weeks exposed to light in a stoppered glass bottle, together with a piece of the Hirtenberg cotton, has become already perfectly bleached. But that an indication of change, such as has been dwelt upon above, should be afforded by so brief an exposure to light as five or six hours, and continue to be afforded after the cotton has been removed from light, appears to me to favour one of the conjectures put forward in the report referred to,—namely, that the gun-cotton may contain traces of high nitro-compounds which are much more liable to decomposition than it is itself

—a conjecture which may receive some support from the fact of the cotton being exposed for a very long period to the action of the acids. Under any circumstances, this is a matter which may be most intimately connected with the question of the keeping qualities of the gun-cotton, and which therefore requires the strictest investigation.

(21) 5. While referring to the question of the stability of gun-cotton, it may be important to record the following fact. It is pretty generally known that, soon after the discovery of gun-cotton by Schönbein in 1846, Messrs. Hall and Son, the extensive gunpowder-manufacturers at Faversham, entered upon the manufacture of this material, but were, after a time, so unfortunate as to have a very disastrous explosion of gun-cotton at their works, which, after a careful inquiry, was ascribed, by the jury and by all connected with the manufacture, to the spontaneous combustion of the material. The manufacture was stopped on the occurrence of this accident, and a considerable quantity of gun-cotton, which existed in the works, was buried by Messrs. Hall's direction (in July 1847), being simply thrown into a hole in the ground and covered up with earth. At my request, Messrs. Hall have been so kind as to have a sample of this gun-cotton, which has been buried for sixteen years, dug up and forwarded to me. This cotton, after being freed from dirt by washing, presented a discoloured appearance, and is stained in many places with oxide of iron, but it exhibits not the slightest evidence of having undergone change. The fibre is perfect throughout, and there is, as might have been anticipated, no trace of acidity manifest in any portion. It is not a rapidly burning gun-cotton, and leaves, upon ignition, a considerable carbonaceous residue; it does not therefore consist, or at any rate not entirely, of the most explosive substitution-product. A specimen, purified in the first instance by treatment with dilute hydrochloric acid, has been examined synthetically, and yielded 59·63 per cent. of cotton,—a result which agrees most closely to that which would be furnished by a product of the composition $C_{36}\left\{\begin{matrix}H_{23}\\7NO_4\end{matrix}\right\}O_{30}$ (which would furnish 60·66 per cent. of cotton). Messrs. Hall manufactured the gun-cotton by Schönbein's original process, which consisted, as far as I can learn, in the treatment of the cotton for about one hour with a mixture of one part of nitric acid of spec. grav. 1·45 to 1·5, and three parts of sulphuric acid of 1·85 spec. grav. The cotton was washed in running water until no acid was detected by litmus-paper, and afterwards dipped in a very weak solution of carbonate of potassa. The finished cotton was sometimes soaked in a weak solution of nitrate of potassa.

The examination of Messrs. Hall's buried gun-cotton appears to afford an interesting and important proof of the permanence of gun-cotton when excluded from air and light, but not protected from moisture—though it is necessary to bear in mind that this particular material does not correspond in composition to the regular Austrian product.

(22) 6. Referring once more, in conclusion, to the manufacturing experiments which form the main subject of this communication, it only remains to be stated that the very high price paid for the cotton for these experiments, the necessarily temporary arrangements, and the impossibility of fully economizing labour and material in carrying out the manufacture with such accommodation as could be furnished without any important outlay at Waltham Abbey, rendered the formation of any reliable estimate regarding the cost of the gun-cotton out of the question. But the scale upon which the manufacture was conducted has been quite sufficient to demonstrate most satisfactorily that, with a properly organized system of operation, the production of the gun-

cotton is certainly not more difficult or complicated, and is attended with considerably less risk of accident to the workmen and the manufacturing establishment, than the production of gunpowder.

IV.—*Information given by* Baron LENK *on June* 22 *and July* 14, 1863.

1. *What weight of gun-cotton and gunpowder give equal effects?*—In accordance with experience, gun-cotton produces the same effect as three times its weight of gunpowder, which proportion, under certain circumstances, may be increased to six times its weight of gunpowder; for the effect of gun-cotton in proportion to gunpowder is the greater the more resistance is offered to the charge by the sides which enclose it, *and the less gas can escape at the beginning of the explosion.*

2. *What bulks of each give equal effect?*—The space required for a gun-cotton cartridge, to produce an equal effect, is scarcely half as large as that of a gunpowder cartridge; and it is only made equally large or slightly larger, if secondary circumstances should demand it.

3. *Is the effect more constant with gun-cotton or with gunpowder.*—The effect of small fire-arms and of artillery in general is considerably more uniform and constant with the use of gun-cotton than with gunpowder, provided the proper charge and cartridge has been taken.

That superiority gun-cotton partly owes to the chemical process by which I have produced it, and partly to the uniform formation of the cartridge, which can only be attained by its regular texture, using it in the shape of cotton-yarn.

4. *Which admits of more precise aim?*—On account of the more constant effect of gun-cotton, and because its use prevents fouling of the gun, which further admits to reduce the space between shot and barrel, and on account of less heating of the gun, as well as by the uniform position of the cartridge, there must be a more precise aim of shot with gun-cotton—which, moreover, has been fully proved by experience.

5. *Which occasions least recoil?*—Chiefly on account of the smaller space of time the projectile requires to pass through the barrel of a gun to attain a certain initial velocity, the recoil of the gun is less than with the use of gunpowder. It may be stated that, by the official trials of the Commissioners in the year 1860, the recoil of the gun with gun-cotton was found to be 0·68 of that with gunpowder.

6. *What is the relative effect as to fouling?*—Except an extremely small residuum of carbon, there is no deposit with the use of gun-cotton. The barrel of a gun requires no cleaning out; there is no chemical effect upon cast- and wrought-iron, steel, or bronze barrels by using gun-cotton cartridges.

7. *Is gun-cotton liable to decay when stored?*—Gun-cotton has been stored like gunpowder for twelve years, usually packed in wooden boxes; and no trace of alteration has been discovered. My own experiments go back as far as 1846, and have given most favourable results in this respect.

8. *How is it affected by water or damp?*—Gun-cotton placed under water is unalterable. By the transformation of ordinary cotton into gun-cotton, it loses the greater part of its hygroscopic property, so that gun-cotton, properly manufactured, resists the influence of damp much better than gunpowder; and moreover it cannot, like gunpowder, get permanently spoiled thereby. Gun-cotton, if dried in the open air, contains 2 per cent. moisture; ordinary cotton about 6 per cent. Gun-cotton, placed in a room completely saturated with