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Memo on GC II

FA Abel

9-1873

F. A. Abel

Memorandum on question II. 23rd September 1873,
With prefacing remarks by C.W. Younghusband,
Col. R.A. (Superintendent RGPF) dated
9th October 1873.
(TYPED COPY 1963)

MEMO. SIGNED F.A. ABEL, DATED 23rd SEPTEMBER, 1873

CJ

D.A.

1. My remarks on Mr. Abel's second Memo. on Guncotton must consist chiefly in confirming the statements therein contained. All the points referred to in it are within my knowledge, and little can be said on them beyond a recapitulation. I propose, however, to offer a few general observations on the principal points of the Memo., dividing them into:-

1. - The establishment of a Government Factory of Guncotton;

2. - The modifications which have been proposed in manufacture;

3. - New application of this Explosive.

2. In the autumn of 1870, the Secretary of State for War having had before him several Reports on the value of Guncotton for Military purposes decided to establish a Government Factory for its manufacture on the system invented by Mr. Abel. After an investigation of the sites available, and a consideration of the processes to be followed in manufacture, it was determined to erect the Works at Waltham Abbey, and the Superintendent was directed to consult Mr. Abel on all matters connected with the arrangement of the Works, and in providing the necessary means for manufacturing compressed Guncotton on his system. The Works were commenced early in 1871.

3. In consequence of the destruction of the Stowmarket Factory by explosion in August 1871 while the Waltham Abbey Works were still in progress, the Secretary of State deemed it necessary to institute a full enquiry into certain points attending the manufacture, employment, and storage of Guncotton, especially as regards safety. The Committee appointed for this purpose obtained and studied all procurable documents relating to the history and progress of Guncotton, including reports of experiments that had been made up to that time; and having taken evidence from many persons who had had experience in the manufacture, use or transport of this substance, made their report on the 13th December, 1871.

4. A report of the Coroner's Inquest held on the deaths caused by the Stowmarket explosion was made to you immediately on its conclusion. Since that time the whole of the technical evidence adduced at the Inquest had been printed, and also an elaborate report by Major Majendie upon his enquiry into the cause of the catastrophe. Having had the advantage of attending the Inquest and hearing the whole of the evidence, I am fully convinced that the spontaneous decomposition of the material, which resulted in explosion, was caused by design, and not by any accidental or inherent defect in the manufacture.

5. In accordance with the opinions expressed in the Committee's report of 13th December, 1871, the Waltham Abbey Works were ordered to be completed on the original designs, with the exception of the final drying process which it was contemplated would be carried out elsewhere.

6. As regards the storage of Guncotton on a large scale, experience was wanting; the Committee therefore proposed to ascertain whether the accidental ignition of a Store of dry Guncotton would necessarily be followed by explosion under any circumstances in which Guncotton would be stored for Service. Experiments with this view were made near Hastings in April, 1872, which are described in the Committee's Report dated 25th July of that year. The result showed that whilst under certain conditions a Store of dry Guncotton, if ignited, might not be followed by explosion, yet under other conditions, explosion would take place. The Committee therefore recommended that dry Guncotton should under

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all circumstances be treated as an explosive. Damp Guncotton in the condition in which it is ordinarily stored was found practically uninflammable.

7. Further experiments regarding storage were carried out near Eastbourne, in May of this year, with the object of ascertaining whether, if large quantities of damp Guncotton were ignited within solidly constructed buildings, such as bomb-proof Magazines, an explosion would result.

The Report of these experiments is dated 3rd June, 1873, and showed that a store of damp Guncotton may be considered perfectly free from all danger of explosion.

8. As to modifications proposed by Mr. Abel in manufacture. Under this head are included very many matters of detail which have suggested themselves to one or other of us in the progress of the manufacture, tending to simplify the processes, or improve the final product. Some of these are very important, and are due to Mr. Abel's special knowledge and experience in dealing with this material.

9. The substances called by him "Nitrated" Guncotton, in the form of a combination of nitrate of potash with Guncotton, and of nitrate of soda with Guncotton, are now under experiment. The former gives promise of very good results, and can be produced, weight for weight, considerably cheaper than ordinary Guncotton when suitable arrangements have been made for its manufacture. These consist principally in preserving the saturated solution of saltpetre squeezed out during the operation of pressing.

10. Experiments with wet compressed Guncotton for Torpedoes and Engineering purposes are now in progress. It has been demonstrated that Guncotton discs, saturated with water, can be exploded under certain known conditions; but the relative effect, as compared with dry Guncotton, and the precautions to be observed in order to develop the full power of the explosive, have not yet been fully worked out. Enough has, however, been established to show the great value of this discovery; for while Guncotton in this state is stored in safety as an uninflammable substance, it can be employed without preparation as an explosive.

11. The applications of Guncotton to the explosion of shells proposed by Mr. Abel, and described in his Memo. are also under trial. The experiments already made are promising and clearly establish the practicability of employing Guncotton for shells in the manner proposed.

12. A great future may fairly be anticipated for Guncotton. As regards safety in manufacture, storage, transport and use, it is unrivalled by any other explosive, while in power it has not been surpassed by any substance with which it has been compared.

(Signed) C.W. Younghusband, Col. R.A.

9th October, 1873

MEMORANDUM ON GUNCOTTON

II

In continuation of Memo. prepared by Mr. Abel for the Director of Artillery, 18th November, 1870.

1. With reference to §§ 11, 12 and 13 of the former Memo, describing the improvements in the manufacture of Guncotton for which Mr. Abel secured the patent in 1865 which was relinquished by him in January, 1872, it should be pointed out that the new system of manufacture brought out by him consisted in the application of the well known processes and machinery used in paper making, to the purification of Guncotton and its conversion into convenient forms. The general mode of applying those processes etc. to Guncotton did not differ from their application to paper materials, and consequently no public funds were devoted to the elaboration of the process patented by Mr. Abel. Its subsequent application upon a manufacturing scale was worked out solely at private cost by Messrs. Prentice, who began to employ the process experimentally in 1867 and became exclusive licensees under the patent in 1868 (as stated in § 13 L.C.). After the Patent had been taken out, some small quantities of the compressed Guncotton for the use of the first Government Committee on Guncotton were produced with existing paper making and wad making machinery in the Royal Arsenal between 1865 and December 1867; exclusively with the view of applying compressed Guncotton to Artillery and Small Arms (vide § 14 of former memo.) but the manufacture of compressed Guncotton as an article of commerce was, in the first instance elaborated at Stowmarket, without any aid whatever from Public Funds.

Chemist W.D.W.
D. of A. 22. 8.70
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2. In August 1870, Mr. Abel submitted a Memo. to the Director of Artillery, directing attention to the importance of establishing a Government Factory for the manufacture of Guncotton according to his system with the view of preventing monopoly, and exercising increased control on the quality of any supplies obtained from the trade. His original suggestion was to produce the Guncotton at Waltham Abbey and to apply the pulping and pressing processes at the Arsenal with existing machinery. Mr. Abel's Memo. was referred to the President of the Committee on Explosives and the Superintendent Royal Laboratories who reported it desirable that the complete manufacture of compressed Guncotton should be carried on at Waltham Abbey. Subsequently the Superintendent Royal Gunpowder Factory assisted by Major Scratchly, R.E. and Mr. Abel prepared an estimate of the cost of machinery etc. for the establishment of Guncotton works upon a small scale at Waltham Abbey. The preparation of works, upon the basis of this estimate was approved of by the Secretary of State for War on November 9th, 1870, and the Superintendent Royal Gunpowder Factory was instructed to consult Mr. Abel on all questions relating to the arrangement of the Works, etc.

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3. On receipt of instructions to proceed with the preparation of the Works, Colonel Younghusband (November 10th, 1870) urged the importance of concluding a contract with Messrs. Prentice for the supply of a quantity of compressed

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Guncotton, upon a basis which he had recommended and which included the stipulation that, provided an order to the extent of 200 tons were given them, which would warrant their incurring the cost for the necessary enlargement of their Works, they should furnish the Government with all details required, respecting the arrangement and management of their Works.

4. On the 15th November, 1870, the Surveyor General of Ordnance sent for Mr. Abel and received from him a verbal statement the substance of which was afterwards embodied by desire of Sir Henry Storks in the "Memorandum on Guncotton" submitted to the Director of Artillery on November 18th, 1870.

5. The correctness of the statements made by Mr. Abel in the concluding part of that memo. with respect to the reasonable nature of the price which the Guncotton Company demanded for 200 tons of Guncotton (2s/-d per lb) on the understanding that they were to furnish Colonel Younghusband with all information which could aid in setting on foot the Government Guncotton Works, have been confirmed by the first year's experience at Waltham Abbey. The cost of compressed Guncotton produced at the new Works during the first year has been 2s/0½d per pound.

6. The Contract with the Guncotton Company for the supply of 200 tons of Abel's compressed Guncotton was concluded shortly after the memo. referred to was submitted, and Mr. Abel then prepared a Specification including rigid terms of chemical inspection. This was submitted by the Superintendent Royal Gunpowder Factory and himself, and was accepted by the Company to govern supplies made by them. On their Contract being accepted, they at once furnished the information desired, to aid in the establishment of the Works at Waltham Abbey.

7. The Stowmarket Company was not in a position to commence delivering supplies to Government until the summer of 1871. On July 12th they made the first delivery of 10 tons at Upnor Castle and a second delivery of a corresponding quantity was made on August 11th; the first delivery had then been sampled by the War Department Chemist, and was under examination when the explosion occurred (on August 11th, 1871) which destroyed the Stowmarket Works.

8. The cause of the explosion at Stowmarket was made the subject of very searching enquiry, during the Coroner's Inquest, with the assistance of the Home Office and of the Guncotton Committee, Scientific men of eminence being engaged to investigate the subject.

9. The evidence produced conclusively established the following facts:

(a) that the explosion was caused by the spontaneous ignition in one of the magazines, of some very highly impure Guncotton, forming part of a batch included in the second supply sent to Upnor for Government;

/(b) .....

(b) that the quantity of acid found to exist in portions of this impure Guncotton could not possibly have been accidentally left in the material during manufacture, even if only the preliminary purifying process had been applied, and that most carelessly;

(c) that the acid must have been added to the finished discs of Guncotton, because of the irregular manner in which it was found to be distributed in one and the same alike.

10. After a protracted enquiry the verdict returned was to the effect that the said explosion "was produced by some person or persons unknown adding sulphuric acid to the Guncotton subsequent to its passing all the test required by Government".

Report on the explosion at Stowmarket by V.D. Majendie presented to Parliament, 1872

11. A special examination into the cause of the explosion at Stowmarket was made for the Home Office by Major V.D. Majendie, the Government Inspector of Powder Magazines, etc., and in the elaborate report submitted by him, he states as his conclusion that the accident "was due to the spontaneous explosion under the accelerating influence of hot weather of some impure Guncotton the impurity consisting in the presence, in the Guncotton, of a large quantity of sulphuric acid or mixed sulphuric and nitric acids, which acid was wilfully added by some person or persons unknown, after the cotton had passed through the regular processes of manufacture and testing".

12. It was therefore conclusively established by the enquiries instituted, that the explosion at Stowmarket was not attributable to a liability to spontaneous decomposition of the material properly manufactured according to the improved system, but was due to circumstances having no more connection with the stability of Guncotton, than the accidental or intentional introduction of a lucifer match, or a nail and flint into Gunpowder would have with the stability of that substance.

13. Notwithstanding the conclusive nature of the results of enquiry into the accident, the Secretary of State for War entertained a natural hesitation to persist in the employment of compressed Guncotton as a service explosive agent, and in the erection of Guncotton Works at Waltham Abbey, without additional investigation and ample confirmation of the evidence, collected during the Inquest by Major Majendie, that Guncotton could be manufactured, stored, and used with safety. The completion of the Government Factory was therefore suspended, and a Special Committee consisting of Officers of the Navy, Artillery, and Engineers, and several Scientific men of eminence was appointed by the Secretary of State for War, to report whether the employment of Guncotton "was attended with such uncertainty or peril as to render it advisable to abandon the manufacture and use of the material"; whether the manufacture of Guncotton and its storage, wet, or dry, were attended with danger, and whether the material either pure or impure, was liable to spontaneous combustion, and consequent accidental explosion.

Supplementary enquiry into the best mode of storing Guncotton was also included in the Committee's labours.

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Parliamentary Report
Special Committee on
Guncotton 13.12.71
74/9/123

14. In December, 1871, the Committee submitted a preliminary Report, in which they state, as the conclusions arrived at by careful enquiry "that the employment of compressed Guncotton is not attended either with uncertainty or peril but as an explosive agent, it is effective, certain, safe, and easy in employment". They express themselves very favourably with respect to the safety of manufacture, and the stability of compressed Guncotton, produced according to Mr. Abel's system, and while deprecating the drying of the Guncotton, in or near a town, according to the plan pursued at Stowmarket, they consider that a safe method of drying can readily be devised. Finally, they state that there is no reason why the manufacture of compressed Guncotton should be relinquished by the War Department.

15. Consequent upon this favourable report orders were given in January 1872, to complete the works at Waltham, and manufacture commenced in February 1872.

16. In co-operation with Colonel Younghusband in the arrangement of the works, Mr. Abel suggested several modifications in the mode of manufacturing previously pursued at Stowmarket, the adoption of which have combined to raise considerably the standard of quality of the material produced, as regards explosive power, purity, and uniformity. He has continued up to the present time to devote attention to the improvement of the manufacture; thus, a simple modification introduced recently, at his suggestion, into the washing process has not only raised the standard of purity of material very importantly, but also bids fair to cheapen the manufacture by greatly curtailing the purifying operations.

Chemist to D. of A.
23. 2.72 and
12. 3.72

17. In February and March 1872, Mr. Abel submitted to the Director of Artillery an account of results of considerable promise obtained by him in applying his system of manufacture to the production of Guncotton preparations some of which appeared to possess decided advantages over simple compressed Guncotton.

These preparations consist of nitrates or chlorates, e.g. saltpetre or chlorate of potash intimately incorporated with Guncotton pulp, in such proportions as to develop the full explosive power of the latter, - the mixtures being either pressed into discs or granulated. Thus the incorporation of Guncotton with about one-third of its weight of saltpetre, furnishes a material (called by Mr. Abel nitrated Guncotton) which is decidedly more powerful than compressed Guncotton bulk for bulk, and quite as powerful weight for weight, with the advantage of replacing one-third of the Guncotton by a material of about one-fourth the value.

The "nitrated" Guncotton possesses some other advantages over the ordinary compressed material especially with reference to its employment in the Field, and for mining purposes.

18. Mr. Abel's new improvements in Guncotton were referred to the Special Committee on Guncotton for investigation.

/Experiments .....

Experiments are still being carried on by that Committee in conjunction with the Royal Engineer and Torpedo Committees with the object of thoroughly comparing the relative merits of nitrated and ordinary Guncotton.

19. In the course of Mr. Abel's experiments on the detonation of mixtures of Guncotton with saltpetre, and with other substances his assistant Mr. Brown found that compressed Guncotton might be exploded by detonation when in a damp state provided a sufficiently large "primer" of dry compressed Guncotton was detonated in contact with it. Further investigation of this subject showed that even if Guncotton discs are saturated with water (containing from 30 to 35 per cent) they may be detonated by means of a disc of dry Guncotton, exploded by a detonator when in close contact with the wet material. Compressed Guncotton as it leaves the hydraulic press, contains about 15 per cent of water, and in this state it is almost unignitable when a red hot body is held in contact with it, if soaked in water for a short time it absorbs about 15 per cent more, and it is then absolutely unignitable. Holes may be bored in the wet discs without the slightest risk of ignition, by means of a red hot iron or by ordinary boring machines. If they are placed in a fire the water will gradually be expelled from the surfaces of the discs, and these will smoulder away long before they are sufficiently dry even to burn rapidly. It follows therefore that wet Guncotton may be confidently stored as a non-explosive material, if saturated with water, and packed in properly closed receptacles, and that in order to apply its explosive powers it is not necessary to dry it, provided a disc or piece of dry compressed Guncotton of sufficient size be exploded in contact with it, by means of a detonating fuze.

Chemist to D. of A.
19.11.72

20. In November, 1872, Mr. Abel recommended that experiments be made on the employment of compressed Guncotton in the damp or wet state for the purposes to which dry Guncotton had hitherto been applied, and the subject was referred to the Guncotton Committee. Experiments of various kinds carried out by them in conjunction with the Royal Engineers and Torpedo Committee have already demonstrated that the explosive force of compressed Guncotton is at any rate not diminished by employing in it the damp or wet state, and Mr. Abel has recently demonstrated that the velocity with which detonation is transmitted from mass to mass of compressed Guncotton, is decidedly greater with the wet than the dry material. It has also been found that provided the individual discs composing a charge in a submarine mine are in contact with each other at some parts, and are closely surrounding the priming charge of dry Guncotton (enclosed in a watertight case) the charge is effectively exploded by the latter even if the mine (or torpedo) is entirely filled up with water. It follows therefore that a leak in a mine, charged with compressed Guncotton would not interfere with the explosion of the latter provided the dry priming charge and fuze be properly protected from access of water.

21. The Committee on Guncotton, having been instructed to report whether the storage of Guncotton either wet or dry, is necessarily attended with danger, instituted a series of experiments near Rye, in April 1872, with dry compressed

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Guncotton stored in quantities of 5 cwt. (packed in boxes of different strengths) in wooden sheds, and in a brick magazine. Fierce fires were kindled in the buildings and immediately in contact with the boxes. When the Guncotton was packed in the strong service boxes, violent explosions occurred a few seconds after the Guncotton itself had become ignited by the fire in the buildings. But with similar quantities (5 cwts.) packed in boxes of lighter construction, the sheds and their contents were entirely consumed without any explosion occurring. A building containing 5 cwts. of wet Guncotton (with about 20 per cent of water) packed in strong boxes and surrounded with inflammable material was burned down without any explosion.

Report of
Guncotton Committee
July 25th, 1872

22. The Committee concluded from these results, that although the risk of an explosion resulting from the ignition of a store of dry Guncotton might be considerably reduced by storing the material in lightly made packages, affording ready escape for gases generated by the action of heat upon the Guncotton, yet the extent of security against explosion would be regulated by the quantity of dry Guncotton stored in one building, and that, therefore, dry Guncotton must, when stored, be treated with the usual precautions adopted with explosives generally, as regards position and nature of the store buildings, etc. The Committee considered moreover that dry Guncotton should not be stored in larger quantities than required for the current wants of the service, and that as it is perfectly uninflammable when wet, and is not subject to material deterioration when so kept, it should be stored in that state, apparatus for drying it, when required, being established at the store stations.

Committee on Guncotton
D. of A. 1. 2.72
74/9/239

23. It having been demonstrated some time after the above experiment, that wet Guncotton is susceptible of detonation by the fulfilment of certain special conditions, it became obviously important to ascertain as far as was possible by a large experiment, whether the explosion of the wet compressed material could be brought about by exposure of a considerable mass to the extremes of heat susceptible of development by the ignition of stores or magazines. Accordingly in February 1873, the Guncotton Committee recommended that two bomb proof magazines be constructed, in one of which 1 ton of wet Guncotton should be packed in a tank of the kind adopted for storing wet compressed Guncotton in, the other to contain a similar quantity packed in the service boxes used for transporting Guncotton. The Guncotton packages were to be surrounded by inflammable material in both buildings, and the contents fired.

Second
Report
Guncotton Committee
3. 6.73
74/9/287

This experiment was approved of and carried out at Pevensey Bay on May 9th 1873, with Guncotton containing 30 per cent of water. Very fierce fires were kindled in the buildings and continued, in both instances, to burn for nearly two hours. By that time the 2240 lbs. of wet Guncotton in each building had gradually burned away, but there was no explosion. The Committee, in reporting the results which they considered very satisfactory, expressed their conviction that a store of damp Guncotton is safe from danger of ignition from within, and that the only precaution to be observed in the storage of this substance is to place it in a building constructed of uninflammable material, and in one not situated in the immediate vicinity of other buildings liable to conflagration.

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Chemist to
Committee on Explosives
7. 4.73

24. In April, 1873, Mr. Abel communicated to the Committee on Explosives the results of some experiments of an entirely novel character, which he had instituted on the application of Guncotton in shells. He showed that by detonating a very small charge (say half an ounce) of compressed Guncotton in a shell, filled with water the force suddenly developed is so uniformly transmitted in all directions, by the incompressible fluid, that the shell is broken up into a number of fragments very many times greater than those produced by completely filling the shell with powder (or with a more violent explosive agent) the fragments being scattered with considerable force. The possibility of applying the common shell of Field guns to fulfil the functions of a Shrapnel, by simply substituting a special fuze and a charge of water, in place of powder, was thus demonstrated. Mr. Abel also showed that Guncotton the safe employment of which in shells of large calibre had been in vain attempted in a variety of ways was susceptible of application with perfect safety by charging the shell with a mixture of Guncotton pulp, or small pellets or grains of Guncotton and water, a sufficiently large "primer" of compressed Guncotton for effecting the detonation of the wet charge suspended in water being attached to the service concussion fuze.

The detonative force developed by this priming charge is transmitted by the water to each particle of Guncotton before the shell is burst and thus the latter, while perfectly protected from explosion by the shock of the discharge (by being suspended in the water with which the shell is filled) may be made to exert its full destructive force, and thus convert the shell into a mine. These modes of applying Guncotton in shells are at present under investigation by the Committee on Explosives, who are determining the relative merits of the charge of Guncotton and water for large shells with that of picric powder, a powerful explosive agent devised by Mr. Abel some years since for employment in shells.

25. It will be seen from the facts recorded in the latter part of this memo. that Mr. Abel's continued labours in connection with Guncotton since the explosion at Stowmarket (and his relinquishment of his patent rights) have resulted in important improvements in its manufacture and application, and have opened up prospects of a further development of its utility as a very safe and powerful explosive agent.

(Signed) F.A. Abel

23rd September, 1873