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Commentary on
Frederick Augustus
Abel 2010

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Frederick Augustus Abel - Career Summaries

Frederick Abel

From Wikipedia, the free encyclopedia

Sir Frederick Augustus Abel, 1st Baronet GCVO, KCB, FRS (17 July 1827[1] – 6 September 1902) was an English chemist.

Contents

Sir Frederick Abel, Bt
GCVO, KCB, FRS

Born	17 July 1827 London, England, UK
Died	6 September 1902 (aged 75)
Nationality	English
Fields	chemistry
Alma mater	Royal Polytechnic Institution Royal College of Chemistry
Doctoral advisor	A. W. von Hofmann
Known for	cordite
Notable awards	Royal Medal (1877) Albert Medal (1891)

Education

Born in London as son of Johann Leopold Abel, Abel studied chemistry at the Royal Polytechnic Institution and in 1845 became one of the original 26 students of A. W. von Hofmann at the Royal College of Chemistry.[2] In 1852 he was appointed lecturer in chemistry at the Royal Military Academy, Woolwich,[2] succeeding Michael Faraday,[2] who had held that post since 1829.

Early career

From 1854 until 1888 Abel served as ordnance chemist at the Chemical Establishment of the Royal Arsenal at Woolwich,[2] establishing himself as the leading British authority on explosives. Three years later was appointed chemist to the War Department[2] and chemical referee to the government. During his tenure of this office, which lasted until 1888, he carried out a large amount of work in connection with the chemistry of explosives.

Notable work

One of the most important of his investigations had to do with the manufacture of guncotton, and he developed a process, consisting essentially of reducing the nitrated cotton to fine pulp,[2] which enabled it to be safely manufactured and at the same time yielded the product in a form that increased its usefulness. This work to an important extent prepared the way for the "smokeless powders" which came into general use towards the end of the 19th century; cordite, the type adopted by the British government in 1891, was invented jointly by him and Sir James Dewar.[2] He and Dewar were unsuccessfully sued by Alfred Nobel over infringement of Nobel's patent for a similar explosive called ballistite, the case finally being resolved in the House of Lords in 1895. He

also extensively researched the behaviour of black powder when ignited, with the Scottish physicist Sir Andrew Noble. At the request of the British government, he devised the Abel test, a means of determining the flash point of petroleum products.[2] His first instrument, the open-test apparatus, was specified in an Act of Parliament in 1868 for officially specifying petroleum products. It was superseded in August 1879 by the much more reliable Abel close-test instrument.[2] Under the leadership of Sir Frederick Abel, first, Guncotton was developed at Waltham Abbey Royal Gunpowder Mills, patented in 1865, then, the propellant Cordite, patented in 1889. In electricity Abel studied the construction of electrical fuses and other applications of electricity to warlike purposes, and his work on problems of steel manufacture won him in 1897 the Bessemer medal of the Iron and Steel Institute, of which from 1891 to 1893 he was president.

Leadership and honours

He was president of the Institution of Electrical Engineers (then the Society of Telegraph Engineers) in 1877. He became a fellow of the Royal Society in 1860, he was a Commander of the Bath (CB) by 13 February 1879,[3] he was knighted on 20 April 1883[4] and received a Royal Medal in 1887. He took an important part in the work of the Inventions Exhibition (London) in 1885, and in 1887 became organizing secretary and first director of the Imperial Institute, a position he held till his death in 1902. He was Rede Lecturer and received an honorary doctorate from Cambridge University in 1888.[5] He was upgraded to a Knight Commander of the Bath (KCB) on 3 February 1891,[6] created a baronet, of Cadogan Place in the Parish of Chelsea in the County of London, on 25 May 1893[7] and made a Knight Grand Cross of the Royal Victorian Order (GCVO) on 8 March 1901.[8] Abel died in September 1902, aged 75, and was buried in Nunhead Cemetery, London.[2] The baronetcy became extinct on his death.

Books

- *Handbook of Chemistry* (with C. L. Bloxam)
- *Modern History of Gunpowder* (1866)
- *Gun-cotton* (1866)
- *On Explosive Agents* (1872)
- *Researches in Explosives* (1875)
- *Electricity applied to Explosive Purposes* (1898)

He also wrote several important articles in the ninth edition of the Encyclopædia Britannica.

See also

- Internal ballistics

References

1. The Chambers Biographical Dictionary gives his year of birth as 1826. Chambers Biographical Dictionary, ISBN 0-550-18022-2, page 3.
2. Greenwood, Douglas (1999). *Who's Buried where in England* (Third ed.). Constable. ISBN 0-09-479310-7.
3. *The London Gazette*: no. 24678. p. 736 (https://www.thegazette.co.uk/London/issue/24678/page/736). 14 February 1879.
4. *The London Gazette*: no. 25225. p. 2240 (https://www.thegazette.co.uk/London/issue/25225/page/2240). 27 April 1883.
5. "Abel, Frederick Augustus (ABL888FA)". *A Cambridge Alumni Database*. University of Cambridge.
6. *The London Gazette*: no. 26131. p. 615 (https://www.thegazette.co.uk/London/issue/26131/page/615). 3 February 1891.
7. *The London Gazette*: no. 26406. p. 3055 (https://www.thegazette.co.uk/London/issue/26406/page/3055). 26 May 1893.

8. *The Edinburgh Gazette*: no. 11284. p. 293 (https://www.thegazette.co.uk/Edinburgh/issue/11284/page/293). 12 March 1901.

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Further reading

- Chrimes, Mike (2008), "Abel, Sir Frederick Augustus", *A Biographical Dictionary of Civil Engineers*, **2**, London: Thomas Telford, p. 2

External links

- Works by or about Frederick Abel (https://worldcat.org/identities/lccn-n88-2757) in libraries (WorldCat catalog)
- Portraits of Sir Frederick Augustus Abel, 1st Bt (http://www.npg.org.uk/collections/search/person.php?LinkID=mp00007) at the National Portrait Gallery, London

Baronetage of the United Kingdom		
New creation	**Baronet** (of Cadogan Place) 1893–1902	**Extinct**

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Categories: 1827 births | 1902 deaths | English chemists | Cordite | Ballistics experts | Fellows of the Royal Society | Presidents of the Smeatonian Society of Civil Engineers | People associated with Imperial College London | People from London | Knights Bachelor | Baronets in the Baronetage of the United Kingdom | Burials at Nunhead Cemetery | Royal Medal winners | Bessemer Gold Medal

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Frederick Augustus Abel

From Wikipedia, the free encyclopedia.
(Redirected from Frederick Abel)

Sir Frederick Augustus Abel, Bart. (17 July 1827 – 6 September 1902) was an English chemist.

Born in London, Abel studied chemistry for six years under A. W. von Hofmann at the Royal College of Chemistry, then became professor of chemistry at the Royal Military Academy in 1851, and three years later was appointed chemist to the War Department and chemical referee to the government. During his tenure of this office, which lasted until 1888, he carried out a large amount of work in connection with the chemistry of explosives. One of the most important of his investigations had to do with the manufacture of guncotton, and he developed a process, consisting essentially of reducing the nitrated cotton to fine pulp, which enabled it to be safely manufactured and at the same time yielded the product in a form that increased its usefulness.

This work to an important extent prepared the way for the "smokeless powders" which came into general use towards the end of the 19th century; cordite, the type adopted by the British government in 1891, was invented jointly by him and Sir James Dewar. He and Dewar were unsuccessfully sued by Alfred Nobel over infringment of Nobel's patent for a similar explosive called ballistite, the case finally being resolved in the House of Lords in 1895. He also extensively researched the behaviour of black powder when ignited, with the Scottish physicist Sir Andrew Noble.

At the request of the British government, he devised the Abel test, a means of determining the flash point of petroleum products. His first instrument, the open-test apparatus, was specified in an Act of Parliament in 1868 for officially specifying petroleum products. It was superseded in August 1879 by the much more reliable Abel close-test instrument.

In electricity Abel studied the construction of electrical fuses and other applications of electricity to warlike purposes, and his work on problems of steel manufacture won him in 1897 the Bessemer medal of the Iron and Steel Institute, of which from 1891 to 1893 he was president. He was president of the Institution of Electrical Engineers (then the Society of Telegraph Engineers) in 1877. He became a member of the Royal Society in 1860, and received a royal medal in 1887. He took an important part in the work of the Inventions Exhibition (London) in 1885, and in 1887 became organizing secretary and first director of the Imperial Institute, a position he held till his death in 1902. He was knighted in 1891, and created a baronet in 1893.

Books

- *Handbook of Chemistry* (with C. L. Bloxam)
- *Modern History of Gunpowder* (1866)
- *Gun-cotton* (1866)
- *On Explosive Agents* (1872)
- *Researches in Explosives* (1875)
- *Electricity applied to Explosive Purposes* (1884)

He also wrote several important articles in the ninth edition of the Encyclopædia Britannica.

Frederick Augustus Abel

From an old 1911 Encyclopedia

Sir Frederick Augustus Abel , Bart. (1827-1902), English chemist, was born in London on the 17th of July 1827. After studying chemistry for six years under A. W. von Hofmann at the Royal College of Chemistry (established in London in 1845), he became professor of chemistry at the Royal Military Academy in 1851, and three years later was appointed chemist to the War Department and chemical referee to the government. During his tenure of this office, which lasted until 1888, he carried out a large amount of work in connexion with the chemistry of explosives. One of the most important of his investigations had to do with the manufacture of guncotton, and he developed a process, consisting essentially of reducing the nitrated cotton to fine pulp, which enabled it to be prepared with practically no danger and at the same time yielded the product in a form that increased its usefulness. This work to an important extent prepared the way for the "smokeless powders" which came into general use towards the end of the 19th century; cordite, the particular form adopted by the British government in 1891, was invented jointly by him and Professor James Dewar. Our knowledge of the explosion of ordinary black powder was also greatly added to by him, and in conjunction with Sir Andrew Noble he carried out one of the most complete inquiries on record into its behaviour when fired. The invention of the apparatus, legalized in 1879, for the determination of the flash-point of petroleum, was another piece of work which fell to him by virtue of his official position. His first instrument, the open-test apparatus, was prescribed by the act of 1868, but, being found to possess certain defects, it was superseded in 1879 by the Abel close-test instrument (see Petroleum). In electricity Abel studied the construction of electrical fuses and other applications of electricity to warlike purposes, and his work on problems of steel manufacture won him in 1897 the Bessemer medal of the Iron and Steel Institute, of which from 1891 to 1893 he was president. He was president of the Institution of Electrical Engineers (then the Society of Telegraph Engineers) in 1877. He became a member of the Royal Society in 1860, and received a royal medal in 1887. He took an important part in the work of the Inventions Exhibition (London) in 1885, and in 1887 became organizing secretary and first director of the Imperial Institute, a position he held till his death, which occurred in London on the 6th of September 1902. He was knighted in 1891, and created a baronet in 1893.

Among his books were -- *Handbook of Chemistry* (with C. L. Bloxam), *Modern History of Gunpowder* (1866), *Gun-cotton* (1866), *On Explosive Agents* (1872), *Researches in Explosives* (1875), and *Electricity applied to Explosive Purposes* (1884). He also wrote several important articles in the ninth edition of the Encyclopædia Britannica.

The People of the Factory
1787 - 1991

On purchase by the Crown the Mills were termed The Royal Gunpowder Mills. In 1830 this was changed to The Royal Gunpowder Manufactory, later Factory (RGPF). For the sake of regularity the term Factory will be used throughout.

The people involved with the Factory reflected a rich spectrum of type and experience, ranging through military Superintendents, managers, Government scientists, scientific and laboratory staff, specialised skilled staff, engineering staff, process workers and admin and maintenance staff – all subject to varied influences, from the initial activity of purchase and extensive refurbishment, the pressures of war, the demands of changing technology, particularly the transition from gunpowder to chemical explosives, the need to direct scientific research to the most productive avenues and not least the special demands on all employees arising from work in a danger industry.

Drawing on material from the extensive Factory Archive, the following seeks to convey the Waltham Abbey experience over 200 years of Crown ownership by a blend of career commentaries and briefer vignettes.

The Victorian Scientist
Sir Frederick Augustus Abel

Frederick Augustus Abel was born in London in 1827, the son of a music master of German descent. He was the leading Government scientist of the Victorian era. In his capacity as Chemist to the War Department amongst many other studies he conducted influential studies both in gunpowder and the later chemical explosives, materially contributing to the development of gunpowder technology in the latter part of the 19th century and in the case of chemical propellant explosives leading the development of the militarily vital guncotton and cordite. In all of this Waltham Abbey played a key role as the site for post laboratory development through pilot plant to full scale production. Abel's advice was sought in a wide range of activities in the civil field also, recognised in many honours and appointments to high office in professional institutions. He was an urbane man, moving easily in the highest levels of scientific, political, public and artistic society.

Comment on genetic influence on character can only be speculative. However it is interesting to note that Abel's ancestor, Karl Friedrich, after moving to England from Germany achieved a post in Court circles becoming chamber musician to Queen Charlotte. Karl Friedrich was described as ' a man of considerable presence ', as attested by a portrait by Gainsborough, and the same description could be applied to Frederick.

From an early age Abel had an interest in science. Again it is tempting to see genetic influence. At age 14 he had visited an uncle A.T.Abel a mineralologist and it is possible that his interest was clarified and strengthened by this visit. In 1844 Abel elected to study chemistry. The timing could not have been more fortuitous. In mid 19th century the study of chemistry stood on the brink of exponential growth following an earlier explosion of interest in the natural world. This interest had partly found expression in the practice in the aristocracy of setting up collections of ' objects of interest '. To determine what were suitable subjects the novice scientists sought the advice of prominent philosophers. Peter the Great consulted Leibniz. Reputedly the answer was ' everything '. Similarly in the mid 19th century the new science of organic chemistry, the science of natural products particularly one vital element carbon and how their molecules could be re arranged, opened up a virtually limitless vista which was poised to grow into what became a chemical revolution.

> Organic chemistry just now is enough to drive one mad. It gives me the impression of a primeval forest full of the most remarkable things, a monstrous and boundless thicket, with no way of escape, into which one may well dread to enter.
> Friedrich Wohler 1835

Abel started at the Polytechnic Institution and a year later dissatisfied with the curriculum moved to the newly founded Royal College of Chemistry. By great good fortune Abel's mentor was the charismatic Dr. A.W.Hofmann. Hofmann had been a pupil of the ' Father of Organic Chemistry ' Liebig and Hofmann translated to Abel the deep enthusiasm for this branch of science which he had acquired from Liebig. Abel's ability was quickly recognised and Hofmann appointed him as his assistant. In this capacity Abel was able to pursue his own study, writing several significant papers and in 1848 on the strength of this work he was elected Fellow of the Chemical Society of London. In 1851 he took up the post of Demonstrator of Chemistry at St. Bartholomew's Hospital.and in 1853 he was appointed Lecturer on Chemistry at the Royal Military Academy at Woolwich, the Academy of the Royal Artillery. Thus began his life long connection with military science. Scientific advice to the War Office was followed a year later in 1854 by appointment as the first Chemist to the War Department, based at the Royal Laboratory at Woolwich, a post which he held for 34 years and which was to shape his life.

RSC Paper 3 P.5 'Ordnance Chemist'

The timing was critical. The Crimean War was exposing almost catastrophic deficiencies in Army structure, equipment and supply. In parallel with this there was a growing pressure for the new science to come up with what were termed smokeless powders, chemically based. The Austrians, employing a process which was to become fundamental in industrial chemistry – nitration, succeeded in producing a nitrocellulose material, guncotton. However they encountered severe difficulties in producing it safely and abandonned their programme. Crucially Abel, who had studied the Austrians' efforts pushed forward with his research and succeeded by a process of pulping in eliminating the problem of impurities which had plagued the Austrians. Together with work by E.O.Brown , one of his staff, who demonstrated that in a moist condition guncotton could be handled and stored safely and could be detonated by fulminate of mercury, guncotton was finally established as a practicable smokeless powder. In this process the Factory had a vital role as the link between research at the Government Laboratory and investigation of industrial scale production. In 1872 in buildings at Waltham Abbey associated with the Factory saltpetre refinery a guncotton production plant with a capacity of 250 t.p.a. was established and guncotton entered service with the British Forces as a filling for mines, torpedoes and shells and a demolition agent. However one major goal eluded Abel. Guncotton could not be used as a propellant explosive as it was too powerful and would have caused damage to the guns.

Abel re concentrated his research energies on gunpowder and together with the Ordnance officer Andrew Noble undertook a massive study in laboratory conditions of gunpowder explosion and ballistics in the propellant role. This ' Research on Explosives ' published in 1875 and 1880 was the most significant study of gunpowder so far undertaken and was a major influence in creating the type of gunpowder suited to the ever larger calibre guns which were being produced.

In the 1880's it would have appeared that the position of gunpowder as the military propellant was still unassailable. However two events took place in the development of the chemical smokeless powders which fundamentally changed the situation. In the mid 1880's P. Vieille in France successfully developed a nitrocellulose based smokeless propellant powder, the first. Secondly Alfred Nobel the prolific Swedish explosives manufacturer, scientist and inventor in 1887 patented ballistite, a highly effective blend of nitrocellulose and nitroglycerine. The British Government reacted by forming in 1888 a Committee on Explosives with Abel as President and including James Dewar, later to find fame as the inventor of the system on which the Thermos flask was based. Abel and Dewar successfully produced a propellant based on nitrocellulose and nitroglycerine which was patented in 1889 as Cordite. Cordite quickly became the standard propellant for the British Forces. It was a product of high quality, effective in performance and robust in storage, capable of ongoing development and adaptation to changing requirements. The fact that it continues in use to this day is a tribute to these characteristics.

As with guncotton, the Factory played a vital role in cordite, acting as a test bed for scaled up laboratory procedures and setting up facilities for full scale production, including the building of nitroglycerine plant. This fundamental change in technology from gunpowder to smokeless powders was a massive challenge for the Factory with all the implications for procedures, staff training, buildings, machinery, laboratory practice etc. and was accomplished over a remarkably short space of time.

Abel's scientific activities by no means stopped at explosives. As his scientific stature increased the world of civil science increasingly turned to him for advice. Much of this had a safety and quality orientation. As new chemical products became available it became increasingly important to have uniform tests of characteristics in order that safe storage and use could be ensured. In explosives Abel had already developed his heat test to determine the stability of guncotton. For the new petroleum industry he devised a closed test apparatus for determining the flash point of petrol. For the Home Office he made a study of 'dangerous dusts ' with particular reference to the reasons for the deadly coal dust/fire damp explosions in mines. Electricity attracted his attention and he carried out extensive research on the use of electrical fuses for military purposes and various aspects of electricity in civil use. The science of metallurgy was constantly seeking ways of improving steel. This was materially advanced by Abel's research into the conditions under which carbon exists in steel.

All this brought many appointments to high office in professional institutions. Abel was at various times President of the following – Chemical Society, Institute of Chemistry, Institution of Electrical Engineers, Society of Chemical Engineers, Iron and Steel Institute, British Association for the Advancement of Science
In the world of education and the arts Abel was extremely influential. He was Organising Secretary of the Imperial Institute, member of the Board of Managers of the Royal Institution, Chairman of the Society of Arts and a Member of Council of the Royal Academy of Music.

It is not surprising that Abel's work brought him a succession of honours – 1877 Companion of the Bath, 1883 knighted, 1891 Knight Commander of the Order of the Bath, 1893 Baronet, 1901 Knight Grand Cross of the Victorian Order.

Abel was a scientific colossus of the Victorian age with an astounding range of achievements, civil and military. The second half of the 19th century saw what has been termed a chemical revolution with organic chemistry being applied to produce a range of products which ultimately spread into every facet of life. Abel's work in to the use of chemistry to produce nitro propellant explosives puts him in the front rank of the instigators of the chemical revolution.

In the writing of this commentary grateful thanks are extended to the Wallis family for their kind permission to view the Wallis Abel Archive.

Les Tucker

Lecture on Wallis Abel Archive
given at WAACH Feb. 2003 by
Prof. Sy Mauskopf

history enquirers, answering a wide variety of technical enquiries, availability of photographs etc. for talks and tours, writing of articles. Some future projects were outlined - career summaries of the RA Superintendents, joint studies with other organisations, setting up of an Archive website, further sub collections. Finally the speaker offered the assistance of the Archive to enquirers and emphasised the debt owed to Malcolm McLaren without whose foresight and leadership none of the above would have been possible.

The morning session concluded with Sy Mauskopf's survey of the newly available Abel Papers, which amply conveyed the thrill of the historian at the discovery and reading of previously unknown documents. Our speaker had been able to compensate for the shortness of time in the Archives by photographing many of the documents which, portrayed on the screen, allowed us to enter more fully into the world of this eminent War Department chemist of the second half of the nineteenth century.

THE WALLIS ABEL ARCHIVE: NEW LIGHT ON THE CAREER OF FREDERICK AUGUSTUS ABEL (1827-1902) Professor Seymour Mauskopf

Although historians employ all sorts of material to reconstruct the past, the essence of our evidence remains the written record. To the research historian, there are few things more enjoyable or exciting than 'contacting' someone long since dead through the perusal of his writing. The Wallis Abel archive of original documents of (or about) Sir Frederick Augustus Abel provides just this opportunity. Moreover, it does so for a nineteenth-century chemist who has been unduly neglected, no doubt in part because of a dearth of original manuscript material on him.

Significance of Abel

The career of Frederick Augustus Abel has a three-fold significance for the development of modern British science. As a charter student in the Royal College of Chemistry, Abel was one of the first professionally-trained chemists in England.[1] The Royal College of Chemistry, founded in 1845, was based on the model of research training in chemistry that had recently been developed in German universities, particularly the University of Giessen under Justus Liebig.

Secondly, Abel was one of the earliest scientists in Britain to spend virtually his entire career in government service, working for the military arm as 'Chemist to the War Department'. And thirdly, Abel had a wide-ranging technological interest; he carried out investigations in areas that became particularly prominent in the late nineteenth and twentieth century, such as metallurgy, petroleum chemistry, and electricity.

But the focus of his research was unquestionably in military chemistry, particularly explosives and munitions. His research in these areas falls rather neatly into the three principal decades of his career. In the 1860s, Abel worked at purifying and stabilizing 'guncotton' (trinitrocellulose), initially as a military propellant but then for other military uses (mines and torpedoes) and as a blasting agent in civilian mining and construction activities. In the 1870s, Abel carried out the most comprehensive scientific study of gunpowder undertaken up to this time in concert with the artillery officer and gun manufacturer, Andrew Noble. In the late 1880s, Abel was appointed president of an Explosives Committee to develop a smokeless propellant. The

committee succeeded in developing a double-base powder (nitrocellulose/nitroglycerin), based on a similar powder of Nobel ('ballistite'), which they patented under the name of 'cordite'.

Although Abel was never an academic chemist in the strict sense, he possessed the prestige of a fully professional scientist, as shown by the numerous offices he held in scientific societies and his publications in the most prestigious scientific journals. At the same time, Abel took out patents for a number of results of his scientific investigations. But his attempts to develop some of these patents commercially raised serious issues of conflict of interest since he was a government-employed scientific expert and advisor. These issues were highlighted in two conflicts with Alfred Nobel: over dynamite versus guncotton around 1870, and then, twenty years later, over ballistite versus cordite. This latter resulted in a celebrated patent-infringement suit brought by Nobel's Explosive Company over cordite.

Documentary Sources on Abel

The Wallis Abel archive is one of the few repositories of written historical material pertaining to Abel. Aside from sources scattered through the archives of the Public Record Office, I know of only three other significant collections: (1) A collection of about two hundred letters of Abel to Andrew Noble, formerly held at the archive of the Library of the Royal Artillery School in Woolwich Arsenal: (2) Some thirty letters of Abel contained in the collection of the physicist, George Gabriel Stokes, in the archive of the Cambridge University Library; (3) A considerable quantity of correspondence in the Alfred Nobel Archive in the (Swedish) National Archives, Stockholm.

The Wallis Abel Archive

The archive consists of extensive correspondence and other written documents of Abel's as well as a cache of Abel's account books and his diary for two years. Mr David Wallis, the discoverer and owner of the archive, and a collateral descendant of Abel, has organized the written documents into three categories, the material in each separately boxed: (1) 'Letters and career summaries' (the green file); (2) 'Events' (the red file); (3) 'Personal letters, 1888-1902' (the blue file). For each file box, Wallis has provided an inventory of the contents. A good part of the contents of the red file concern what Wallis has titled 'The Affair of the Gun Cotton Patent;' for this, he has provided a very detailed and useful chronology.

Utility of the Wallis Abel Archive for Historical Research

In the three days that I spent exploring the archive, I found much of real significance pertaining to Abel's scientific career and to his personal life. By implication, the archive is also a rich source of material on late nineteenth-century science and society. In conclusion, I shall give a few examples of material that I found useful to my own research:

The details of Abel's career

One of the problems in studying the life of any scientist is establishing the details of his career, especially the early years, which are often poorly documented. In the case of Abel, there has been uncertainty about the precise details of his career before he

became Chemist to the War Department in 1855. Documents in the 'green file' provide complete clarification. Firstly, there are a number of documents that give a narrative of his career in military chemistry. One begins with an entry for 1849:

> First established classes of instruction in practical chemistry, of cadets, Rol Mily Academy and Officers R.A. [2]

These documents are complemented for the early years by a copy of Abel's letter of 9 February 1852, in which he applied for the position of Professor of Chemistry at the Royal Military Academy, Woolwich. The letter itself was addressed from St. Bartholomew's Hospital, London, at which institution he mentioned in the letter that he had been employed for 'twelve months' as 'Assistant Teacher of Chemistry'. He also gave a very detailed account of his education in chemistry and the various positions he held.[3]

I would like to return to the narrative document of Abel's career in military chemistry for it provides an invaluable account of how Abel created a niche for himself as a government military chemist:

> When the chemical establishment of the War Dept (Ordnance) was created in 1854, no special duties were assigned to the chemist, on whom depended the development of the Department. – During the first few years they were chiefly connected with the purchase and inspection of stores for the Manufacturing Establishments. And other branches pf Supply Departs (the system of select competition being introduced in many directions through Mr Abel's exertions). [4]

Abel went on to delineate in great detail the very complex functions that he and his staff took on. Although space constraints preclude illustrations of them, this and similar documents will afford the researcher information on Abel and, more generally, on the development of government scientific activities in nineteenth century Britain.

Abel's social connections

As a sign of the success with which Abel established his position as a government scientist, he came to move in the very highest social circles. This was recognized by his quondam opponent, Alfred Nobel. In a letter of Nobel to the General Manager of Nobel's Explosives Company of 19 January 1892, over the impending patent-infringement lawsuit over cordite, Nobel cautioned that 'one of the opponents is on very friendly terms with a powerful Prince'.[5] Nobel was undoubtedly referring to Abel and the Prince of Wales, and this royal friendship is borne out in correspondence in the blue file. I quote a charming example from a few years later. Dated 13 February 1900, it is an invitation (or friendly royal command) from the Prince of Wales to Abel by Sir Francis Knollys, the Prince's Private Secretary:

> The Prince of Wales desires me to say that Prince Charles of Denmark would much like to dine with you tomorrow, if you would kindly ask him, and go to the concert afterwards.
> Perhaps you will take care there are not 13 at dinner as the Prince of Wales Is rather superstitious on that point.

> H.R.H. hopes that you will be good enough to tell those who have stars and ribbons that they could [possibly 'should'] wear them, but only of course one star.[6]

Conclusion

I have endeavoured to give a few glimpses of how the rich and valuable material in the Wallis Abel archive can be deployed in connection with other archival resources to illuminate the life and career of Frederick Abel. This archive is a splendid addition to the available historical resources on nineteenth-century British science, technology, and government.

NOTES

1 I say 'England' here because there had been somewhat more of an academic chemical tradition in Scotland.
2 Green file, Document No.5 (in Wallis' inventory). Title is very faint but inventory gives it as: 'Memo: Nature of F.A.A.'s Services, 1849-1887'.
3 *Ibid.*, Document No.1, titled:'To Colonel Portlock Application for Appointment as Prof of Chem to Royal Mil Academy'. The letter appears to be a contemporary copy not in Abel's hand (at least the hand is very different from Abel's mature hand). The letter refers to testimonials 'which I shall shortly have the honour to submit to you'. I found a copy of this sixteen page testimonial booklet in an unlikely place, the papers of James Dewar at the Royal Institution (D1b/3).
4 Green file, Document No.5. I have largely maintained Abel's capitalization. I do not know to what 'the system of select competition' refers.
5 Alfred Nobel – Thomas Johnston, Riksarkivet, Alfred NobelsArkiv, Signum: BI:8 (De12): Kopiebö 1890-1894, p.119.
6 Blue file.

Afternoon Session We were doubly fortunate in our next presentation, for it was the chance discovery of the once-restored but now closed Ballincollig Royal Gunpowder Mills by Jenny Webb that had sparked her interest in the site, and the help received from the writer Anne Donaldson and Jenny's own family, that allowed us to have such a splendid pictorial tour, courtesy of PowerPoint. The site is known to many of us, not least through the account by Brendan Kelleher of the initial restoration of the site, in his contribution to the volume I edited entitled *Gunpowder: The History of an International Technology* (Bath Univ.Press, 1996). That gave a jubilant portrayal of the help received from all the levels of government up to the then European Community, but the account of its fate just a decade later, presented by Jenny, is a sad lesson in the difficulty in keeping such brave projects going.

1849. First established Classes of instruction in practical Chemistry, of Cadets R.M. Academy & Officers R.A.

1852 Succeeds Profr Faraday as Lecturer on Chemistry - R.M. Military Academy -

1854. appointmt of Ordnance Chemist created & Mr Abel appointed - Duties as R.M. Acad.y at first included

1855. Appointment altered to War Departt Chemist Instructor in Chemistry appointed at R.M.A. under Mr Abel

1855. Appointed Member of Ordnance Select Ctee -

1856. Appointed Examiner in Chemistry & Physics for admissn to R.M.A. - afterwards under Council of Military Education - Served till 1874 - when his other duties rendered it impossible. -

When the Chemical Establishment of the War Dept (Ordnance) was created in 1854, no special duties were assigned to Chemist, on whom depended the development of the Departmt - During the first two or three years, they were chiefly connected with the purchase & chemical inspection of Stores for the Manufacturing Establishts & other Branches of Supply Depts (the system of select competition being introduced in many directions through Mr Abel's exertions) - the examination into the merits of scientific inventions - the work of the O.S. Cttee & Sub-Comtes - and Missions to report on Continental Arsenals Iron Works &c. — The services of the Chemical Department were, however, rapidly extended by Mr Abel's exertions, and for many years past he has rendered important service to every Departmt of the War Office, including the Majority of Military Stations at home & abroad. Advice & Assistance have been constantly furnished to the Supts of Manufacturing Depts at Woolwich Enfield & Waltham, to the Heads of Clothing & Commissariat Depts - of the Contract, Control (Store) Depts - to Experimental & other Committees, to the R.E. Authorities at home and abroad, &c. - He has rendered specially valuable services to the R.L. Labs, Gunpowder Factory & Mr Store Dept

and

Illustrations of work done by Mr Abel for other public departments.

Admiralty. – Frequently consulted, for many years past, on scientific & practical subjects of various kinds. Matters connected with N. School of Gunnery, Torpedo School &c

Member of Admiralty Cttee on Naval Electric Stores – preparation of Manual for Torpedo Service and of Admiralty Torpedo Commee

Commee on Gas Explosions in Coal Bunkers and on Ferotine Siccative – (arising out of Mr A's evidence before Court-Martial on Doterel 1881.

Special thanks several times sent by Admiralty through W.O., for "services rendered to the Navy".

Office of Works &c. – Commee on the decay of Stone of the Houses of Parliament, and special advice & assistance, subsequently, on this subject, & on others connected with Public Works.

Important reference in regard to dispute between Officials of Science & Art Dept & of Works Department (re Rl School of Mines) – Special thanks recorded.

Foreign Office. – Series of Reports relating to difficulties between French Govrnt & British Mineral Oil Trade. – Negotiations for settlement of difficulties carried on, for Secy of State, in Paris, 1877–78. Evidence given before Internatl Tariff Commission – 1881, Paris. (Repeated thanks, through W.O. for services rendered – attention called to their value, by Lord Lyons, in Dispatch, presented 1878).

Board of Trade. – Aid in working out system of guncotton Fog signals (Trinity Board) & other professional services.

Home Office. – Advice & Assistance furnished in the elaboration of the Explosives Act (special thanks received. –

[Margin note, written sideways:] Services by [illegible] of difficulty [illegible] between Italian Government & British Mineral Oil Trade, now pending – [illegible] Engineering [illegible] evidence [illegible] in the explosion in [illegible] Doterel

and has, by his scientific & practical advice & assistance
contributed greatly to the improvements effected, from
time to time, in War Materiel, and to the solution
of difficulties connected with its manufacture,
storage, &c. Has also carried out many scientific and
practical investigations, of substantial value to the
Service. Thus, his experiments on the application of
electricity to the explosion of Mines, &c, - commenced
in 1855, resulted in the invention of the first efficient
Service electric Fuze and Gun-tubes, and in the per-
fection, & of these, from time to time, to meet the
increasing requirements of Mil[y] Engineering, Submarine
Mining, and Naval Services. The foundation of the
existing system of defence by Submarine Mines &c
was laid by the work done in the Chemical Department.
Again, Mr Abel's researches & practical labors connected
with explosive compounds furnished the Service with
the only permanent and practically efficient form
of gun-cotton (which Germany & France, we have adopted
in imitation of the English Mil[y] & Naval Service) - besides
other valuable materials & appliances of this class.
By Foreign Powers, Mr Abel is regarded as one of the
highest Authorities on the above subjects. - In connexion
with the supply of Necessaries of the proper quality to
the Troops at all Stations (e.g. Water, Foods, waterproof &
other Clothing; illuminating & cleansing & disinfecting
agents) - also with the solutions of difficulties
arising out of the wide climatic variations, in the Empire
Mr Abel has also rendered many important Services.

In addition to the general duties of which the
above is an outline, the following are illustrations
of special Services performed by him: -

The more important Committees upon which
he has served, or is serving, in connexion with the War
Office are as follows:

The Ordnance Select Committee - from 1855,
until the first paid Committee was appointed. Was
afterwards associated with that Committee - affording constant
assistance to it in reporting upon & experimentally
investigating inventions & subjects of importance.

As Associate Member of the Ordnance Committee
on matters relating to Explosives - Construction of Guns &

The Royal Engineer Comᵉ first as assistant, and for several years past as Member.

Comᵉ on the Lubrication &c of Small Arms Cartridges (during the Indian Mutiny).

Comᵉ on the application of Asphalte to W.O works and Buildings.

Special Comᵉ on Bronze (1870-75) Improvements in Bronze as material for War appliances.

Special Committee on Gunpowder (1858) - by which the first improvements in Powder for large rifled guns & small arms were worked out.

Comᵉ on Explosive Substances (1869 up to appointment of Ordnance Comᵉ) (In connexion with this work Mr Abel is the joint Author with Captain A Noble, of a series of elaborate Researches on the action of fired Gunpowder, &c, which have been & are being published by the Royal Society).

Committee on Military Balloons. (Special thanks were received from War Office for services connected with this subject, before appointment of the 1st Comᵉ 1871

Committee on Guncotton 1863-1868 (Mr Abel conducted almost exclusively, the experimental work connected with this Comᵉ).

War Office & Admiralty Comᵉ on Floating Obstructions - 1863-1868 - which laid the foundation to the present system of Defence by Submarine Mines. - Special Letter of thanks (with from Comᵉ itself) for Services rendered on this Comᵉ.

Comᵉ on the Provision of Submarine Mining Stores.

War Office Torpedo Comᵉ 1870-74 (Special thanks officially recorded for services rendered to this Cᵉ

Comᵉ on the Storage & Transport of Gunpowder, Guncotton, &c,

Comᵉ on the Color of Uniforms and Accoutrements (the Experiments carried on by this Comᵉ were devised & conducted by Mr Abel)

Comᵉ on Defence of Channel Tunnel

Home Office, contd. – Advice given in reference to Petroleum Act of . Elaboration of present system of testing Petroleum. – Act of 1879 passed for the purpose of prescribing this as the legal Test. – (Special thanks from the Home Secy and from Public Bodies. The "Abel Test" has been adopted in the United States, Germany & other Countries.

Investigation of the destructive effects of small detonating Charges (Infernal Machines on Buildings & Ships – 1880-81 – jointly with Colonel Majendie, Inspector of Explosives).

Advice & experimental assistance constantly given to H. M. Inspectors of Explosives. –

Laborious investigation on the influence of Coal dust in producing or aggravating Colliery explosions; and scientific evidence given at the Inquest on the great explosion at Seaham Colliery 1880 (Special thanks recd

especially of late in connexion with Lesser outrages

India Office. – Advice & assistance furnished from time to time, for many years past, in connexion especially with the Store Department of the I. Govt.

Enquiry into difficulties in India in connexion with importation of Petroleum and the application of legislation & testing adopted at home. – Special advice sought – & experimental investigation made. (Special thanks recd) Subject still being pursued. –

Royal Commissions served on by Mr Abel

1. On explosions & spontaneous combustion in coal-laden ships. – Mr Childers, Chairman
2. On Noxious Vapors. Lord Aberdare, Chairman
3. On Accidents in Mines. The larger proportion of the heavy experimental work of this Commission is conducted by Mr Abel (work still being pursued).

4. Special W. O. Comm on the Chemical Science 1852

Knighted 1891 Baronet 1893

ABEL. Sir Frederick Augustus 1st Baronet Created 1893. Born 1826 aged 67
K.C.B. F.R.S. G.C.V.O. D.C.L Oxon D.Sc Cantab Died 6/9/1902. Age 76

House and Director Imperial Institute
Professor of Chemistry Royal Military Academy. 1851-55.
Chemist War Dept. 1854-1888.
President Special Committee on Explosives 1888-91
President British Association
President Iron and Steel Institute.
" Chemical Society
" Institute of Chemistry
" Society of Chemical Industry.
" Institute of Electrical Engineers
Chairman Society of Arts
Prime Warden of Goldsmiths
Medallist Albert. Royal. Telford and Bessemer.

SEE OVER

Abel. Sir Fredk Aug Bart. 1827-1902

Born. 17 July 1827.
Studied 6 years under Hofman at Royal Coll of Chemistry
Say from 1847-1853

	Age.	
1827.		
1837	10	
1847	20	Prof of Chemistry 1851. ∴ 1845+6 = 1851.

Abel must have been one of the first pupils of A.W.H. from 1845-1851 (6 years)
In 1851 Prof of Chem

Flash point of Petroleum 1879

May not

President Iron & Steel Inst 1891-93.
" Soc Telegraph Engs. 1877
Member Royal Soc. 1860

F.A.A. Books
Handbook of Chemistry with C.L. Bloxam.
Modern History of Gunpowder 1866
Gun Cotton 1866.
On Explosive Agents 1872.
Researches on Explosives 1875.
Electricity Supplied to Explosives 1884.
Also Several articles in Enc Brit 9th Edition

Studied 6 yrs under A.W. Von Hofmann.
at Royal Coll of Chem est 1845 Became Prof of Chem
at Royal Military Academy 1851 - In 1854 Chemist to
War Dept & Chem referee to Court ~1888
FRS 1860

1875 Age 49 See Ency Britt Vol XXI P. 948.

Arctic Expeditions British
29 May 75 Exped leaves Portsmouth
S Steamers 'Alert' & 'Discovery'
Personnel: – Capt. Geo S Nares (from Challenger) } 'Alert'
Cmdr. Albert H Markham Lt Pelham Aldrich }
Capt Henry Wemyss Fielden R.A. Lt Parr Lt Aldrich, } Discovery
Capt. Henry F Stephenson Lt Lewis A Beaumont. }

Also 1875. Sir Allen Young. in S.S. 'Pandora'
C

Imperial Institute Members.

A. W. Von Hofman
John Lloyd Bullock.
Karl. H. Reinginus Fresenius
Heinrich Will
John Gardner.
Henry Cole.
De la Beche. Sir Henry.
Lyon Playfair
Sir Norman Lockyer.
Huxley. T H.
Frankland. Sir Edwd.
Tyndall. John
A W. Rucker.
W A. Tilden
John W. Judd.
John Percy.
Frederick Guthrie
Sir Otto Beit
Lord. R. B. Haldane.
Sir Julius Wernher
Philip Magnus.
H. E Armstrong
W. E. Ayrton.
Sir James Thompson
W. H. Perkin
H. L. Callendar.
Adam Sedwick

WASC-2127-2

Frederick Augustus Abel - pages from personal daily diary. 1875.

Work all day
at Lecture

8 Mon [67-298]
Russian officer came
Town, admiralty over Hall —
Brought Fish
Sent Tickets to Bosanquet & Blomfield
The Lines as good in Evening
accepted Spottiswoode invitation for Friday
Work late at Lecture.

9 Tu [68-297] Southampton Committee took chair
Office all day — at telephone
Invitation from Hillsborough Friday
Anderson C. E. came in afternoon
Town late in afternoon
Home to dinner worked late
Cheque from Ladd for Fuze Royalties

10 Wed [69-296] Beer communicat
Portsmouth — discussion of Reports
Read Lecture notes
Home 9 o'clock
Worked late —
Cheque from Nicholson Foreign & Colonial repellers

Fred & Charlie in afternoon
Wrote to Hoffmann, abt
Dining with me at Lancaster

11 Th [70-295]
Office — saw Leahy & Lyon Kazer &
all day.

Town late in afternoon
Paid Sarah £10 — paid Bills
wrote Davis putting off for this week

12 Fri [71-294] Very cold — sleet —
very poorly
To R^l Institution at 2 —
Spottiswoode abt my Lecture
Lecture on Accidental explosions
Sarah with Fields to my Lecture
Dividend from D K Boring Co

13 Sat [72-293] To Burlington House abt
my Lecture Dinner arrangements
Office early Friday
Town — Wrightson & Allen
Talk with Longbourne abt Trench
for Southampton — Stuart Gainsworthy
W.O. Revision of Transport Report
Wrote Hoffmann about Dining with me
Dilly accepts for 22nd

Church
wrote Thredder & Gebhard
abt 3 missing Bottles.
[illegible]

10 Mon [130–235]
Cook 2 wages paid Gave warning
To Portsmouth Storm Co
returned to Town 9 p.m. and met
Kebble at Club discussed his
Junction results, home 11 train
Letter from Nicholson abt Field's [illegible]
Took water to [illegible]

11 Tu [131–234] Mr Price returned
Office in morning Younghusband
To Lambeth saw [illegible] abt office
Town afternoon Club wrote [illegible]
home to dinner
wrote Thredder & Gebhard abt 2 wine [illegible]
letters fr Delaken & Ld Rayleigh
abt my affair
Beer began

12 Wed [132–233] ☽
To S. Kensington Loan Collection in
Lunch at Windham wrote.

£5 from Blyham for Johnson
Saw Younghusband at Athenm R.P. Eykyn
Saw Williamson at Ath abt
Simms Stock
Dinner at Simmons — last train

Letter from [illegible] Basil ill [illegible]
Gustel gone to Margate — wrote [illegible]
and Bell

13 Th [133–232] NOTE Office till 4
Met Scratchley abt water works
wrote Attfield abt Pharm'l Dinner [illegible]
To Shaws home 11 train
Sent Heathcote signed [illegible] card
Sir F Dr Oberon Egypt (returned)
Chapman wrote minute abt [illegible]

14 Fri [134–231] NOTE
wrote Gustel [illegible]
Scratchley came early abt water-works case
To Chatham Comm — afternoon
S. Arts Comm — [illegible] Brennan
paid Bills & Paper — Salvini
Letter from Davis — [illegible]
Letter to Hall abt key having written to [illegible]

15 Sat [135–230] NOTE Mr Price left Office early
Town Admiralty Comm
Office [illegible] Storage Co War Office
To Windham
Nugent said name had been sent
Took Sarah & V. to dine Simpson
& Covent Lady Flora

16 **May** Whitsun Day [136-229] NOTE 5th Mo **1875**

Sarah Hysterics - abt child
To Common with Louie
Wrote Spiller abt Johnson

17 Whitsun Mon [137-228] NOTE Bank Holiday

Town early Tapped(?) in
wrote at Athenaeum
To Park - dined at Athenaeum
To Maitland's for Lecture
Slow harding home

18 Whitsun Tu [138-227] NOTE

Office till late -
St. Arts Council -
To Tailors ordered Suits (2)
Sharon(?) Annual Dinner, Speech!!
11 Train -

19 Wed [139-226] NOTE Portsmouth early

Earle Guillard(?) abt hunting
Looked at Arctic Ships
Dined & slept at Simpsons
(Clergyman)

NOTES OF THE WEEK—16 Ember Week 17 Bank Holiday 18 See Holiday Table, page 2 19, 21 Ember Days 22 Trinity Term begins. Ember Day **May**

To Lea saw Fell & Taylor abt affairs
To Charlton, saw Fanny, called Bridge Came
Wrote Thredder abt town breakage

20 Th [140-225] O

Obtain last 9 o'clock
Left 8 o'clock Stormy
Town 11.30 - down then
Aunt Soc Council & wrote Letters
Reply from Gebhard abt breakages
Recd Jeffery's from Thredder
Saw E. C. H. abt Field hitch in money

21 Fri [141-224] NOTE

Office all day
Town - with Sarah & Percy
Dined Simpsons, Gusterhame(?)
Soc Arts Chair Webb's paper & others
What a Price afterwards -
home 11 pm

22 Sat [142-223] NOTE

Office early
Sarah & V. Waterhallen(?)
Town brought Fish Trout re
Admiralty Hall (Chas Hallé)
Dined at Shaws -
11 Train

Maitland

admiralty

23 May Trinity **Sunday** [143-222] 5th Mo **1875**

Church -

24 Mon [144-221] NOTE Shell Explosion R.L.

Office all morning Col Brown & Younghusband to Lunch
Explosives Com in afternoon - then to scene of explosion - took samples
home dinner
Bottled red wine in evening

25 Tu [145-220]

To R.L. early to meet Fraser abt explosion
To South Kensington Com[mittee] Loan
Horse Guards, Majendie & Younghusband Apps Exhibition
Miss Askwith -
home dinner - wrote late

26 Wed [146-219] Derby Day.

Letter from Charles abt Effie & B. outing on Saturday - replied, not going
Letter from Fred asking to see me
Tower afternoon C. Service
Dined at Wrinkham wrote Athenaeum
home 11 train Colonel Young dead
Telegraphed to Gaillardet abt Friday reply

NOTES OF THE WEEK—24 Queen born 1819. See Holiday Table, page 2 27 Corpus Christi **May**

B Dyason came at 16/
Keyl Muller to dinner

Replied

27 Th [147-218] NOTE Mrs Price left - last

Letter of sympathy from Rolling, replied
to Hall Cheltenham (miscarriage of wife)
Office all day.
Tom late - Epsom
Mr Spiller called abt Waltham funeral
paid Sarah £1 after morning
paid Bilson

28 Fri [148-217] (£4. EAR.S)

Sarah to Lee
Tower early - City bridge clothes -
To Markus Fields affair -
negotiations broken off with E.C.R.
left Letter for Prentice
Athenaeum - Dinner L'ade Lodge
home 10 train

29 Sat [149-216]

Queens B'day
Arsenal closed Queens Birthday
Attended Funerals of Young & Walstow
Prentice, Scratchley & Noble called
Letter from Brazil with subscription
~~for~~ Johnson - replied
Walked with Sarah & Children

Church with children
Collection

6 Mon [340-25] ☽

Town afternoon S. Arts
Dined early Richmond Case
Hector called there 1st action –
– home supper
work late.

7 Tu [341-24]

Town afternoon [illegible]
home dinner
Ordered Christmas Groceries
declined to give evidence in Admiralty Service
Boiler Comm

8 Wed [342-23]

W. O. Campbell, abt Cavalry charges
B. Assocn First Council Meeting
home late to dinner
work late at Telegraph Cable Report

Hill[illegible] afternoon

9 Th [343-22]

Office all day
Paid Bills

10 Fri [344-21] Chatham [illegible] Co

Town made Christmas purchases
Home dinner

11 Sat [345-20]

Town [illegible]
Met De la [illegible]
Went office [illegible] Co
[illegible] dinner
Fuller [illegible] abt Richmond case
work late wrote [illegible]

WASC-2127-3

Letter from Director of Ordnance notifying salary increase to £800 per annum. 16.01.1867.

1/121

16/1/67

15 January 1867

Sir

Lieutenant General Peel having had under his Consideration the increased duties devolving upon you as Chemist to the War Department has, with the concurrence of the Lords Commissioners of Her Majesty's Treasury decided upon raising your Salary from Seven to Eight hundred a year -

This decision will take effect from the 1st April next.

I am, Sir
Your obedient Servant

The Chemist to
The War Department

Major General
Director of Ordnance

WASC-2127-4

Letter from J. F. Burgoyne (War Office?) to Frederick Abel expressing surprise that the Austrian Government had abandoned Guncotton (ex wasc-2116). 29.11.1865.

2127/4

29 Nov[r]
1865

My dear Mr Abel

I see in this day's Times the astounding announcement that the Austrian Government ~~had~~ totally abandoned the employment of Gun boats in the Artillery & Engineer Service. — Do you

— Abel Esq[r]

know any thing of this
The Austrian would
be the last service from
which to expect such
a move

My dear Mr Abel

Yours faithfully

J. F. Burgoyne

WASC-2127-5

Summary and chronological of "The Affair of the Guncotton Patent". F A Abel, 19.07.1873.

Summary and Chronology of The Affair of The Gun Cotton Patent

April 1865. Patent taken out for Improvement of Gun Cotton by Prof F.A. Abel

Autumn 66. Messrs Prentice Gun Cotton Co of Stowmarket allowed to work experimentally under F.A.A's Patent for period of 12 months No Royalties due to F.A.A. for Government Contracts i.e. Only. Private Civil work was allowable for Royalties

67. Messrs Prentice receives Licences to Manufacture Gun Cotton

68 " " " Exclusive licence " "

January 70. On enquiry from. Surveyor General. F.A.A Submits details of Patent and his Justification for Securing Patent in his n

August 70. - F.A.A. memo to Director of Artillery advising the Government establish its own glycerine factory at Waltham Abbey Wo

8. Nov 70 - Memo from F.A.A to Surveyor General after interview between about Considerable Supply of Gun Cotton required for Torped purposes. Also question of existing manufacture at Stowm enquired into, and Contract awarded to Prentice Gun C Company Stowmarket for Supply of 200 Tons of Gun Cot Quality Control Proposed by F.A.A.

11 August 71. Explosion at Stowmarket Works of Prentices Gun Cotton Co at 2.10. P.M. A hot summer Contributed to detonation of 14 Tons o 20 dead 30 injured Stowmarket devasted, works razed t ground, Prentice Nephew killed.

" August 71. Voluntary relinquishment of Patent Proposed by F.A.A. and request to see W.O. Solicitor to arrange for it.

21. Sept 71. F.A.A. Called upon to explain exact manner of relinquishm

6. Novembe 71. F.A.A Considering matter Submits Sir Wm Armstrong's ac

12. December 71. Secretary of State asks F.A.A. for relinquishment Sir E. C Chambers Nicholson agrees to purchase payment for £100 t to a nominal Value by the Stowmarket explosion

20 December 71 F.A.A. Reports Nicholsons offer to Sec of State.

6. January 72. Letter from Director of Artillery agrees F.A.A Should See W.O Solici

24 " 72. Mr Slade W.O. Solicitor agrees purchase of Patent by Ni also approved by Mr Cardwell. F.A.A reports holding the purcha of £100 at discretion of Sec of State - Patent rights relin

28 March 72. In response to F.A.A's query Sec of State would not give any di on the £100 payment F.A.A assumes this attitude would be for any sum.

Note Royalties on Patent received by F.A.A over the five years of it Autumn 1866 - Dec 71 Came to £2,142 Less expenses to maintain P i.e £2,000, Newspaper article Aug 1971 Prof Abel received Royalties £10/Ton of G.C made that is exclusive of Govt Contract and 10d/1000 Sporting Cartridges

Director of Artillery — July 19 (1) 1873

In accordance with the desire expressed by Mr Cardwell on the occasion of my interview with him on the 18th Inst. I submit for his Consideration the following Statement, specifying - in the first instance the Points upon which I am anxious to obtain his decision - and Consisting secondly of a Summary of the principal points concerned with the Patent formerly held by me for improvement in Gun Cotton

I

By the deed of assignment approved of by Mr Cardwell and executed by me in January. 1872. I Completely severed myself from all interest in, and from any Connection Whatever with my Patent which then became the Property of Mr E. Chambers Nicholson, who paid to me on the day of assignment, One hundred pounds, as reported to you by me on January 24th 1872. — The relinquishment of my Patent rights was proposed by me about Six months — and was Completed about two months — before the issue of the Treasury Minute relating to Patents

Aug 1865. Several months after the disposal of my patent, the Gun Cotton Company at Stowmarket was resuscitated and it recently purchased my late Patent of the owner Mr Nicholson for the sum of four Thousand Pounds.

Mr Nicholson having received the above amount for the Patent of which he had aquired possession for one hundred Pounds, Considered that in equity this money should be paid to me - as it more nearly represents (than the sum I received) the amount which the Patent would originally have realised but for the conditional Circumstances which rendered it Valueless at the time it was assigned to him. He therefore desires to pay over this money or the greater part of it to me.

I have refused to accept this money, because my personal experience during the last two years of the readiness with which the acts of Public Servants are misinterpreted and distorted, Convinces me that the simple Statement on the part of myself and Mr Nicholson that I have refused the money is not likely to be accepted as a proof that I am not reaping some benefit from the sale of the Patent to the Company.

I therefore hope that Mr Cardwell will see fit to decide, or at any rate to indicate to me, Which of the following steps he thinks it right that I should take

1) To persist in my refusal to receive any of the money which has been Paid to Mr Nicholson for the Patent

2) To accept the money and retain it for my personal benefit, with the Sanction, or at any rate the knowledge of the Sec' of State for War

3) To receive the money and pay it over to the Treasury.

II

The Patent for the improvement of Gun Cotton was taken out by me in April 1865. The Circumstances which led to the taking out of this Patent are detailed in a memo submitted by me to the Surveyor General of Ordnance at his request, on Nov 8th 1870.

N.B) 15. 11. 70. S.G. of O. Called for a report the Substance of a Conversation between Mr Shotts and Mr Abel on that day

My patented improvements in the preparation of Gun Cotton consisted in the application of well known processes and machinery to the more efficient purification of the Gun Cotton and to its Conversion into Convenient homogeneous forms - NO public funds were devoted to the elaboration of those improvements, the expenditure of public money connected with these, and which occurred after my Patent was taken out, was limited to the applications of my improved Gun Cotton to Service purposes. It was not decided to adopt my patented Gun Cotton for Service uses until five years after the date of my Patent, When that time arrived my process had been elaborated in its manufacturing detail and applied to the production of Gun Cotton on a large scale exclusively at private Cost by Messrs Prentice of Stowmarket

In the autumn of 1866 Messrs Prentice began to be allowed to work under my Patent experimentally for twelve months and accordingly received a license for manufacture during 1867. Which was followed by the exclusive licence granted from 1868. In this licence it was stipulated that the Government should have full and free use of the Patent and when supplies were obtained from Government for experimental purposes and subsequently for Service uses, no Royalties were paid to me on such supplies. This Statement is substantiated by documents which I submitted for your inspection at our interviews on the 23rd May last 1873

Those documents (which were the periodical accounts of sales by the Gun Cotton Co) also showed that the total amount received by me as Royalties from the date when Messrs Prentice Commenced manufacturing under my Patent until I relinquished that Patent (a period of five years) was £2,142. Excluding expenses Connected with Securing and maintaining the Patent. I realised less over £ 2,000 during the Period of its being worked as a product,

In January 1870 I reported officially in answer to an enquiry from the Surveyor General. that I held a patent for improvements in the manufacture of Gun Cotton and that I had Consequently an interest in the production of that substance. I also Stated the grounds upon which I had Considered myself justified in Securing Patentage.

In August 1870 I addressed to you a memo in which I pointed out that it was not only advisable but very important that the Government should establish arrangements for the manufacture of Glycerine on its own account - the - - - - - - & my Compressed Gun Cotton for service purposes having been accepted by Several Committees. This memo was refered to the proper officials and the result was the establishment of Gun Cotton Works at Waltham Abbey. In the arrangement of those works the Government had the advantage of the Considerable experience which had been aquired Solely at private Cost in the manufacture of my Patented. Gun Cotton.

In November 1870 When it was desired to obtain as soon as possible a Considerable Supply of Compressed Gun Cotton (For Torpedo purposes) the Surveyor General. Sent for me and enquired into the existing arrangements

→

existing arrangements for the (3) manufacture at Stowmarket under my Patent. The Statements made by me on that occasion ~~of Theirs~~ were immediately afterwards furnished in writing in a Memo which I prepared in obedience to your instructions

A Contract was shortly afterwards ~~Conferred~~ entered into by the Gun Cotton Company, for the supply of 200 Tons of Compressed Gun Cotton. and I prepared very rigid ---- for the Chemical inspection of the Supplies which were adopted on the recommendation of the Superintendant Royal Gun Cotton Factory.

In August 1871. Shortly after the explosion at Stowmarket I ~~Substituted~~ Submitted in a letter to you the offer to relinquish my Patent right and recorded my determination to obstain from holding Patents in the future. I proposed to take such steps as the Secretary of State might Consider desirable and sufficient for carrying out this Voluntary relinquishment, and suggested that I might be placed in communication with the War Office Solicitor.

On September 21st 1871., I was called upon to explain the exact manner in which I proposed to relinquish my Patent right

On November 6th 1871. after much anxious Consideration of the Subject and Consultation with my friends (among others with Sir William Armstrong whose letter of advice I submitted to you.) I wrote stating the difficulties I experienced in proposing a precise Course of action, repeated my desire to relinquish my Patent unconditionally and without any reserve. and again suggested I might be allowed to Consult the Solicitor

On December 12th 1871. I was desired by the Secretary of State to submit a precise proposal without delay, on pain of removal from my appointment.

Under these Circumstances and feeling that it would be undesirable that I should propose to assign the Patent to a relative I applied for advice to a friend (a fellow Student of mine who has acquired Considerable position and distinction as one of the founders of an important branch of industry). This gentleman Mr E Chambers Nicholson, thereupon offered to purchase my patent though only prepared to give a small sum for it - the recent explosion having reduced the prospects for its future value - for a great uncertainty. This was the only Course of action open to me at the time and your letter above refered to rendered it impossible for me to delay longer before submitting a definite Plan.

In December 20th 1871 I therefore reported that I was prepared to assign my patent absolutly to an individual not related to me. And on Jan 6th 1872 a letter from you authorised me to Consult with the W.O. Solicitor with a view to Carrying out the proposed arrangement

After an interview with Mr Slade in which I explained Mr Nicholsons position and circumstance and the nature of his proposal the agreement assigning the Patent absolutely to that Gentleman upon payment by him of one hundred pounds, was prepared by his Solicitors and having been examined by Mr Slade and Submitted by him to Mr Cardwell the approved agreement was executed on January 24th 1872. In a letter of that date I refered this to you, stating at the same time that I held the money paid for the Patent at the Seretary of State's disposal

On March 28th 1872. I was informed with reference to the latter points that it did not fall within the nature of the agreement which I had proposed and carried out, that the Secretary of State should give me any directions as to the disposal of the hundred pounds. Probably his decision would have been the same had the Sum paid for the Patent been four thousand Pounds instead of One hundred. Since January 1872 I have had no Concern. Whatever in matters concerning my late Patent, of the bona fide transaction between Mr Nicholson and myself Mr Slade was I know perfectly satisfied, and it is I presume hardly required of me to say that no other agreement or understanding has existed between Mr Nicholson and myself. But I must take this opportunity to state that Mr Nicholson performed an act of friendship in coming to my aid in the very painful position in which it was Considered right suddenly to Place me with reference to my patent, and that it is my full belief that when he effected the sale of the Patent he had before him the device to be able to present me with a sum of money more adequately representing its value than the small amount which he only felt justified in paying me by the "position of affairs" relating to the Patent at the time it was assigned to him

July. 19th 1873 F.A. Abel

Professor Abel's Royalty
£10/Ton on Cotton for mining purposes } Nil for Govt work
10d/£000 on Cartridges for Sport }

WASC-2127-6

Memorial lecture by F A Abel for A W von Hofmann.

The History of the Royal College of Chemistry and Reminiscences of Hofmann's Professorship.

By Sir F. A. Abel, Bart., K.C.B., F.R.S., &c.

Not from any unwillingness to undertake what can only be regarded as a labour of love, but from a conviction of the inadequacy of my powers, under overwhelming pressure of official work, to worthily accomplish that labour, have I hesitated to accept the task which my colleagues of the Chemical Society, and old fellow students of the Royal College of Chemistry, have pressed upon me, of placing on record some incidents connected with the earlier part of the career in London, of my beloved and revered master and friend, the late August Wilhelm von Hofmann. And, when I recall to mind the interesting account of the difficulties overcome in securing to England the services of the courageous and enthusiastic worker—that masterly organiser and matchless teacher—which his distinguished pupil, Dr. Tiemann, included in the admirable memorial-address delivered to the German Chemical Society last autumn, and the graphic outline which Hofmann, the real founder of the College of Chemistry, himself published, in 1871, of the early history of that school, under the title of *A Page of Scientific History*, I feel that it will indeed be difficult to impart to my brief recital any semblance of novelty, or any interest, additional to that which, for his many pupils, admirers and friends, invests all the circumstances of Hofmann's career, or which may, perhaps, attach to such circumstances as that the narrator of this fragmentary sketch was one of the first students whose names were inscribed upon the register of the College of Chemistry, even before the services of Hofmann had been secured to it; that he was the first fortunate individual who was selected by the master from his pupils as assistant, and that, during the first five years of the struggling but vigorous existence of the New National School of Chemistry, it was his privilege and pride humbly to imitate, to the utmost of his youthful powers, the indefatigable devotion of the enthusiastic teacher to the interests of the School and its students, and, at the same time, to carry on the experimental work connected with some of the brilliant researches which, during that period shared, with his pupils, the untiring energies of that prince of investigators and giant for work.

To Lord Playfair, the fellow student, colleague, and firm friend of Hofmann, we are greatly indebted for the interesting sketch with which he has favoured us, of the position of chemical instruction in

Great Britain at the period when the idea was first conceived, fifty years ago, of establishing an English School of Practical Chemistry, upon the basis of Liebig's School at Giessen, which, at that time, had acquired a world-wide reputation, and to which students resorted from all parts of the world.

The commencement of my own career as a chemist affords no bad illustration of the difficulties attending attempts by young beginners with very limited resources, to acquire a knowledge of practical and analytical chemistry, with a view to adopting the science as a profession, half a century ago. The two or three establishments where chemical tuition was pursued to a very limited extent, were closed to young aspirants of that class; and, when my father remained undeterred by the advice which my subsequent good friend, the late Robert Warington, gave him, not to think of letting his son pursue the study of chemical science as a future means of livelihood, on account of the very limited prospects of advancement in the profession, the Royal Polytechnic Institution presented itself to him as the only place at which the fees demanded were within his means. I accordingly entered the laboratory of that dispensary of so-called popularised science, dazzled by the prospects of a brilliant future, presented to me by the clever popular lecturer of that time: only, to find that not even an attempt was made to impart to the deluded youngster the fragmentary superficial information of the Professor, and that the sole means which were left to him of acquiring some practical chemical knowledge, consisted in plodding, unaided, through Brande's *Manual*, endeavouring to acquire experimental skill by preparing the elements and their compounds, according to the directions there laid down, and to become acquainted with analysis by following the instructions for applying tests given in tabular form by Andrew Parnell. At the expiration of six months' struggle to work steadily in this fashion, amid surroundings by no means conducive to perseverance, I quitted the Institution (in February, 1845), armed with a testimonial certifying that my "analyses and experiments had always been conducted with great skill and minuteness," and that the Professor could "confidently recommend Mr. Abel to any appointment where a knowledge of practical chemistry may be required." Failing to realise that my practical chemical education had attained the degree of completeness pourtrayed by this description, I hailed with joy the tidings that a School of Chemistry was about to be established in London upon the Giessen type. Several other young men, who afterwards became prominent pupils of Hofmann, were in a similar position at that time, and so, when the temporary laboratories of the new college were opened in the autumn of 1845, there was a small band of aspirants impatiently waiting to

avail themselves of the benefits of the system of instruction which had already acquired so high a reputation on the Continent.

The importance of establishing in England an institution where the systematic study of chemistry, as a profession in itself, could be pursued, and where not only the acquirement of proficiency in systematic chemical analysis, but also the attainment of a knowledge of the art of chemical research, could be placed within the reach of a student of moderate means, had then become recognised by some prominent public-spirited men in England, mainly, in the first instance, through the intelligent representations and indefatigable exertions of Dr. John Gardner, the translator of the admirable little work of Liebig's, entitled *Familiar Letters on Chemistry*, which most usefully contributed to awaken the public mind to the benefits to be derived from the pursuit of chemical research. Dr. Gardner was zealously assisted in his first endeavours to place the scheme upon a practical footing, by his intimate friend, Mr. J. Lloyd Bullock, one of Liebig's earlier pupils, a fellow student of Hofmann's at Giessen, who, already in 1843, was the head of a prominent pharmaceutical business in Conduit Street, and is now, at the ripe age of 82, almost as hale and active in mind and body as he was in those days. He recently directed my attention to the following incident in the early history of the College of Chemistry, of which I believe very few of those who have since been connected with that school have any knowledge.

The sympathies of a number of prominent men had been enlisted, and promises of substantial support obtained, in 1843, in favour of a proposal to establish in London a National Practical School of Chemistry, by means of a very skilfully prepared prospectus; it was there pointed out that the progress of Liebig's Giessen School had been watched with deep interest in England, where the researches of that great chemist and his pupils had already given a most important impetus to agriculture and national industries; so that the want of such a school in this country, and the benefits which would accrue therefrom in manifold directions, could not but be recognised. In the autumn of that year Messrs. Gardner and Bullock induced the then Professor of Chemistry at the Royal Institution, Mr. W. T. Brande, to bring this prospectus before the managers, together with a carefully prepared scheme for establishing the scientific section of a British School of Practical Chemistry within the walls of the Royal Institution. In the preparation of this scheme, Messrs. Gardner and Bullock must evidently have had the assistance of Professor Brande, who appears to have been favourably impressed with the proposal.

The appointment of a Standing Committee of Management was

proposed, to consist of members of the Royal Institution and other men of science, of agriculturists, medical men, and of chemists and druggists. One of the earliest steps to be taken was to approach the Government through the Board of Trade, with the view of obtaining State aid. The fees to be charged to students were to be fixed at a very moderate amount, it being proposed to support the School by funds independent of those derived from fees. When these funds had been secured (to quote the scheme) the School was to be "established upon a broad basis"; the scientific section was to be capable of receiving 30 or 40 pupils; a Professor was to be appointed at a salary adequate to secure his undivided attention to the great purposes of the School; and it was considered that, if a thoroughly competent man were appointed from one of the great German Schools, a commencing salary of £250, with a liberal share of the students' fees, would offer sufficient inducement to secure the services of a man of acknowledged eminence.

The scheme proceeded to indicate that the premises in Albemarle Street were adequate to provide a capacious laboratory, where chemical science could be practically taught, and in which each student would have a separate working bench; the establishment was to include a private room and laboratory for the Professor, a balance room, an apparatus room, and store rooms. The plans for fitting up the laboratories were given in some detail. The scheme included the provision, apart from the scientific school, of a practical laboratory for the pursuit of studies on the most important applications of chemistry; this it was proposed should be placed under the direction of Mr. Lloyd Bullock, subject to the supervision of the Professor, and it was to be established in capacious apartments in George Street, Hanover Square (which became the temporary laboratory of the College in 1845). Mr. Bullock proposed to offer his services for the benefit of the practical school gratuitously. Lastly, it was considered that the provision, by subscriptions or grants, of an annual income of £800 to £1,000, would suffice for the maintenance of the School.

The managers of the Royal Institution referred this scheme, in November, 1843, to Professors Brande and Faraday, who reported favourably on the objects of the proposed School to the managers at their meeting on the 4th December, 1843. Messrs. Gardner and Bullock were therefore invited to attend to give explanations, and it was afterwards resolved that the subject be again referred to the Professors for a further report, which was presented by them on December 19th. In this report, after a brief discussion of the scheme, Messrs. Brande and Faraday stated that the existing laboratory in Albemarle Street, with the room and cellars beyond, would appear

to afford sufficient accommodation for the scientific school. The School of Chemistry (lectures) for medical students and others, conducted by Mr. Brande, would be thereby displaced, but, from consultation with Mr. Vulliamy, he was satisfied that accommodation for his courses could be provided in the Model Room, the models being transferred to the Battery Room. It appeared, therefore, "that place *could* be made for the School in the Royal Institution, but at a loss of many conveniences to itself and its Professors."

The words with which the report concludes illustrate in how thoroughly impartial a manner the eminent Professors of the Royal Institution dealt with a proposal which, if carried into effect, could not but have seriously interfered with their convenience and comfort in the pursuit of their work at Albemarle Street, and especially so in the case of that indefatigable investigator the resident Fullerian Professor of Chemistry. They say—

"The result of our consideration is strong approval of the end proposed, and a desire that it may be carried out in the Royal Institution if it can be done well. We venture to submit our impression in such a form to the managers that, if approved, the degree of approbation and assistance which the Royal Institution may be willing to give be expressed as follows:—

"Considering the great object of the advancement of chemical science and of good to the community contemplated by the establishment of the proposed School, and the perfectly disinterested intentions and views of its promoters and supporters, the Royal Institution is willing and anxious to aid such an object as far as it can, consistently with the rights and privileges of its members; and if hereafter the proposers are in possession of names of supporters and pecuniary means sufficient to carry out the objects proposed, the managers will on their part be prepared to recommend to the members of the Royal Institution the appropriation of apartments in the house for the purposes of a scientific laboratory for the proposed School.'

The report of the Professors evidently received very careful and anxious consideration by the managers, and the subject was also exhaustively discussed in correspondence between the Secretary, the Rev. Mr. Barlow, and the President, Lord Prudhoe (afterwards Duke of Northumberland). Upon a resumption of the discussion on the report, the week following its presentation, Professors Brande and Faraday informed the managers that after a closer examination of the limited space within the walls of the Royal Institution, and a careful consideration of the room required for the great and increasing stock of apparatus, minerals, and books, it appeared to them impracticable to afford accommodation to the proposed School,

whereupon the managers requested the Secretary to intimate to Messrs. Gardner and Bullock their regret that the space at their disposal was too limited to justify them in acceding to their request.*

The indefatigable promoters of the scheme for the establishment of the British School of Practical Chemistry did not relax their exertions after the failure of their negotiations with the Royal Institution, and continued to secure important accessions to the list of its supporters. At a public meeting held at the temporary offices of the College of Chemistry in St. Martin's Place, on the 29th July, 1845, a definite form was given to the proposed Institution, and, after the election of a Council and certain executive officers, the first, all-important, subject which received anxious consideration was the appointment of a Professor. One of the earliest and most prominent supporters of the movement was the amiable and accomplished Physician in Ordinary to the Queen, Sir James Clark, Bart., who became at the outset one of the staunchest and most active workers in the interests of the College of Chemistry, and an invaluable friend of the first Professor, and who was soon afterwards associated in both capacities with the Hon. William Bingham Baring, afterwards Lord Ashburton.

In Hofmann's interesting *Page of Scientific History* he points out that there was at that time no lack of most excellent chemical lecturers in England, and that, indeed, the style of experimental lecture-illustrations in general use in England was greatly superior to that which then prevailed in Germany and other parts of the Continent; but that the greatest want felt was easily accessible, efficient instruction, not only in systematic chemical analysis, but also in methods of conducting experimental inquiry, and it was with a view to meet this want that it was decided to follow the counsel of Sir James Clark, and apply to Liebig to select a suitable man from among his own assistants or past pupils for the appointment of Professor to the new College.

The story of the circumstances which secured the services of Hofmann for the foundation and development of the College are graphically narrated by himself in his *Page of Scientific History*. The refusal of the appointment successively by Fresenius, then already Professor at Wiesbaden, and by Will, Assistant Professor at Giessen, and the desire of Hofmann, at that time "Privat Docent" at Bonn, to accept it, mingled with the natural hesitation

* Since this was read to the Chemical Society, in May, 1893, the proposal favoured by Professors Brande and Faraday has been thoroughly realised, through the munificence of Mr. Ludwig Mond, by the establishment of the "Davy-Faraday Research Laboratory," adjoining the Royal Institution, and under the direction of its managers.—F. A. A.

to risk, through the occupation of a possibly precarious position, the serious interruption of a bright career just commenced at the Rhenish University; the happy solution of the difficulty through the gracious and invaluable intervention, at the instigation of Sir James Clark, of the late Prince Consort, who had from the first taken a warm interest in the proposed establishment of the English Chemical College, and who happened to be staying with the Queen at Brühl when the negotiations were proceeding; the appointment of Hofmann as Extraordinary Professor at Bonn, accompanied by an immediate grant of two years' leave of absence, so that he might at once re-enter upon his career in Germany should the English enterprise fail; his speedy departure for England, and the commencement of operations in the temporary laboratories of the College of Chemistry in George Street, Hanover Square, in October, 1845: all these incidents in the early history of the College have been recounted in interesting detail by Hofmann himself and by his pupil and brother-in-law, Dr. Tiemann.

For the first session, 26 students had entered, and among these were Warren de la Rue, F. A. Abel, E. C. Nicholson, Henry How, Thomas Rowney, C. L. Bloxam, and Robert Galloway. The laboratories in George Street were fitted up in temporary and very economical fashion, and I well remember the energetic way in which Hofmann set to work immediately upon his arrival in London, aided by the amiable young Herman Bleibtreu, whom he had brought with him as a temporary assistant, and whose quaint semi-military attire and imperfect English were a little trying to the powers of control of some among the younger students of the first session.

Hofmann's complete sway over his pupils was at once secured by his indomitable perseverance and inexhaustible patience with the dullest, his earnestness of manner—his clearness of exposition, rendered additionally attractive by an inherent quaintness and a power of happily rendering German expressions into graphic English. Those first two sessions of the College, in the scantily equipped laboratories, with makeshift contrivances of the crudest character, and an utter absence of any convenience for conducting investigations, must have been a sore trial of patience and powers of endurance to the impetuous young teacher, and to the enthusiastic worker, whose only recreation was the pursuit of original research. When to these circumstances is added the mental strain involved in the almost continuous pursuit of instruction and discussion in a foreign language for at least eight hours daily, to say nothing of continued anxious consultations with the Council and officials of the College regarding ways and means; the heavy work connected with the erection and equipment of the permanent laboratories; the grappling

with the problems of maintaining and fostering public interest in the Institution, and of keeping current expenses within very moderate bounds,—it is self-evident that no small moral courage and powers of endurance were needed for the successful accomplishment of these duties, and for the maintenance of the confident and apparently light-hearted demeanour, and of the power of instilling into others confidence of future success, which were peculiarly characteristic of Hofmann in those days of supreme difficulty. But these very characteristics, added to his genial and charming manner, high flow of spirits, and originality in conversation and correspondence, secured to him devoted friends, not merely among colleagues and pupils, but in whichever direction social intercourse was opened up to him. Just as his earnestness of purpose and enthusiasm kindled corresponding qualities in a large proportion of his pupils, so also his sanguine temperament and airy treatment of difficulties maintained, among many of the early friends and important patrons of the struggling Institution, a steadfastness of purpose which otherwise would doubtless have speedily waned.

Among the most prominent of the first students at the College, there was one who at once exercised a very marked beneficial influence in establishing a spirit of emulation, combined with good fellowship, among the younger students, and who speedily became one of Hofmann's most intimate and most useful friends; it is almost needless to say that I refer to Warren de la Rue. A bright example to all in industry and unflinching perseverance, manipulative skill, and methodical work; of calm courage and presence of mind in the face of sudden emergencies such as are bound to arise occasionally in laboratories where a great variety of experimental work is in progress; the embodiment of amiability, ever ready to lend a helping hand, in whatever direction it might be needed; now acting as sagacious adviser in difficulties; now as arbitrator in disputes or differences which would occasionally arise between fellow students; always active in the interests of the school;—no man could have made himself more universally beloved than De la Rue. There can be no doubt that he laboured as importantly, as he did unobtrusively, for the good of the College in the days of its greatest troubles, and was a powerful support to the Professor in *his* constant battles against formidable difficulties with which, suddenly launched as he had been upon a new career in a strange land, he would indeed have found it much harder to grapple successfully, in the absence of two such trusty friends and able supporters as Sir James Clark and Warren de la Rue.

There is but one opinion among those who can appreciate the stupendous difficulty of the task so brilliantly accomplished by Hofmann, in placing the College of Chemistry upon a sure foundation,

and in securing to it, within a very few years, a high position among the chemical schools of Europe;—that his success was ascribable to the possession of a happy and rare combination of the highest talents as a teacher with exceptional powers as an investigator, inexhaustible industry and energy, and an enthusiasm not to be subdued by any obstacles; a characteristic quality possessed in the highest degree by his great master, Liebig.

It was Hofmann's rule, to which, during the continuance of my stay at the College he strictly adhered, to visit each individual student twice during the day's work, and to devote himself as patiently to the drudgery of instructing the beginner, or of helping on the dull scholar, as he did, delightedly, to the guidance of the advanced student, whom he would skilfully delude into the belief that the logical succession of steps, in making the first investigation which the master had selected for pursuit by the pupil, was the result of skill in research which he had already attained, instead of being simply or mainly the skilful promptings of the great master of original research.

It was not until the work of the College had been well established in the new laboratories in Oxford Street that Hofmann began to give courses of lectures; but even in the first session he would occasionally deliver, at the bench of a particular pupil, short expositions of certain subjects, addressed to the body of the students in the laboratory, which were very attractive in style and matter, and always listened to with great attention.

In some interesting notes about Hofmann, which have been very kindly shown to me by Professor McLeod, who was his favourite lecture-assistant some considerable time after I had quitted the College, he testifies to the remarkable knowledge of English, and powers of expression therein, possessed by Hofmann; to the attractiveness of his manner, and to the way in which he carried his audience with him by his enthusiasm; so that his great tendency to exceed, and somewhat considerably, the usual hour, never gave rise to impatience or fatigue with the young students. He devoted much time to the suggestion or contrivance of lecture illustrations, and was very particular in having his discourses appropriately, but not profusely, illustrated by experiments.

To return to the early days of the College: its promoters having succeeded in securing premises in Hanover Square suitable for official and residential purposes, with an open space in the rear, facing Oxford Street, plans for a set of commodious laboratories were speedily prepared under Hofmann's guidance and with valuable aid from Warren de la Rue, and the first stone of the building having been laid by the Prince Consort on the 16th June, 1846, the third session of the College was actually commenced in the new labora-

tories in October of that year. In the second session, beginning in March, 1846, 37 fresh students had entered, making 63 in all, and the two small temporary laboratories in George Street became inconveniently crowded. Among the new men were the much-beloved and lamented Charles Mansfield, whose terrible death affected Hofman deeply; Frederick Field, Poet Laureate of the College, who became one of Hofmann's favourite pupils; George Merck, of Darmstadt; Henry M. Noad, and Bransby Cooper—all, long since, passed away. At the beginning of this session I was appointed by the Professor to help Dr. Bleibtreu, and afterwards Dr. Blyth, in the work of elementary instruction, and of maintaining the equipment of the temporary laboratories, and, towards the close of that session, two of my fellow students (dear friends of mine, whom their master long outlived) were selected by the Professor for similar posts of honour and hard work; Edward Chambers Nicholson, and the comparatively very youthful pupil Charles Loudon Bloxam; the first possessed of veritable genius as a *preparateur* (having already acquired some considerable skill during a brief apprenticeship in the business of Mr. Lloyd Bullock); the second, exhibiting at the very outset a marked predilection and talent for tutorial work.

A highly busy time we three young fellows had of it during the summer vacation of 1846, in the back kitchen and scullery of the house in Hanover Square (the George Street laboratories being in course of dismantlement), preparing the material for stocking the sets of reagent-bottles for over 60 students; finding time also for a little special experimental work. Thus, Schönbein having then recently published his instructions for the production of gun-cotton, I prepared a somewhat considerable quantity of that material (little dreaming that, 15 years later, I should begin to become in some measure identified with it); and the small remnant which I have still preserved of that preparation, bears witness to the care with which its purification was accomplished and consequent stability secured by the young student. Our activity in the basement of the College premises in Hanover Square during the summer and autumn of 1846 must, however, have been less to the taste of the immediate neighbours than to ourselves and our Professor, for, in the minute-book of the College Council, is recorded a resolution, dated October of that year, directing the immediate removal of all chemicals and laboratory operations from the kitchen and other apartments into the laboratory.

The new establishment in Oxford Street included a small private laboratory for the Professor, and, before the close of the year, Nicholson was already busily engaged therein upon the work of research which Hofmann at once resumed with an ardour intensified

by the compulsory abstention from the delight of his life—to which he had been compelled for a time to submit. The first investigation upon which Nicholson had to work was on the action of cyanogen on aniline, toluidine, and cumidine, while he, at the same time, carried out, under Hofmann's direction, his own first investigation on the compounds of phosphoric acid and aniline. *My* time was divided between the duties of teaching, which I shared with Bloxam as my junior (for a time under that most amiable and painstaking teacher, Dr. John Blyth, who had been appointed Assistant-Professor), and the work of another branch of Hofmann's prolific aniline researches, viz., the investigation of the action of chloride of cyanogen and bromide and iodide of cyanogen upon aniline (from the effects of which my eyes suffered permanently). At the same time, I also carried out my first organic investigation and the analysis of the mineral waters of Cheltenham. In the latter and other analytical research work I became associated with another fellow-student, Thomas H. Rowney, whom Hofmann appointed as his first lecture-assistant.

It is difficult to estimate the full value, to the individual concerned, of the severe work, and the many-sided training, which an assistant of Hofmann experienced, more especially in those earliest days in the history of the College of Chemistry. Dr. Tiemann quotes from important materials for a biography of Hofmann which Dr. Max Kopp has prepared, the following words of the latter in referring to some of his former master's earlier stupendous investigations:—"Thank God, what cause we have to admire, besides our master, the patience and powers of endurance of the assistants of those days;" and certainly the work which we then accomplished in the arduous but happy life we led was well worthy to be called hard work. As an illustration, I venture to sketch, in a few words, the routine which for five years I pursued as assistant at the College of Chemistry. A walk of about five miles brought me to the College before nine, the students' hours being from nine to five. The work of teaching, and attention to the requirements of the students, then went on continuously, simultaneously with the conduct of research work, and with the incidental production of materials for that work. One-half of my table in the principal laboratory was devoted to the operations connected with the Professor's investigations; the other half to my own researches. Ever and anon a student would come for assistance and advice, which led to my experimental work being of a somewhat perplexingly intermittent character. Hofmann began his first round among the students at half-past nine, and, having completed this, he divided his attention between the research work in Nicholson's hands and that with which

I was entrusted. A roll and butter or some biscuits, devoured while work was going on, constituted my midday meal, and I reached home at half-past six, frequently returning to the laboratory in the evening to carry out combustions (which Nicholson and I learned to do in couples, with charcoal fires, be it remembered) or other special operations, or to work out results, discuss them and prepare papers, with the Professor, or to make some progress with my own investigations, returning home late at night. When not thus employed, the evenings were devoted to the coaching of students, at from three to five shillings the hour, or to literary work, such as the translation of the *Jahresberichte* of Liebig and Kopp, for its English editors, Hofmann and De la Rue, so as to supplement the magnificent income of £40 a year, upon which we assistants were "passing rich." One evening weekly we had a students' meeting for papers and discussions, which Hofmann used to make a point of attending and taking part in. When the two months' vacation-time came round, we assistants used to take, at the most, a fortnight, for there was much to be done to prepare the laboratories for the next session's work; and, before his departure for his well-earned holiday in Germany, the Professor left his assistants a liberal allowance of work to be performed by his return: such as the preparation of a supply of aniline from indigo, the development of new methods for the production of materials for his researches, the analyses of new products, or the construction of special apparatus. But the life, although somewhat arduous, was a thoroughly happy one; *who* would not work, and even slave, for Hofmann? It was a rich reward to receive a word of commendation of a skilfully constructed piece of apparatus (for in those days very much had to be accomplished with tubes and corks and sheets of india-rubber); or to hear an expression of contentment at a successful distillation for aniline (the production of a few ounces being a proud achievement); or the attainment of a good instalment of analytical results. Hofmann highly appreciated skilful work; manipulative dexterity being his weak point (he used to tell us that, in his student's days, all his fingers were thumbs, and that he could hardly handle a test tube without "scrunching" it). There was an indescribable charm in working with Hofmann; in watching his delight at a new result, or a successful operation; or his pathetic momentary depression when failure attended the attempt to attain a result which theory indicated. "Another dream is gone," he would mutter plaintively, with a deep sigh; but not for long was he despondent. "Never mind," he would soon exclaim, "we shall have it to-morrow!" His inherent buoyancy of spirits helped him through all trials, of which those relating to official and personal concerns, or domestic sorrows, of

which he experienced many in quick succession, were apparently as nothing compared with the failure, for the time, to achieve the result which his sagacity predicted, and which sooner or later he attained.

The students who, during my career at the College, which terminated early in 1851, were advanced by Hofmann to the post of Assistant, partly to help with the general work of instruction and to prepare and assist at his lectures, and partly to work at his researches, were Abel, Nicholson, Bloxam, Rowney, Brazier, and Medlock; several of my colleagues left soon after my departure, and the subsequent roll of student-assistants included many names since well known in the scientific world, and many old Fellows of the Chemical Society: Crookes, Spiller, Tookey, Reginald Morley, J. S. Abel, Ansell, Church, Matthew Johnson, H. M. Witt, McLeod, Groves, Valentin, Barrett, Bassett, Vacher, O'Sullivan, and Reynolds; and the private assistants, who were exclusively employed upon his researches, embraced a succession of well-known German names, of which several have become famous: P. W. Hofmann, Fischer, Fries, Bopp, Griess, Förster, Ulrich, Martius, Olshausen, Willbrand, Sell, and Geyger.

When the Assistant-Professor, Dr. Blyth, left the College to become Professor at Queen's College, Cork, an old fellow-student of Hofmann's, Sheridan Muspratt, occupied for a short time the post of Honorary Assistant-Professor, and another Giessen student of more recent date, Dr. David S. Price, was also for a time an Honorary Assistant at the College.

There can be no doubt that one of Hofmann's talents which most importantly contributed to his eminence as an industrious and successful investigator, was his faculty of gauging the powers and special qualifications of those who studied under him; it enabled him to select the fittest workers to aid him in the rapid and successful development of a great diversity of researches, and also to direct their special talents and energies into channels which his prolific mind suggested, and the exploration of which, by those whose powers he, in the first instance, discovered and fostered, laid the foundation to the practical usefulness, or the scientific eminence, which many have attained who are now glad and proud to remember that they were the pupils of Hofmann.

A glance at the contents of two volumes published in 1849 and 1853, entitled *Reports of the Royal College of Chemistry and Researches conducted in the Laboratories*, affords interesting illustrations of the manifold directions in which Hofmann guided the students to whom he opened up the inexhaustible fields of original research, and of the fertility of mind which, while he himself was conducting simul-

taneously several investigations, continually branching off into new ramifications, enabled him to suggest a multitude of fresh subjects for work to his students—many of which developed into researches of considerable importance—and to hold the guiding strings of all firmly within his grasp.

Mindful of the importance, to the struggling Institute of which he was the head, of enlisting and maintaining the interest of representatives of professions, industries, commerce, and of landed property, in its work, and of fostering faith in its utility, he encouraged advanced students of a mechanical turn of mind to undertake analyses of waters, soils, ashes of plants, minerals or alloys, or to seek to improve existing, or devise new, analytical methods, or new forms of apparatus; but there is no question that he best loved to place in the hands of his most capable pupils one or other of the many problems in organic chemistry in the solution of which he took a paramount interest. Hofmann's assistants well remember an inseparable pocket companion of his; a small memorandum book, in which he kept a numbered series of subjects for research, and to which additions were frequently made; from these he selected, from time to time, the subject which he placed in the hands of a sufficiently advanced pupil for investigation.

The two volumes to which I have referred record the original papers published during the first five years of the College's existence; they embrace 21 researches in organic chemistry by 19 different pupils, and 15 analytical and other papers in inorganic chemistry by 14 different pupils. But they also include a series of nine of Hofmann's earlier memoirs on the volatile organic bases, besides other researches of much interest conducted by him during those five years of ceaseless activity. In the two or three years following, the number and importance of published memoirs emanating from the College of Chemistry was at any rate maintained, and some valuable technical investigations were, in addition, carried out by Hofmann in conjunction with Professors Graham, Miller, and Redwood.

I have already referred to Hofmann's intimate knowledge of English, even in the first days of his advent here, and of the immediate success which was secured by his lucidity of exposition, even although many of his expressions were at first somewhat literal renderings of his German thoughts. His mastery of the language was extremely rapid, as was testified by the success of two or three most interesting lectures which he delivered to general audiences (subscribers to the College) within two years of his appointment, and by the "Remarks on Experimental Science" and "Introduction to Researches," which constitute the charming and most suggestive prefaces to the first volume of the researches conducted in the laboratory of the College,

and were written between three and four years after his arrival in England. No one could doubt, who *saw* him and listened to him, when lecturing or taking part in a discussion, that he thoroughly enjoyed public speaking, and no one was followed with closer attention, or with greater interest and enjoyment, than Hofmann when giving the substance of a new research, or taking part in a discussion at this Society's meetings. It cannot be denied that he was somewhat vain of his English; thus, in going through papers prepared by his English students for publication, he did not confine his criticisms to the matter of the treatise, but would not hesitate to alter the language in conformity with his view as to the correctness or appropriateness of expressions or composition. In the preparation of his many memoirs, reports, and addresses he was extremely painstaking, and such truly classical treatises as his discourse "On Ammonia and its Derivatives," published in the *Journal of the Chemical Society* in 1858, and his report on "Chemical Products and Processes," prepared in connection with the International Exhibition of 1862, are monumental illustrations of the thoroughness of his writings. His speeches on festive occasions were a source of much interest to the listeners and of pleasure to himself. The reference to the Exhibition of 1862 recalls to my mind the happy speeches which he delivered in French, German, English, and Italian, when presiding over an entertainment given at Greenwich to the foreign members of the juries, and some there are here present, though, alas! the ranks have been terribly thinned, of his old pupils who will vividly recall to mind that splendid speech in which he bade farewell to them on the occasion of the parting banquet given to him in 1865 by the majority of those who had worked under him at the College of Chemistry.

His famous orations in German, on two recent memorable occasions at Munich and Göttingen, are still fresh in the memory of his many friends here and abroad; but among his many memorable addresses there is one which is invested with a special pathetic interest—the affecting memorial speech which he delivered at the German Chemical Society on the death of his much-loved friend and fellow student, Hermann Kopp, who succumbed to a long and painful illness but a few weeks before Hofmann was so suddenly called away.

Hofmann's life should, and must, have been a very happy one, even although it was often clouded by domestic calamity. He attained to honours and dignity which were tokens of full official and public recognition of his high merits and of valuable services rendered to science and the State. Ample resources and a vigorous constitution enabled him to devote to the great pursuit of his life—research—the little leisure his professorial, literary, and official duties left him. Moreover, he possessed in the highest degree the faculty of making

friends. To be his pupil was to become attached to him—the patient teacher, the enthusiastic worker, the cheering and brilliant companion, to whom it was a pride and pleasure to render service; he readily made and bound to himself powerful and influential friends, and was cordially welcomed wherever he went. He was treated with much kindness by the Queen, and by the Prince Consort who paid repeated visits to the laboratories of the College of Chemistry; he several times delivered lectures at Windsor Castle. Upon his appointment at Berlin he was at once most graciously received by the then Crown Princess of Prussia, the Empress Frederick of Germany, who recently spoke to me of her great sorrow at the death of her dear master and friend, as she called him, and of her high admiration of his talents and character.

The ease with which Hofmann made friends at the very outset of his London career, and the rapidity with which he adapted himself to English customs and mode of life, combined to speedily make him thoroughly at home here, and strongly attached to England and the English. Even after his return to Germany he was fond of speaking of England as his adopted country, and I remember in 1849, when replying to my inquiry whether he had enjoyed his summer vacation in Germany, his saying that he never felt thoroughly at home until he once more trod the London pavement.

The following passages from a charmingly worded German letter, addressed by Hofmann to the Prince of Wales, who, as President of the Society of Arts, wrote to him in 1882, congratulating him upon being the recipient of the Albert Medal, illustrate the pleasure with which, whenever occasion offered, he referred to his career in London.

"The gracious words of your Royal Highness carry me back to the most charming period of my youth—to the time when the August Father of your Royal Highness, the ever memorable Prince Consort, exercised a most important influence upon my destiny—as he did upon those of many—by determining the direction of my future life. I shall never cease to be thankful for the fortunate combination of circumstances whereby I was brought into contact with the high-minded Prince, whose active sympathy opened up to me, at a comparatively early period of my life, a sphere of action in the English metropolis, replete with stimulation and instruction, such as never could have been secured to me by my personal exertions.

"Your Royal Highness will therefore appreciate the depth of feeling with which I receive from the hands of the Son, the medal founded in memory of the Father, and the profound emotion with which I gaze upon the faithful reproduction of the noble features of the so-early

departed one, to whom I, in reality, am indebted for the honour now bestowed upon me.

"With the assurance that the Albert Medal and the letter of your Royal Highness which accompanied it will be inherited by my family as an inseparable legacy,

"I am, Sir,

"Your faithful servant,

"A. W. HOFMANN."

I have endeavoured in this notice to present to the Fellows of the Chemical Society some details of interest relating to the foundation and early history of the School of Chemistry with which the name of Hofmann is identified, and to pourtray some characteristics of this eminent chemist, more especially in the capacity of teacher.

With the nature of the multifarious invaluable research work which he has accomplished I have not ventured to deal in any way; the interesting task of reviewing that work is in much abler hands than mine—in the hands of one of Hofmann's most distinguished pupils, of whose achievements he has often spoken and written in glowing terms; whom I envy the splendid work he himself has accomplished and is still pursuing with undiminished ardour; and who, free from the trammels of official life, has been able to keep pace with, and continue intimately concerned in, the rapid strides which chemical science has made since, half a century ago, the cultivation of that science became a branch of national education in this Country through the invaluable combination of circumstances which placed England under a lasting debt of gratitude to August Wilhelm von Hofmann.

WASC-2127-7

WAI-0475-01

WAI-0475-02

Sir Frederick Abel b/w photographs (ex wasc-1290).

FIG. 23. SIR FREDERICK ABEL, K.C.B., F.R.S.

FIG. 23. SIR FREDERICK ABEL, K.C.B., F.R.S.

WASC-2127-8

Invitation to Prince of Wales dinner. 13.02.1900.

Marlborough House,
Pall Mall. S.W.

13 Feb. 1900

My dear Mr Redwood

The Prince of Wales desires me to say that Prince Charles of Denmark would much like to dine with you tomorrow, if you would kindly ask him, and so to

the Concert afterwards.

Perhaps you will take care that there are not 13 at dinner as the Prince of Wales is rather superstitious on that point.

H.R.H. hopes that you will be good enough to tell those who have Stars and ribbons that they should wear them, but only of course one star,

Yrs Sincerely

Francis Knollys

WASC-2127-9

Summaries of talks from the meeting on Sir Frederick Abel (1827-1902) and related material. Royal Society of Chemistry, February 2003.

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ROYAL SOCIETY OF CHEMISTRY

Historical Group

Gunpowder and Explosives History Group

Summaries of talks from the meeting on Sir Frederick Abel (1827-1902) and related material

Reprinted with permission from the RSC Historical Group Newsletter February 2003

Sir Frederick Abel (1827-1902)

The autumn meeting of the Historical Group was held at Waltham Abbey, Royal Gunpowder Mills on Friday 8 November 2002 to commemorate the centenary of the death of Sir Frederick Abel. The meeting started with the first Wheeler Lecture by Professor Sy Mauskopf (Duke University) on *Long Delayed Dream: Sir Frederick Abel and the Development of Cordite.* This is reproduced in full in Occasional Paper No 3 distributed with this Newsletter.

Chemical Archaeology of Explosives

Wayne Cocroft from English Heritage talked on the history of the Royal Gunpowder Mill and the surviving buildings and artefacts. He explained that archaeologically it is a complex site with buildings from many phases. Apart from redevelopment and adaption to changing requirements others were lost from explosions. The first production of gunpowder probably dates to about 1665. The site is well documented from 1787 when the government took over the site. Major William Congreve was the Comptroller of the Royal Laboratory and was largely responsible for the sucess of this government enterprise. He greatly improved the quality and relibility of the black powder produced by rigorous control of the consistancy and purity of the ingredients. Many inovations in production methods were introduced; ideas which then filtered down to the private gunpowder industry. The gunpowder mills were worked by waterwheels until 1857 when steam powdered incorporation mills were introduced.

Guncotton was first prepared in about 1846. In 1863 Frederick Abel developed a process for its production using cotton waste that was used at Waltham Abbey. Later nitroglycerine was developed which, when combined with guncotton and a mineral jelly, were blended to form the propellant cordite; patented by Abel in 1889. Some buildings involved in these processes survive although the nitrating plant was demolished in the 1990s. After an explosion in 1894 a new nitroglycerine plant was built. By the early 20th century a third of the cordite produced in this country was made at the Royal Gunpowder Mills. Later most of this production moved to Gretna. Cordite needs a solvent in its production. During the first World War supplies of acetone were lost so Woolwich developed cordite production using ether. Later Chaim Weizmann developed a fermentation method for the production of acetone at Holton Heath.The Quinan stove built in 1935 for drying guncotton used an inovative form of concrete construction.

The Royal Gunpowder Mills were also involved in the production of other explosives; tetryl (*N*-mthyl-*N*,2,4,6-tetranitroaniline) from 1910, picrite

(nitroguanidine) in the 1920s and RDX (cyclonite, hexahydro-1,3,5-trinitro-1,3,5-triazine) in the 1930s. RDX was used in the bouncing bomb of the Dambusters raid. Gunpowder production at Waltham Abbey finally ceased in 1940-41 and the whole factory closed in 1945. The site then became a Research and Development Establishment, finally closing in 1991. The site was opened to the public in 2001.

GPM

Decontamination of Waltham Abbey Royal Gunpowder Mills

This paper provides a synopsis of the decontamination of the Royal Gunpowder Mills at Waltham Abbey Essex. This site played a significant role in the support the of the nation's defence for some 380 years and now being redundant, contaminated and surplus to requirements the owner needs to dispose of the liability. On closure the owner decommissioned most of the explosives plant and equipment and removed it from the site.

The dilemma – how was the owner to realise value in this unique 200 acre site to enable its disposal? The decision was made to prepare two southern areas for sell of to residential development and clean up the rest to a standard acceptable for an alternative use. That alternative use was to be a heritage centre preserving and unlocking its long industrial history for the enjoyment of the public who had never been given access to this site, they could only guess at its mysteries from beyond the high security fence.

A project team was assembled and the task was defined as follows.

- Investigate and document the site's history (this helps to understand the contaminative processes undertaken at the site)
- Investigate and determine the general contaminative condition of the site
- Investigate the potential for selling off parts for residential development
- Determine a costed strategy for decontaminating the site (in accordance with the UK regulatory regime) for appropriate changes of use
- Determine the costs involved in decontaminating the site
- Provide budgets for the exercise, this required ministerial approval
- English Heritage were to ensure any intrusive works did not unduly affect the archaeology, to this end they listed and scheduled specific areas and buildings of special importance, and similarly English Nature designated a large percentage of the site as a Site of Special Scientific Interest

Gunpowder manufacture did not result in any significant contamination but the manufacture (and experimentation) of propellants and high explosives dating from the late 1800's did. Coupled with this was the demands of WW1 and WW2 and the effect of continuous development of the site over time to accommodate new technologies and processes. The main causes of contamination of ground and buildings was the deposition of wastes arising from the sites uses of over considerable period of time. These wastes were deposited in dump sites and used to fill redundant canals. Other sources of contamination arose from spillage of raw materials and finished products, in particular the propellant cordite and the high explosive tetryl. Another significant source of ground and building contamination resulted from the prolific use of asbestos in the fabric of structures and as insulation to many 'miles' of steam pipe. The research activities at the site also resulted in the displacement of some items of ordnance.

The site now prepared to enable public access was to be handed over to a Trust Company in order that it could be refurbished to create a Heritage Centre where the public can enjoy the marvels of its history.

Over a three year period thousands of tons of contaminated soils and bulk asbestos were removed from the site. Canals rivers and ponds were drained and the silts lifted to ensure cordite and items of ordnance were removed. The Environment Agency assisted with the capture and relocation of fish during this work. All wastes were removed to a 'sorting area' where samples were taken for analysis, artefacts could be retrieved, and searches made for items of ordnance. The waste was categorised according to type and disposed of to licensed appropriate landfill sites. Groundwater was sampled and analysed to ensure its quality was not prejudiced by the activity on the site. Canals were cleared and foundations of old gunpowder buildings were exposed during the works revealing their original profile orientation. All of the works were conducted under the watchful eye of English Heritage, English Nature, Environment Agency and the Local Authority Environmental Health Department.

The works conducted to prepare the site are an example of how environmental work can be successfully carried out within a regime of co-operation and understanding in respect of the preservation of the nations industrial and military heritage.

Graham Vincent
BAE Systems

Sir Charles Frederick (1709-1785), FRS FSA, Comptroller of the Royal Laboratory at Woolwich, 1746-1782

Sir Charles Frederick became Comptroller of the Royal Laboratory at Woolwich and Surveyor General to the Board of Ordnance in the mid-eighteenth century, at a time when gunpowder making was still a craft industry, and the government was reliant on private contractors. In the theoretical vacuum that then existed he had to undertake a process of self-education, serving what may be described as an apprenticeship with the learned societies of London, and presenting a dramatic 'masterpiece' in the form of the great firework display of 1749 in celebration of peace and victory, before becoming an acknowledged master of his subject. Portraits of Sir Charles illustrate these three stages of his career. Plans and paintings of the Royal Laboratory also shown in the presentation of this paper raise questions about the work undertaken there. This is especially the case with the production line of workmen filling round shot of varying diameter with powder, and sealing the shell with a plug that was presumably to be replaced by a fuse before firing. Proof testing was also carried out here, but this was notoriously unreliable and it seems likely that the standardization of formula and of grain size was used as a way of setting the minimum qualities required. The central pavilions of the old Royal Laboratory still survive at Woolwich, but these once fine buildings of the late seventeenth century have fallen into a sad state of dereliction.

When Sir Charles retired in the early 1780s he had nudged the industry towards the more consciously scientific approach of the last decades of the eighteenth century, through his close attention to the processes of manufacture and his encouragement of experimentation. But today he is not so much underrated as unknown, perhaps because the end of his career was marked by the political difficulties associated with the loss of the American colonies and the criticisms then being voiced of the powerful and independent Board of Ordnance, and because his successors were able to benefit from insights not available to him. Historians too have not served him well, being generally more interested in weapons and campaigns than in the critical matter of the supply of gunpowder. Sir Charles's contemporaries however had no doubts about its significance, for as a distinguished military man at the Board of Ordnance wrote to him in 1757, with campaigns underway in Europe, North America, India and at sea, 'all...Hope of Success...is Gone for nothing Without this material'.

It is to Sir Charles's credit and a matter of historical record rather than triumphalism, that in the third quarter of the eighteenth century, despite difficulties of supply and a lack of understanding of the problems of internal

ballistics, gunpowder was produced in Britain on a scale and of a quality that enabled the country to emerge on the world stage as a naval, colonial, and trading power.

Brenda J. Buchanan
(Chairman Gunpowder and Explosives History Group)

Oswald Silberrad, superintendent of research, Royal Arsenal, Woolwich, 1901-1906

The paper resulted from the speaker's work at the National Cataloguing Unit for the Archives of Contemporary Scientists, Bath, on the archive of this little-known industrial consulting chemist and the research laboratory that he founded. The paper highlighted some of Silberrad's important contributions to munitions research at the Royal Arsenal while he was still in his early twenties. An experimenter of rare ability, Silberrad discovered a new means of detonating high explosive shells by using a substance known as 'tetryl'. He also demonstrated that TNT worked well as a high explosive shell filling, possessing advantages over the lyddite then in use, and successfully developed and tested a 'flameless' artillery propellant for small calibre guns. The archive contains part of Silberrad's unpublished memoirs which document this period of his career, in particular his difficult relations with the War Office which resulted in his resignation as Superintendent of Research. The paper sought to show the value of an archival cataloguing project such as this in 'rescuing' a scientist and his work from relative obscurity. The Silberrad Papers are held by the Science Museum Library.

Simon Coleman
National Cataloguing Unit for the Archives of Contemporary Scientists
(University of Bath)

The Chemical Laboratories at the Royal Arsenal Woolwich

Wesley Harry, historian of the Royal Arsenal Woolwich, talked about the Chemical Laboratories at the Royal Arsenal Woolwich. Some time after 1665 the proof of ordnance moved from Moorfields to Woolwich. By 1695 many new buildings had been erected including a laboratory originally attached to the Tilt Yard at Greenwich. Various aspects of the manufacture and testing of ordnance were concentrated onto the Woolwich site in the 18th century. Frederick Abel was a professor of chemistry at the Royal Military Academy and was appointed in 1854 Ordnance Chemist at the Royal Laboratories at Woolwich. Another notable name there was James Marsh who developed the Marsh test for arsenic. The chemical laboratories

built in 1864 were the first custom built chemical laboratory at the Arsenal. The room on the west side was the full height of the two storey building. It was designed like this to disperse fumes and gases produced at the benches. From the gallery, off which were the offices, Frederick Abel would lower a wicker basket containing samples and instructions to the Asssistant Chemist. The east wing contained a photographic department and library. In addition to the ordnance work the laboratory was also concerned with forensic science.

GPM

Mossband – last link with the greatest factory on earth – under threat

The future of the last remaining building associated with WW1's greatest munitions factory remains in the balance. Mossband House was the headquarters of HM Factory Gretna, which produced more cordite than all the other UK propellant sites put together. The factory, built on the dispersal principle, stretched nine miles long across the Anglo-Scottish border from Dornock in Dumfriesshire to Longtown in Cumbria. At its height, 30,000 people were on the payroll either completing the construction of the plant or producing cordite.

The first sod was cut in September 1915 and the first cordite produced in August 1916. The factory was soon meeting its target of 800-1000 tons of cordite per week, using a process which involved the manufacture of all the chemicals used in the process: glycerine, nitric and sulphuric acid to make gun-cotton, and nitro-glycerine. These were made into a paste – the devil's porridge – which was treated with an alcohol/ether solvent and mineral jelly to produce RDB cordite.

On 14 November 2002, Eastriggs and Gretna Heritage members learned that demolition was to commence at Mossband within 24 hours. The Ministry of Defence had declared the building surplus to requirements on their large munitions-storage site at Longtown. Demolition would also allow the MOD to store more ammunition. No community consultation was thought necessary by the military-led management of DM Longtown. English Heritage were brought in for comments and recommended that Mossband was not of great enough architectural importance to be listed. An assessment that normally takes six weeks was completed in just one.

Since then our Heritage Group has been battling against the odds to save this building of local and national importance. (Eastriggs and Gretna Heritage run 'The Devil's Porridge', an annual exhibition which commemorates the factory's 30,000 workers.) We mounted a fierce campaign in newspapers, radio and on Border TV and halted demolition, but not before the windows had been removed. Apparently the MOD had failed to give six weeks notice to the planning authority.

The historical importance of retaining Mossband as the last significant building of HM factory Gretna is beyond doubt. HM Factory Gretna made a unique contribution to World War I – not just an important one. It was the largest WW1 factory in the Empire. It should be unthinkable that the sole building of substance left to remind us of 'the greatest factory on earth' could be destroyed.

Its retention is important because of its association with great chemists and explosives experts who gave their skills and energies to make the project a success. Above all there was Kenneth Bingham Quinan, referred to by Sir Arthur Conan Doyle as 'an American by nationality, a South African by experience, a man with a drive like a steam piston', who was the head man in explosives at the Ministry of Munitions. He designed a number of factories but his greatest achievement was HM Factory Gretna. A *Times* editorial commented, 'It would be hard to point at anyone who did more to win the 1914-18 war than K. B. Quinan'. In recognition of his work, King George V awarded him the Companion of Honour.

The factory was also innovative in many ways. In addition to size and workforce, it was the first to produce RDB cordite, a process in which alcohol and ether were used instead of acetone. In fact so much alcohol, including whisky, was used that it was necessary to curb the drinking habits of the Scots to meet Gretna's demand. The Quinan stove also proved a more efficient method of drying gun cotton. A number of new solutions had to be found to speed up chemical processes and use precious materials efficiently. The use of fireless locomotives and electric tractors were also groundbreaking.

Mossband is also our last remaining symbol of the contribution of women to the war effort. No group of women did more than the 12,000 lasses that produced cordite at Dornock and Mossband to advance the cause of suffrage for women. Conan Doyle, a sceptic before WW1, said of the smiling khaki-clad Gretna girls: 'Hats off to the women of Britain; even all the exertions of the militants shall not in future prevent me from being an advocate for their vote'.

On the architectural side, there is scope for English Heritage to look at Mossband in the context of the whole WW1 munitions area. Mossband is a vital piece of architecture in the context of similar buildings in Gretna and Eastriggs Township, many of these hostels for the munitions workers which have been listed by Historic Scotland in recognition of their national importance. The Barracks at Gretna was used by the military police in WW1 and has been converted into flats by the local authority. We believe there is a good case for cross-border consistency in an area of common heritage. The townships of Eastriggs and Gretna and Mossband were designed in a pleasing neo-Georgian style to garden city principles by famous architects including Raymond Unwin and Courtney Crickmer.

In the six-week period of grace, we lobbied MPs, government ministers and put forward a detailed case to the Department of Culture, Media and Sport and English Heritage to re-examine the listing issue. We also discovered the power of the Internet and e-mail to enlist support for campaigns of this nature.

Ten weeks later Mossband still stands, still a proud landmark on the main road between England and Scotland, but forlorn with its open windows exposed to seasonal gales. English Heritage has not yet responded but the Ministry of Defence has postponed demolition to carry out consultation with local organisations. A new Commandant has taken over DM Longtown and there is a glimmer of hope. Meetings will take place within the next few weeks to decide whether the last remaining link with the great factory will be severed forever.

Richard Brodie
Chairman, Eastriggs and Gretna Heritage
richardrbrod@aol.com

WASC-2127-10

Long delayed dream: Frederick Abel and Smokeless Powder. Royal Society of Chemistry, February 2003.

RS•C

ROYAL SOCIETY OF CHEMISTRY

Historical Group

OCCASIONAL PAPERS
No 3

Long Delayed Dream: Frederick Abel and Smokeless Powder

Seymour H. Mauskopf

February 2003

Long Delayed Dream: Frederick Abel and Smokeless Powder

Seymour H. Mauskopf

(Duke University)

The First Wheeler Lecture

Waltham Abbey, November 8, 2002

I am deeply honored to have been invited to such a notable occasion and, especially to have been asked to deliver the First Wheeler Lecture. Indeed, I am a bit abashed by the occasion, for its importance was underscored in a manner that is certainly novel for me: Last week, an e-mail query appeared on the history of chemistry website about the Abel Centenary meeting and, while it was not directly addressed to me, it clearly pertained to the substance of my talk: Frederick Abel's work on guncotton and cordite, and the patents that he and his colleagues took out on them. Thanks to the new technology of websites and chat pages, discussions can now take place before a talk is even delivered! Although I shall allude to the patent controversy over cordite, I shall not discuss it in any detail in this talk.

Before I begin, I should like to express my special appreciation to the staff of the Royal Artillery Institution Library for its help (and forbearance) during the weeks and months I spent there ferreting out old, musty Ordnance Select Committee minutes and reports of the various guncotton, gunpowder, and explosives committees. This talk would not have been possible without this material, access to which the staff of the Royal Artillery Institution Library facilitated with efficiency and good humor.

Now to my talk.

In 1871, Frederick Abel (1827-1902) recollected that:

> My first acquaintance with guncotton dates from within a few months of its discovery. In the autumn of 1846, I prepared 2 lbs. or 3 lbs. of guncotton according to Schoenbein's receipt, which had recently been published, a portion of which guncottonI still have in my possession.[1]

For the next forty-five years after this "acquaintance", Abel was involved with the attempts to develop the military potentials of the material, particularly its potential as a smokeless propellant replacement for gunpowder.

Abel was unique among nineteenth-century prominent chemists in devoting his entire ca reer primarily to military chemical concerns. As Chemist of the War Department, Abel was requested to provide evaluations and

recommendations for a wide variety of subjects. Their range can be gauged by examining the Minutes of the Ordnance Select Committee. Let me share with you some of Abel's activities, chosen from the Minutes for 1861. You will note a certain "tough mindedness" in Abel's evaluations, especially regarding materials or proposals submitted from outside or abroad. In March, we find Abel performing chemical and physical analysis of a sample of French gunpowder and commenting that "the sample in question would be considered in this Country as very badly manufactured ."[2] A Minute of September 9 reports Abel's evaluation of proposals from a Mr. J. Bruce for a new type of gunmetal ["Mr. Bruce's proposal to employ an alloy of platina and iron for gun-metal, is based upon erroneous ideas regarding the properties of such an alloy, and upon a very imperfect knowledge of the subject, with which he attempts to deal."] and for preserving and increasing the force of gunpowder ["Mr Bruce's suggestions with regard to Powder Magazines and increasing the strength of Gunpowder result equally from want of knowledge."][3] A Minute of November 22 reports on Abel's comparative evaluation of a waterproofing liquid proposed by a Mr. Gant, with the waterproofing solution of beeswax in coal tar naphtha then in use; the latter exhibited "a decided superiority over Gant's liquid."[4]

Finally, on a more somber (and prophetic) note, we find Abel reporting, at the end of the year, on a suggestion " to employ cyanide of kakodyle [cacodyl cyanide] in Shells as an asphixiating agent." Expressing doubts on its effectiveness, Abel did suggest that "if required, there are several other chemical compounds which could be employed with like effect, and with much less difficulty."[5]

Thus, Abel's day-to-day life as Chemist to the War Department entailed advice on a very wide variety of subjects and materials. And, of course, beyond work for the military, Abel became involved in important research in other industries, such as steel and petroleum. But his longest lasting and, I dare say, most prominent work was his military research and here, I would give special importance to munitions and explosives, including, of course, guncotton. He invariably served on the various guncotton and gunpowder committees formed in the 1860s, 1870s and 1880s to investigate how to improve munitions (including propellants and shells).

In regard to guncotton, Abel's *formal* involvement began with the request early in 1863 from the Secretary of State for War to him, as Chemist of the War Department, to investigate all aspects of the chemistry and fabrication of guncotton.[6] Abel's involvement became intense for about five years. It then went more-or-less dormant for almost twenty years, to be rekindled in connection with an "Explosives Committee," whose President Abel was

named in 1888, and under whose direction the first version of cordite, Britain's smokeless military propellant, was developed.

What I want to do in this talk is to give an overview of Abel's efforts to transform guncotton into a safe and reliable military propellant. Abel, as one of the first (and few) government military chemists, was not his own master regarding what he investigated. One of my themes will be the role that military authorities, particularly the Director of Artillery, played in directing Abel's interests towards or away from guncotton as a propellant. Another is the nature of the material itself – and its complex and often difficult to master performance as part of an armament system. Yet a third is the comparative trajectory of the development of smokeless military powder in Britain and in other European countries. My thesis here is that Abel was the most advanced student of this in the 1860s but, by the 1880s, leadership had passed to the Continent. By the time the Explosives Committee was formed, many Continental powers were already in possession of some form of smokeless powder, and Abel's erstwhile competitor, Alfred Nobel, had just developed and patented what proved to be perhaps the best. Abel's Explosives Committee relied on these as its templates for developing its own for Britain.

The history of guncotton from its discovery (or invention) in 1846 by Schoebein until Abel's involvement is well known and I will give only a brief sketch of it here. Guncotton's military potential as a smokeless propellant was almost immediately recognized but this was soon countered by disasters at production sites resulting in the prohibition of its manufacture and testing by most countries. The question of guncotton's stability was recognized as being the key to the problem. An Austrian artillery officer, Wilhelm Von Lenk, claimed to have solved the problem of stability by developing an elaborate method of producing and cleansing the material. He also claimed he had developed methods of deploying it as a propellant and to have shown that it was superior in many respects to gunpowder in artillery.[7]

These claims of Von Lenk were the immediate context for Abel's five-year initial involvement with guncotton. Von Lenk had received a reasonably favorable response in Austria and had been allowed to communicate his improvements to the British. Although I said that Abel's formal involvement with guncotton began in 1863, in fact, the British military establishment had already taken a serious interest in Von Lenk's guncotton the year before, and on Septermber 12, 1862, requested that Abel meet with the Ordnance Select Committee to arrange supplying guncotton (made presumably by Von Lenk's method; the text is not clear on this point) for ballistic testing in a variety of different guns.[8] Von Lenks's guncotton favorably impressed a

scientific panel of the British Association for the Advancement of Science but there was soon concern about his purification methods when the factory for producing his guncotton suffered an explosion soon after production commenced.

It was in this mixed context of promise and peril that Abel was invited to pursue his scientific study of guncotton, which he did intensely over the next five years. Like Von Lenk, Abel recognized that the *sine qua non* condition regarding guncotton was its stability, especially under exposure to light and heat. But to achieve this, he went beyond Von Lenk in addressing comprehensively chemical and physical considerations in developing processes for purifying and stabilizing guncotton.

The chemical considerations pertained to the chemical nature of guncotton. Abel espoused the dominant English view that guncotton represented the most nitrated (and most explosive) of three stable forms of cellulose; hence it was trinitrocellulose.[9] This position was challenged during the 1860s by the French chemist, Jules Pélouze.

Abel argued that the results (and formula) obtained by Pélouze were the result of incomplete nitration of the cotton, either due to insufficient proportion of acids for complete nitration or to the use of acids of weaker concentration than those used to achieve complete nitration. Abel demonstrated that that subjecting the less highly nitrated cellulose of Pélouze to a addition digestion by more concentrated acids raised its weight to that of his own guncotton.[10]

In the course of his chemical investigations of guncotton, Abel demonstrated that the main cause for its instability was the presence of partially oxidized organic impurities present in the cotton.[11] These could be largely removed by washing the guncotton with an alkaline carbonate. But, to insure as perfect purity as possible, Abel instituted a physical procedure : pulping the cotton after nitration "according to the method commonly employed for converting rags into paper"[12] to destroy the tubular structure of the guncotton in which the impurities could lurk. Abel's pulping procedure became standard for the rest of the century. Immersed in water or impregnated with moisture, guncotton seemed more stable and safer to handle and transport than gunpowder.

But what about its use as a propellant? Von Lenk had claimed that it offered a host of advantages to gunpowder for large guns: absence of smoke, freedom from gun fouling, increased speed of firing, diminished recoil, a much lighter charge, and stability whether damp or dried.[13] Abel's pulping procedure was also – indeed, primarily – designed to make guncotton into a propellant, as he made clear in his patent:

> Now my invention has for its object to assimilate the physical condition of gun-cotton as nearly as possible to that of gunpowder, by mechanically converting it into a solid conglomerate state, and imparting to it either a granular or other suitable form that will present the exact amount of surface and compactness required for obtaining a certain rapidity or intensity of combustion.[14]

A special Gun Cotton Committee was appointed by the Secretary of State for War on February 2, 1864, upon the recommendation of the British Association for the Advancement of Science to investigate whether guncotton could realize the potential outlined for it by Von Lenk. Of the eleven members of the committee, five were F.R.S.[15] Several out-of service brass 12-pounders were secured for testing guncotton cartridges.

The basic cartridge consisted of a wooden cylinder of a length of one foot (usually but not always hollow) around which guncotton yarn was wound. This cartridge was enclosed in a serge bag and fitted into the gun bore. The principal parameters that were tested were the "compactness" of the cylinder guncotton, determined by the amount of strain put on the guncotton as it was wound around the wooden cylinder, and the weight of the guncotton charge.[16]

The analysis of this series of tests, written by the distinguished physicist George Gabriel Stokes, was generally favorable:

> It does not appear unreasonable to expect that by modifying the construction of the cartridge it may be possible to fire the required charge without an undue strain upon the gun.[17]

Abel himself carried out tests from 1865 until 1868 using pulped guncotton and he was equally optimistic. However, he noted that he had not succeeded in securing uniformity of action, due to the rapidity of guncotton explosion.[18] He also conducted small-arms tests on the Enfield and Snider rifles Although he "describes his latest results as being of a promising nature,"[19] he admitted that there were still severe problems caused by the over-rapid action of the guncotton.[20] In order to reduce the rapidity of the explosion, Abel began a series of experiments in which retardants, such as cotton and paper pulp, or the less nitrated (soluble) nitrocellulose in the Snider rifle, were mixed with the guncotton.[21]

Although clearly no unambiguous success had been attained with guncotton either for large guns or small arms, there was a general sense of optimism that progress was being made in both of these domains, and the General Conclusion of the Committee Report supported the continuation of research.[22]

In a memorandum of June 10, 1868, Abel himself called for a resumption of tests with compressed guncotton in large guns as soon as arrangements for comparing its bore pressure with that of gunpowder were complete. A newly formed "Committee on Gunpowder and Explosives" (which included Abel) was instructed to continue the Guncotton Committee's investigations as outlined in Abel 's memorandum.[23] But, in the details of these same instructions, the investigations pertaining to large guns had disappeared, although it was allowed that "the Committee are at liberty to employ gun-cotton for purposes of comparison in the smaller calibres, to any extent permitted by the means at their disposal."[24]

And, indeed, the investigations on employing guncotton as a propellant for large guns were abruptly discontinued. In a talk given by Abel in 1872, he noted that:

> No progress has been made since 1868 in the application of explosive agents, other than gunpowder, to artillery purposes.[25]

Several years ago, I suggested that the abandonment of this line of investigation was related to the fact that black powder itself underwent transformation in the 1860s that greatly improved its potential for servicing large guns.[26] After proposing this hypothesis, I came upon direct corroboration of it from Abel, in a popular lecture on guncotton that he delivered in 1872. Abel noted that gunpowder had been transformed from small grains to "pellets or pebbles and prisms of powder," which enabled the rate of burn in large guns to be gotten under considerable if not perfect control. He concluded:

> I am consequently pretty certain that, as far as big guns are concerned, guncotton has no future.[27]

But even investigations into its use in military small-arms was not pursued with any vigor in the two decades after the first Guncotton Committee was dissolved. An exception in these years was Abel himself. He summarized his studies in February, 1875 in an appendix to the 1876 *Progress Report of the Committee on Explosives Substances.* Pointedly noting that the original instructions to this committee had directed them "to give their attention to the application of guncotton to small-arms,"[28] Abel detailed his own research employing a Henry rifle furnished him by the committee.

What now appeared most promising was the procedure of impregnating the pulped but uncompressed guncotton with a solution of stearic acid soap of fixed strength and then plunging the pulp into dilute acetic acid. Since the cartridges were awkward to use and the charges had to be pressed by hand, this procedure had not yet been 'fairly tested:"

> Want of leisure has prevented my pursuing these experiments for some considerable time past, but I consider that the results obtained were sufficiently promising to warrant the Committee in taking up the subject.[29]

But despite the forward-looking tone of this memorandum, nothing more was heard about small-arms guncotton investigations in the reports of this committee, which concluded its work in 1881.

In a talk at the Royal Institution in 1890, Abel summarized the history of his earlier work on developing guncotton as a military propellant. Admitting that safety in artillery weapons had "appeared indeed to be beyond absolute control, even in so small a gun as the twelve-pounder," Abel nevertheless laid the blame for the stalling of research on the military:

> Military authorities, not being, in those days, alive to the advantages which might accrue from the employment of an entirely smokeless explosive in artillery, the lecturer received no encouragement to persevere with experiments in this direction, and the same was tbe case with respect to the possible use of a smokeless explosive in military small arms, with which, however, far more promising results had at that time been obtained at Woolwich.[30]

But, by the 1880s, gun technology was revolutionized with the development of powerful breech-loading, rapid-firing rifles and machine guns. Moreover, the caliber of small-arms grew smaller and the projectiles lighter and more elongated for greater ballistic accuracy. All these developments made the need for a powerful, non-fouling, smokeless powder insistent; by the middle of the decade, the French under the direction of Paul Vieille had developed the famous "Poudre B."

Already in 1885, expressions like "I fancy it is in the direction of a smokeless powder rather than a slow burning powder that we now look for an improvement in manufacture" were bring voiced in England.[31] The next year, the Lords of the Admiralty opined that "the want of a smokeless powder for using with case shot especially for ships guns & for repelling Torpedoes boat attacks, is much wanted [*sic*] by the Navy."[32] To this, Abel and the Superintendent of the Royal Gunpowder Factory, Waltham Abbey, responded:

> It is not impossible that a powder giving very little smoke may be desired which shall be susceptible of safe employment in machine guns or even in ordnance of the smallest calibre but no hope can be held out with our existing knowledge of greater results being obtained.[33]

Nevertheless, in 1887, Abel himself became once more deeply involved in the testing of guncotton in the form of cakes or pellets, impregnated with ammonium nitrate and with a heavy mineral oil as a retardant.[34] An amusing exchange between the Superintendent of the Royal Gunpowder Factory and Abel illustrates both the still-existing difficulties of getting guncotton-based charges under control – and perhaps also the resistance to this sort of innovation by the chief powder-maker. On August 12, 1887, several samples of these powders were tested at Waltham Abbey in a Nordenfelt 1 inch gun, with highly variable results. After noting the variability, the Superintendent took exception to such tests because of their potential danger:

> I wish to point out that our proof range is not a safe one for carrying out these experiments, as it is not improbable that a bullet might miss the butt and injure some person walking along the lower island path.[35]

Abel had to move his tests to the proving grounds of the Royal Small Arms Factory, Enfield Lock, although the danger to the external environment was only somewhat less than at Waltham Abbey – there were still "a farm house – cattle & workpeople near the line of fire" according to the superintendent of that factory.[36]

Endfield was the site for most of the tests carried out for the "Explosives Committee," which was appointed July 10, 1888 by the Secretary of State:

> for the purpose of considering questions relating to new explosives agents, and to new applications of, or improvements in the production and application of, known explosive agents.

What the Explosives Committee was really about was the fabrication of an effective organic smokeless powder.

The Committee was a small but very distinguished one scientifically: under the presidency of Abel served two F.R.S. scientists: James Dewar and August Duprè.[37]

Its work ceased one day shy of its third year, with the publication of a massive "Final Report of the President Explosives Committee, 1888-1891," of more than 300 pages, on July 9, 1891.

For the remainder of my talk, I shall discuss the extraordinarily detailed and comprehensive account of the fabrication and testing of cordite, contained in this document.

Cordite for small arms: the .303 inch rifle:

The report began with consideration of smokeless powders for small-arms, needed not only because of changes in these weapons (as outlined above)

but also because the leading Continental Powers had adopted such powders for use in their small-caliber rifles.[38] A large variety of nitrocellulose-based powders were experimented with in 1888, with the German Duttenhofer powder more-or-less leading the pack into 1889.[39]

Meanwhile, on December 14, 1888, Alfred Nobel submitted samples of brown, semitransparent, horny tablets of a *double* base powder of soluble nitrocellulose and nitroglycerine, which he had named "ballistite"; additional samples were submitted in January and February, 1889.[40]

Nobel's own career in explosives had some remarkable parallels to Abel's. If Abel's signature was guncotton, Nobel's was nitroglycerine. In precisely the years when Abel was "taming" nitrocellulose (1863-1866), Nobel was doing much the same for nitroglycerine, resulting in the commercial production of "dynamite" late in 1866. As I am sure many of you know, Nobel and Abel came into collision over the production of dynamite in Great Britain with the Nitroglycerine Act of 1869. Under this act, a license from the Home Secretary was required for the manufacture of nitroglycerine and its products (such as dynamite) and, initially (until 1871) this was denied for dynamite except for manufacture at its place of use. Nobel viewed Abel as one of his chief – and not entirely disinterested – opponents in this matter.[41] More famously – and notoriously – they came into collision over patent rights of their respective smokeless powders, ballistite and cordite.

In the summer of 1887, Nobel patented in France his double-based "ballistite," which had been developed out of another of his inventions: blasting gelatin, composed of nitroglycerine and nitrocellulose. Nobel had apparently been working on ballistite for about a decade but his activities had intensified in the 1880s. This was the first successful double-based smokeless powder and, perhaps, the first smokeless powder suitable for rifles and heavy ordnance.[42] He secured a British patent for ballistite on January 31 , 1888.[43] Thus, although Nobel's interest in smokeless powder was much more recent than Abel's, it was Nobel who had realized the dream of a stable, effective, general military propellant using nitrocellulose.[44] Interestingly, although Abel was thoroughly familiar with all of the Nobel manufactories of nitroglycerine and blasting gelatin and had even reported on them to the Director of Artillery in 1884,[45] he himself seems not to have thought of transforming this material into a military propellant prior to ballistite.

Despite the unfortunate earlier episode with Abel over dynamite, Nobel offered ballistite to the Committee ungrudgingly, no doubt because he felt that it was fully protected by patent. Comparative tests carried out between ballistite and Duttenhofer powder early in 1889 gave the palm to the former

in virtually all categories: smaller charges of ballistite were needed to give equal muzzle velocities, and ballistite produced less pressure. Duttenhofer was "by no means smokeless"; ballistite was "almost absolutely smokeless." Neither fouled the guns.[46] Regarding stability under changes of temperature and atmospheric moisture, ballistite was greatly superior to Duttenhofer powder. Exposure of ballistite to temperatures of up to 170° F. "had no effect either in increasing or diminishing the velocities obtained, and the pressures developed."[47] Ballistite also was less affected by moisture than was Duttenhofer powder.[48] The overall superiority of ballistite to Duttenhofor powder, including the financial and legal stipulations for adoption by the British military, led the Explosives Committee to inform the purveyor of Duttenhofer powder, the Chilworth Powder Company, that no further action would be taken regarding this powder.[49]

The one test that gave concern regarding ballistite (but not Duttenhofer Powder) was that of storage in imperfectly closed containers. When exposed to air at ordinary temperatures (55 to 70° F.) under these conditions, ballistite lost weight due to the evaporation of its retardant, camphor; this led to a steady rise in produced velocity and pressure after fourteen days' exposure.[50] The volatilization of camphor in ballistite posed a serious problem to a world imperial power like Great Britain, since:

> The storage of ammunition in warm localities, or tropical climates, may give rise to a sufficiently considerable escape of camphor from the cartridges to importantly affect their shooting qualities.[51]

Although Nobel had been apprised of this problem, the Committee deemed that had he not appreciated sufficiently its gravity. The Explosives Committee therefore took it upon itself to develop a double-based powder with a non-volatile retardant substitute for camphor. Judging from the log of their test results, the Explosives Committee hardly gave Nobel any time – and perhaps no time at all – to respond before it got to work.[52] The result was "cordite," named after the novel mode of "graining" it: the powder was made into bundles of wires or rods by forcing it, when in a plastic state, through a die of the diameter that would produce the desired thickness.[53]

The very completeness of combustion of smokeless powder, and the consequent lack of traditional gunpowder fouling of the gun bore, engendered an additional – and novel – problem: "metallic fouling". This was the tendency of the bullet, abraded by friction as it passed over the clean gun bore, to adhere to the steel bore surface. What was needed was a lubricant film to be deposited on the gun bore surface during firing; a solution was found by incorporating a small quantity of Vaseline (petroleum jelly) with the two nitro-bases.[54] "Moreover, insoluble nitrocellulose

(trinitrocellulose) was substituted for the soluble nitro-cotton used in the early forms of cordite, as it had been in ballistite."[55] These changes and an adjustment of the proportions of nitroglycerine and trinitrocellulose to 58% and 37% respectively (with 5% vaseline) resulted in what appeared to be a very satisfactory smokeless powder: cordite 128, also known as "Mark I."[56]

Indeed, so pleased were the authorities with cordite that, on May 10, 1889, the Director of Artillery authorized the Explosives Committee to contract for the construction of a model plant for the manufacture of cordite and for the design and construction of a machinery to knead the ingredients and to squirt the cordite wires.[57]

Already on March 17, 1889, the Committee submitted to the Director of Artillery a sealed memorandum containing an account of their experimental results; this was lodged with the Treasury Solicitor in the event of future contestation over priority. On April, 3, at the verbal direction of the Director of Artillery, an application was placed at the Patent Office for the specification of the production of the explosive "in the cord form," which patent would be assigned to the Secretary of State for War. To forestall contestation over patent claims concerning the actual chemical composition of the mixture (very close to Nobel's blasting gelatin), the Committee suggested to the Director of Artillery that the government reject the petition by Nobel's Explosives Company, the British manufacturer of blasting gelatin, for an extension of the patent for that substance as

> Prejudicial to public interests, if its claims could be so interpreted as to include particular varieties of preparations of a similar nature to blasting gelatine, which the Government might desire to apply as explosives suitable for propulsive purposes.[58]

Time constraints and principles of coherence keep me from exploring further the very controversial actions of the Explosives Committee in securing the patent but I would mention one pertinent fact: The Committee had considered the opportunity (or necessity) of taking out patents virtually as soon as it had begun work. On August 20, 1888, a memorandum was submitted to the Director of Artillery arguing the need for patent protection because of the openness of British governmental military research practice (in contrast to the secrecy of that of Continental governments):

> By taking out patents for novelties in the production or application of Explosives as soon as they are sufficiently matured, the Committee will secure to the Government the practical results of their Official investigations, and private workers will, at the same time, have no excuse for complaining that they are kept in ignorance of the operations of scientific officials.[59]

The memorandum recommended that the Committee members relinquish domestic patent rights to the government but be allowed to secure foreign patents at their own cost.[60] Whether these scenarios really applied to the case of cordite (versus Nobel's blasting gelatin and ballistite) became the personal and legal point at issue between Abel and his fellow committee members (particularly Dewar) and Alfred Nobel.

From the spring of 1889 onward, cordite 128 (and other varieties at times) were subjected to a massive battery of tests similar to those administered to the earlier smokeless powder candidates. One of the most important was the test for the stability of cordite under extremes of temperature, particularly important to the British Navy in the imperial age: Cordite was sent by ship to India for an extended stay there; *en route*, the cordite was stored in ships' hot magazines both in bulk and as cartridges.[61] The opposite end of the British Empire – Nova Scotia – was utilized for testing cordite for the effects of cold and, at home, a "refrigerating apparatus" was used to subject cordite to artificially produced cold.[62] Another series concerned the comparative tendency of cordite and other explosives for susceptibility to detonate.[63]

At the same time that cordite was being developed for small-arms, experiments were also being carried out for its use in artillery. That had, of course, been one of the original objectives for guncotton but, as was noted, by the late 1860s, even Abel seems to have given up on that objective and, as recently as 1886, held out very little hope for a smokeless powder for large guns.[64] By May, 1889, experiments with cordite commenced, starting with a strengthened 12-pounder.[65]

Many of the same variables that challenged the deployment of cordite in small-arms had also to be considered in the larger guns. But there was an additional, comprehensive problem that was first seen in the 6-pounder Hotchkiss gun: Because of the nature of cordite's rate of burn (slower, initially, than gunpowder), the pressure in the chamber of the gun was lower than the corresponding pressure of black powder. Therefore, the forward pressure (in the chase) had necessarily to be higher in order to obtain comparable muzzle velocities because "the muzzle velocity depends on the mean pressure in the bore." But the chase of this gun had "comparatively little strength." Hence, it was necessary to modify the form of the gun, either by reducing the air space in the cartridge case[66] and/or strengthening the chase. As it turned out, the problem for this gun was manageable using cordite 128.[67]

But with considerably larger guns, such as the 4.7-inch Q.F., a length of 40 calibers, and the 6-inch Q.F. gun, modifications of this nature proved to be

necessary. Preliminary tests and modifications to the 6-inch gun were made by Andrew Noble;[68] by November 1890, these had been even more drastically modified at the initiative of Naval Ordnance.[69] The Explosives Committee went on to experiment on the use of cordite in a variety of breech-loaders: 12-pounder, 20-pounder, 4-inch, 5-inch, 6-inch, and 9.2-inch.[70]

In his "Concluding Observations" to this massive report, Abel reiterated in general terms the Committee's recommendations concerning modifications in the structure of guns to make them suitable for cordite, promising:

> That, if "Cordite" maintains the position which it has so far secured as a reliable explosive agent, the efficiency of both light and heavy artillery will be considerably increased in directions distinct from the advantages which the employment of a smokeless powder may secure.[71]

Of course, the cordite that emerged from the work of the Explosives Committee was not perfect.[72] Within two years of the report, as cordite was being tested for larger guns, a problem that had not figured in the report became insistent: wear on the gun.[73] Moreover, despite the testing and assurances of the Explosives Committee, there was continued unease about how well cordite traveled in high temperatures. By the beginning of the new century, another Explosives Committee, headed by another distinguished scientist, John William Strutt, Lord Rayleigh had been charged specifically with ameliorating these problems.[74] The improved cordite prevailed; in 1917, at the height of World War I, Arthur Marshall characterized cordite as undoubtedly "one of the most successful smokeless powders".[75]

In my conclusion, I should like to return to my three original themes to see where they now stand, and introduce one more particularly important to me as an historian of science.

(1) My first theme was the degree to which a government scientist can pursue his own research program independently of government supervision, command or pressure. In the case of Abel, it seems quite clear that he was compelled to abandon his own investigations of the mid-1860s on perfecting guncotton as a military propellant, although there is considerable obscurity over just what happened. Had he been encouraged, might Abel have gone on to forestall the French team led by Paul Vieille in developing a gelatinized nitrocellulose powder for small arms? It is, of course, hard to say. But he was not encouraged and, although there is good evidence that he kept working at a guncotton propellant for small arms throughout the 1870s and 1880s, this project had to contend with many others both relating to his official capacity as Chemist to the War Department and relating to his monumental study of the physics and chemistry of black powder carried out with Andrew Noble.

(2) A second theme was that of the intractability of the material itself.

In another paper – on black powder – I have used Ken Alder's inelegant but useful phrase, a "thick thing" to delineate the recalcitrance of complex material substances to being readily modeled and "controlled" through scientific understanding.[76] Guncotton falls at least partially under this rubric. Early in his career, Abel faced the challenge of "taming" guncotton's propensity to decompose and explode, through scientific understanding of its chemical and physical characteristics. Here he was largely successful. But he found guncotton to be much more of a "thick thing" when it came to adapting it for use as a military propellant, and it is not clear that he ever quite got it under control before the Explosive Committee began its work in 1888. One could certainly infer that this was the case from the exchange Abel had with the Superintendent of the Royal Gunpowder Factory in August, 1887 over the dangers to passing pedestrians of testing Abel's latest form of a guncotton-based propellant.

My narrative of the work of the Explosive Committee of 1888 illustrates, I think, another feature in the consideration of materials as "thick things." Namely, it is not just the materials, per se, that have to be taken into account but also what I would call their multiple "environments." For propellants, these "environments" would, first of all, include the weapon itself: the cartridges and the components of the gun, as well as their forms, strengths, their other material characteristics, and their interrelations.

Consideration of this "environment" might shed some light on why Abel was discouraged from pursuing his search for a guncotton propellant in the 1860s and 1870s. Abel himself admitted that he was not encouraged to develop his 1875 guncotton propellant because "its employment in the bottle-nosed cartridge necessitated the use of a pellet that did not fit the cartridge case."[77] This, perhaps combined with less than perfect control over the propellant's ballistic action, and also with a lack of a compelling reason for developing a smokeless military propellant at this time (e.g. no perception yet that other countries were surpassing Britain in this domain) might explain the reluctance of the military authorities to support the continuation of Abel's guncotton propellant research.

In the case of cordite, we have seen multiple instances of unanticipated results and consequent new challenges that appeared as it was being tested in guns.

For instance, cordite's very virtue of *not* fouling guns in the manner of black powder engendered the new problem of "metallic fouling" of the gun bore. And the scaling up of cordite to large guns like the 6-pounder Hotchkiss engendered new challenges in gun construction.

What I mean by "environments" extends far beyond the gun to include, for instance, the venues in which the propellants were transported, such as the ship holds taking them to the ends of the British Empire, and the climates of the lands in which they would be deployed. Hence, the need to test the stability of the propellants under a wide range of conditions and temperatures.

(3) The third theme that I raised in my introduction was that of comparative leadership or backwardness in the development of new munitions. In the twenty years between the abandonment of Abel's development of guncotton as a military smokeless propellant by the government in 1868 and its resumption of support for such study in 1888, England (and Abel) had lost the lead in the development of a smokeless propellant. As I have indicated in my talk, the urgency of the Explosive Committee's work was the realization that the leading Continental Powers had adopted smokeless powders for their small-caliber rifles, yielding higher velocities without undue pressure. Virtually all of the powders that the Committee considered were foreign ones. Whatever one thinks of the propriety or merits of the Explosive Committee's patenting cordite, there is little doubt that its points of departure were Nobel's blasting gelatin and ballistite. I might add that a similar falling behind in the state of the art had come to pass regarding black powder for large caliber guns during roughly the same time period (1860s to 1880s).[78]

The "environment," if I may style it that, that promoted leadership or backwardness in munitions is certainly the most encompassing and challenging to deal with. The relative change in status of Britain in munitions has barely been recognized in the recent historical literature, although it certainly was noted in the contemporary polemical press. I certainly cannot attempt to do more today than note that, to treat this theme adequately, it would be necessary to analyze comprehensively the "systems" of research and development of military and commercial explosives and munitions in each country as well as in the international cartel formed by Alfred Nobel in the 1880s, first for dynamite and then for munitions. Certainly my first theme, that of the role of the military authorities in fostering or obstructing research, would be a major factor in analyzing this issue.

(4) I shall leave you, finally, with a series of questions, whose answers will require further research. They particularly intrigue me in my capacity as an historian of science. I would like to know more than I presently do about Abel's style of scientific practice in the development of guncotton (and cordite) as military propellants, especially in comparison with those of his chief foreign competitors, such as Paul Vieille and his group, and Alfred

Nobel. I would term this yet another "environment" of the propellant, if this is not stretching the term beyond any linguistic utility. For example, one gets some sense of how Abel combined chemical and physical considerations in his early work on "taming" guncotton from his published papers on that subject of the mid-1860s. And I have analyzed the research style of the monumental work Abel carried out with Andrew Nobel on black powder during the 1870s. In that research, they employed an interesting mixture of investigative techniques designed to imitate, in a laboratory setting and on a laboratory scale, the conditions that obtained when the explosive was actually fired in the gun. These laboratory data were, furthermore, compared with data obtained from field use of the explosive.[79] I would argue that this approach also characterized the research carried out by Paul Vieille and his group using the *bombe calorimétrique.*

But, to date, I have much less information about how Abel conducted his research on adapting guncotton as a military propellant in the 1860s through the 1880s, mainly because he published virtually nothing on it in the public domain. Even the memorandum of 1875 and the brief recapitulation of his research on this subject at the beginning of the Explosives Committee report shed very little light on his research style and strategy.

And I would like to know much more about what kind of research the distinguished scientific members of the Explosives Committee actually conducted for the Committee and where they did so. At the conclusion of the committee report, Abel gave credit to a variety of people and institutions for their help but did not specifically cite his committee colleagues for anything.

Perhaps the most intriguing member of the Explosives Committee was James Dewar. I would very much like to know what role Dewar played in the committee's work. Dewar happened to be conducting research at this time on the physics and chemistry of explosion, investigating such things as the temperature, pressure and energy of explosion of various explosive substances and the velocities of their explosion waves.[80] I have recently discovered that he proposed to the Committee a research program on the spectroscopic study of explosion in April, 1889, that might produce "results of importance bearing on the theory of explosion."[81] But I find no evidence of this research in the Committee Report.

In 1916, when resisting the requisition of his Royal Institution laboratory for ammonia synthesis and munitions work, Dewar querulously appealed to the state of affairs that existed twenty five years earlier when he was working with the cordite Explosives Committee:

> Why should I not be allowed to give the best fruits of my invention alone from my Professorial Laboratory, like other Professors of my status, in the same way as I did long ago, when I worked on the behalf of the Government on the evolution of Cordite.[82]

This offers a tantalizing window at least on where Dewar's scientific work took place in the days of the Explosives Committee. I would like to know more about both the venues of work and the substance of what the members did, individually and collectively. For if a "thick thing" like cordite ultimately escapes complete scientific control, nevertheless, the "environment" in which it is brought into existence is that of scientific practice. But (I hope), more on this in another talk, after further research.

References

1. *Report and Proceedings of the Special Committee on Guncotton, &C., 1871 to 1874* (London: Printed for Her Majesty's Stationery Office, 1874), Addendum XXVII: "Minutes of Evidence Taken Before the Committee on Guncotton at the War Office," p. 10 (November 1, 1871). Royal Artillery Institution Library. MR 115.

2. Minute 3640/ 2020: Foreign Artillery. French Gunpowder. Mar. 25, 1861. Royal Artillery Institution Library MR 56: *Minutes of the Ordnance Select Committee*, 1861.

3. Minute 4848/2217: Mr. J. Bruce. *Ibid.* The proposal involved adding 3 ounces of pulverized quicklime to one pound of powder.

4. Minute 5417/ 2182: Chemist, War Department, 19. 11. 61. *Ibid.*

5. Minute 5654/ 2254. Mr. W. Hope. Proposal to employ cyanide of kakodyle in Shells as an asphixiating agent. December 30, 1861. *Ibid.* As Abel noted, this idea had been suggested previously by Lyon Playfair (1854).

6. F.A. Abel, "Researches on Gun-cotton: On the Manufacture and Composition of Gun-cotton. On the Manufacture and Composition of Gun-Cotton," *Phil. Trans. Roy. Soc. London*, 1866, Vol. 156, p. 273

7. Seymour H. Mauskopf, "'From an Instrument of War to an Instrument of the Laboratory: The Affinities Certainly Do Not Change' Chemists and the Development of Munitions, 1785-1885" [1998 Dexter Award Address]. *Bull. Hist. Chem.*, 1999, Vol. 24, pp. 6-11.

8. Minute 7350/ 2322. Gun cotton as made in Austria. September 12, 1862. The guns were a 12 Pr Armstrong gun, a 9 Pr. Smooth bore and a

5½ Inch Mortar. Guncotton was also tested in shells.The manufacture of the guncotton was ordered on November 12. Minute 7747/ 2322. Gun cotton as made in Austria. November 12, 1862. Royal Artillery Institution Library MR 58: Minutes of the Ordnance Select Committee, 1862.

9. F.A. Abel, *Phil.Trans.Roy.Soc. London*, 1866, Vol. 156, p. 294. This was produced by "the complete action upon it [cotton-wool] of one part by weight of nitric acid of specific gravity 1.52, and thee parts of sulphuric acid of specific gravity 1.84." Abel noted that the acids the French chemists used had lower specific gravities than those yielding the English formula. p. 299.

10. *Ibid.*, p. 307. The French had reported a weight gain of about 78% (theoretically 77.78% according to Pélouze's formula); Von Lenk and the English of a range between 81.8 and 82.6% (theoretically 83.3%)

11. F.A. Abel, "The Bakerian Lecture. Research on Gun-cotton. Second Memoir. On the Stability of Gun-cotton," *Phil. Trans. Roy. Soc. London*, 1867, Vol. 157, pp. 206ff. Abel ruled out the presence of less nitrated, soluble nitrocellulose (collodion) as contributing to the instability of guncotton; indeed he thought that this could contribute to stability by somehow sealing or protecting the guncotton fibers. p. 208.

12. *Ibid.*, p. 219.

13. "Memorandum presented to the Right Honourable the Secretary for War, on January 10, 1864, by Major-General Edward Sabine, R.A., on the part of the British Association for the Advancement of Science." Quoted in *Report and Proceedings of the Gun Cotton Committee, 1864 to 1868. Together with Reports on Mining Experiments at Allenheads, 1864 to 1869* (London: Printed at the War Office, 1869), p. 3. Royal Artillery Institution Library. MR 52.

14. U.S. Patent Office. F.A. Abel, "Improvement in the Manufacture of Gun-Cotton." *Patent number* 59,888 (November 20, 1866).

15. Major-General Hay (President), Captain Thomas Brandeth, R.N. (subsequently withdrawn for other duties), Lieutenant-Colonel Boxer, R.A., Lieutenant–Colonel Lovell, R.E. (subsequently withdrawn for other duties and replaced by Lieutenant-Colonel Scott, R.E.), Commander W.H. Liddell, R.N.(subsequently withdrawn for other duties), F.A. Abel, Esq., F.R.S., Thomas Sopwith, Esq., F.R.S., Professor Stokes, F.R.S., Cambridge, Professor Miller, F.R.S., King's College, Dr. Gladstone, F.R.S., Major Miller, R.A., Secretary.

16. *Report and Proceedings of the Gun Cotton Committee, 1864 to 1868*, pp. 5-7. The guncotton used in these tests does not appear to have been subjected to pulping.

17. *Ibid.*, p. 14.

18. The cartridges consisted of a solid disc of compressed pulped guncotton preceded by a "prime" loose guncotton and succeeded by pellets of compressed pulped guncotton of ½ inch thickness and constituting two thirds of the charge. *Ibid.*, p. 9.

19. *Ibid.*, p. 10.

20. Poor accuracy of aim, apparently due to deformation of the bullet.

21. Cotton and paper pulp, and then soluble nitrocellulose (in the Snider rifle), which seemed to be the most promising. Appendix to Report. No. 5: F.A. Abel, "Further Statement of General results obtained in Preliminary Experiments with Gun-Cotton in the solid form, prepared from Pulp, and applied in various manners, up to 31st December, 1867," *Ibid.*, p. 54.

22. "Conclusion," *Ibid.*, p. 11.

23. Minute 26,964/1641. Committee on Gunpowder and Explosives. Royal Artillery Institution Library MR 69: *Minutes of the Ordnance Select Committee*, 1869.

    D.G.O., 8.5.69., notifies to Colonel C.W. Younghusband, R.A., F.R.S., that the S. of S. for W. having approved of the continuation of the enquiries which were in progress under a Sub-Committee of the late Ordnance Select Committee, *Minute* 25,108, at the time of the dissolution of that body, has appointed the following gentlemen as a Committee to take over the charge of the instrumental and experimental means provided, viz.: - President

    Colonel C.W. Younghusband, R.A.

    Members

    Captain C.M. Malony, R.A.
    Captain W.H. Noble, R.A.
    Captain A. Noble, C.E., late R.A.
    Mr. Abel, Chemist W.D.

    All the above, with the exception of the President and Captain Malony, being Members of the late Sub-Committee.

It is difficult to determine whether the reference of the "late Sub-Committee" is to the previous Gunpowder or Guncotton Committee. But the Minute 25,108 is explicitly to Abel's Guncotton Committee memorandum.

24. "And with reference to the application of gun-cotton to small arms, it is the desire of the S. of S. that this branch of the Committee's enquiry be pursued with special reference to the Martini-Henry B.L. rifle, lately recommended for introduction." Minute 26,964/1641. Committee on Gunpowder and Explosives. *Ibid.*

25. F.A. Abel, "On the more important Substitutes for Gunpowder," (May, 1872) *Proc. Roy. Inst. Gr. Brit.*, 1870-1872, Vol. 6, p. 517.

26. Mauskopf, *Bull.Hist.Chem.*, 1999, Vol. 24, pp. 9-10. What role, if any, the explosion at the Stowmarket guncotton factory in August, 1871 played in the abandonment of this work is unclear to me.

27. F.A. Abel, "Gun Cotton." [A Lecture Delivered in the Hulme Town Hall, Manchester, on Wednesday, November 19th, 1873] *Science Lectures for the People: Fifth Series of Science Lectures delivered in Manchester, 1873* (Manchester: John Heywood, 1874), p. 69.

28. *Progress Report of the Committee on Explosives Substances, Appendices* [1st April, 1876.] (London: Printed for He Majesty's Stationery Office by Harrison and Sons, 1877), Appendix H: F.A. Abel, "Guncotton Charges for Small-Arms" [26.2.75], p.74. Royal Artillery Institution Library MR 108.

29. The impregnated pulp was then washed, lightly pressed into cylindrical cartridges, dried, and heated for a short time to 150° F. to distribute uniformly the stearic acid in the cartridge. Cartridges consisting of 33 grains of guncotton impregnated with 3-4 grains of stearic acid were tested with "a few fairly satisfactory targets (at 500 yards). *Ibid.*, pp. 74-75. Abel also gave details about how to adjust the cartridge to fit properly into this gun and he said that he had been in touch with the Superintendent of Royal Gunpowder Factory, who planned to carry out more preliminary tests on a Martini-Henry gun.

30. Sir Frederick Abel, "Smokeless Explosives," [address given at the weekly evening meeting of the Royal Institution of Great Britain, January 31, 1890] *Proc. Roy. Inst. Gr. Brit.*, 1890-1892, Vol. 13 p. 16.

31. Public Record Office Supply [SUPP] 5: Ordnance Establishments: Headquarters and Factory Records 568: Powder: Experimental (115C

22/29) Header: Waltham Abbey: Royal Gunpowder Factory Subheader: Files Text Date: 1885 Aug - 1891 July. G.C.O. to D. of A., 28/10/85.

32. Public Record Office, SUPP5:586. Admiralty to D. of A., 9/9/86.

33. Public Record Office, SUPP5:586. W. H. Noble, Superintendent, RGF and F.A.Abel to D of A, 21/9/86.At the outset, they noted that "this is by no means the first occasion on which a desire has been expressed on the part of the Naval authorities especially for a smokeless powder."

34. Public Record Office. Supply [SUPP] 5: Ordnance Establishments: Headquarters and Factory Records:794: Final Report of President of Explosives' [*sic*] Committee. Header: Waltham Abbey: Royal Gunpowder Factory. Subheader: Miscellaneous Books & Papers. Text Date: 1888-91

    Final Report of President Explosives Committee [on Cordite], 1888-1891 [9th July, 1891, (London: Printed at the War Office by Harrison and Sons, 1891) pp. 2-3.

35. Public Record Office, SUPP5:586. Supt. [RGF] -- no addressee specified but unquestionably to Abel. 16/8/87. To which Abel gave vigorous answer: "In reply to your mem° of the 16th Inst., I regret that you do not see your way to continue to afford facilities for the working out of the experiments made with a view to ascertain whether a smokeless powder for machine guns is attainable, *a subject which was referred to us jointly to investigate*.

    Public Record Office, SUPP5:586. F.A. Abel – Supt. Royal Gunpowder Factory, 17/8/87. My italics.

36. Public Record Office, SUPP5:586. Superintendent RSAF – D. of A., 29/8/87.

37. *Final Report of President Explosives Committee*, p. 1. The Secretary was Captain J.H. Thompson, R.A., Director of Artillery's Department. Duprè is listed as the "Consulting Chemist to the Explosives Dept of the H.O. [Home Office]" in a note from the Treasury [Mr. Jackson] to the Under Secretary of State of the Home Office, apprising it of the proposed committee, March 16, 1888. There was a good deal of resistance to having Duprè's functions subsumed under a committee of the War Office. See: Public Record Office, HO 45/9787/B3062: EXPLOSIVES: War Office Committee on Explosives.

    In response to a question in Parliament on May 11, 1888 about the formation of a "promised Committee to experiment with shell charged

with high explosives," the Secretary of State listed the above-mentioned scientists as members of the committee and reported that "They are, during the present week, making experiments with shell charged with high explosives." *Hansard's Parliamentary Debates*, 3rd series, Vol. 326 (11 May, 1888 – 12 June, 1888) (London: Cornelius Bush & Sons., 1888), 43 (11 May). On the other hand, in response to a parliamentary question to the Secretary of State for War (Broderick) on May 12, 1892 about the exact dates for appointment and dissolution of the Explosives Committee, the date of appointment was given as July 10, 1888 and its dissolution just three years later. *Parliamentary Debates*, 4th series, Vol. 4 (3 May, 1892 – 26 May, 1892) (London: Reuter's Telegram Co., Ltd., 1892), 711 (12 May).

There appears to be discrepancy between the Parliamentary account and that in the Final Report about the date of formation of the Committee and of its primary task.

38. *Final Report of President Explosives Committee*, p. 1.

39. Some of the others were "hornite," a picric acid-trinitrocellulose mixture made into a paste through the solvent agency of acetic ether, and dried into a translucent horny material. This was made in imitation of Paul Vieille's original powder; Johnson-Borland powder, probably a form of nitro-cotton with an oxidizing agent and incorporated with camphor, discontinued because of too much smoke and fouling; and Wetteren powder, discarded because of possible patent infringements due to secret nature of manufacture. Duttenhofer powder was also a guncotton-based powder with the incorporating agent probably being acetic ether. It had been submitted by the Chilworth Powder Co. in March, 1887, prior to the establishment of the committee. *Ibid.*, pp. 2-9. The Chilworth Powder Co. had founded as an English manufactory for German gunpowder firms.

40. It is called this in the Minutes of the Proceedings of the Explosives Committee For 15th December, 1888). p.1. Public Record Office SUPP 6/512: "Minutes and Reports Committee on Explosives 1888 to 1891. As early as Nov. 1, 1888, Nobel submitted his first powder sample. Minutes of the Proceedings of the Explosives Committee, 2nd November, 1888. See *President Explosives Committee: First Half-Year Progress Report (31/12/88)*, Public Record Office SUPP6/512, pp. 11-12 for a detailed narrative. The submitted samples had been made in the Nobel Dynamite factory at Honfleur.

41. W. J. Reader, *Imperial Chemical Industries, A History*, 2 vols. [I: "The Forerunners 1870-1926"] (London: Oxford University Press, 1970), pp. 25-26. Abel apparently was behind the stipulation that dynamite could only be made where it was to be used.

42. *Ibid.*, pp. 137ff.

43. Patent No. 1471 for the production "of a horny or semi-horny explosive compound capable of being reduced to grains or pellets of any suitable size for use as a propellor of projectiles." "President Explosives Committee. Second Half-Year Progress Report (30/6/89)." Public Record Office SUPP6/512, p. 12.

44. The nitrocellulose used was not guncotton but the less nitrated collodion.

45. "Report by Sir Frederick Abel, C.B., D.C.L., F.R.S., Chemist to the War Department On Manufactories of Nitro-Glycerine Preparations in Germany and Austro-Hungary. April 1884." (London: Printed at the War Office by Harrison & Sons, 1884.) Public Record Office FO881/5157X..

46. Appendix VI, *Final Report of the President Explosives Committee*, p. 151. The ballistic tests were in a 303 [rifle] barrel of the Woolwich Crusher-gauge machine.

47. *Ibid.*, p. 152. Heating ballistite cartridges to 180° F. for 45 minutes, there were indications of a rise in velocity and of pressure.

48. Amount of moisture taken up during 18 hour exposure to a moisture-saturated atmosphere was: 1% for Duttenhofer powder and 0.46% for ballistite. *Ibid.*, p. 153.

49. *Ibid.*, p. 9. The Committee had met on March 28, 1889 to take this action. It was subsequently learned that the German government had abandoned Duttenhofer powder due to lack of uniformity of action and of stability. The financial and legal stipulations of the Chilworth Powder Company were outlined on p. 7; those of Nobel on p. 12.

    Other candidates were tested in the first part of 1889, such as The Smokeless Powder Company's rifle powder, Maxim-Nordenfelt Company's Maxim powder. None compared with ballistite.

50. An increase about 200 feet/second and 3.5 tons respectively. *Ibid.*, p. 11 and Appendix VI, p. 153. This test seems to have been carried out on

the first samples Nobel brought in December, 1888. Later samples exhibited much less tendency toward ballistic variance when subjected to these conditions. Both ballistite and Duttenhofer powder were more resistant to detonation than compressed guncotton. p. 154.

51. *Ibid.*, p. 13.

52. In fact, by early April, 1889, Abel was discussing the need to take out patents on the Explosive Committee's already-improved version of ballistite because "Mr. Nobel is actively engaged in acting upon suggestions which were made to him by the Committee when he attended experiments with his powder, and has quite recently secured several patents, most probably relating to modifications of his powder." Already, by March 9, 1889, the Committee had reported success in replacing camphor with a non-volatile retardant and was at work on other "modifications." Public Record Office, SUPP 6/512: Proceedings and Reports Committee on Explosives 1888 to 1891. *Minutes of the Proceedings of the Explosives Committee*, 6th April, 1889: 290: Ballistite. Modification by Committee. p. 11: Question of Patent, Minute 281 i.

53. The forms were intended to insure uniformity of igniting surface and of distribution of air spaces in the cartridge. The ingredients were also incorporated differently from ballistite: they were kneaded together with a solvent (acetone) rather than worked between steam-heated rollers without a solvent. *Final Report of the President Explosives Committee*, p. 24.

    The earliest test, of cordite, No. 69, composed of equal quantities of nitroglycerine and soluble nitrocellulose (45%) and 10% nitronaphthaline, and of cordite, No. 70 (same ingredients, in proportions respectively of 46%, 46%, 8%) , took place on March 5, 1889. On that date, it was tested in the form of grains, but two days later, cordite 69 was tested in "strips." Appendix XII: "Results of Experiments with varieties of Cordite," *Ibid.*, pp. 186-187.The first species of cordite contained a non-volatile retardant but by late April, 1889, the retardant was dispensed with without problem. Cordite, No. 78 (50% nitroglycerine, 50% soluble nitrocellulose), April 23, 1889. Appendix XII, *Ibid.*, p. 187.

54. Arthur Marshall noted that the petroleum jelly did not in fact work as a lubricant but rather more indirectly by lowering the temperature of the explosion and hence diminishing barrel erosion while at the same time augmenting gaseous volume. It also promotes the chemical stability of

cordite by absorbing nitrous gases given off during storage. *Explosives*. 3 vols.; 2d ed. (London: J. and A. Churchill, 1917 [vol. III, 1932]), I, p. 304.

55. *Final Report of the President Explosives Committee*, p. 25. Vaseline had the additional advantages of being insoluble in water and facilitating the squirting of wires by its lubricity. Cordite 92 seems to have been the first form to be made with trinitrocellulose. It was tested in June, 1889. Appendix XII: "Cordite, No. 92," p. 189.

56. *Ibid.*, p. 25 and Appendix XIII: "Composition, Velocities and Pressures of Varieties of Cordites," p. 194. This appendix lists all of the varieties of proportions of the two principal ingredients that were tried as well as the different ancillary chemical agents. The diameter of the cordite 128 wire was 0.035 and 0.036".

57. *Ibid.*, p. 33. At the same time, Colonel [W.H.] Noble, Superintendent of the Royal Gunpowder Factory, was sent to Germany to secure information about the manufacture of nitroglycerine, and to help prepare an estimate of the cost of establishing facilities for the large-scale production of nitroglycerine and cordite on a site near Waltham Abbey. The factory was completed in early 1891 and in April of that year the manufacture of nitroglycerine commenced. *Ibid.*, p. 34. Blasting gelatin rather than pure nitroglycerine had been used.

58. *President Explosives Committee. Second Half-Yearly Progress Report (30/6/89)*, Public Record Office, SUPP 6/512, pp. 12-14.

59. *President Explosives Committee. First Half-Yearly Progress Report (31/12/88)*, Public Record Office, SUPP 6/512, p. 31. In a letter to Andrew Noble of 18/8/93 (very difficult to decipher), Abel appears to blame James Dewar for his having "entered the Patent world again." Royal Artillery Institution Library, MD 2586, Letters: F.A. Abel - A. Noble.

60. *Ibid.*, p. 32.

61. *Final Report of the President Explosives Committee*, p. 27. The cordite's ballistic performance was unaffected by the trip.

62. *Ibid.*, pp. 28-30. It had been noted that cordite "sweated" small quantities of crystallized nitroglycerine in very cold weather, which was reabsorbed under normal temperatures. Nevertheless, it was decided to test the cordite with surface nitroglycerine for enhanced tendency to detonate, by detonating samples of cordite smeared with a film of

nitroglycerine in a small lead cylinder and comparing the force of the detonation with that of untreated cordite. The nitroglycerine-coated cordite "was no more susceptible to detonation than in its normal condition." Moreover, cordite subjected to artificial cold was not found to sweat nitroglycerine; therefore, it was hoped that "the exact conditions which produced it will prove to be exceptional." There was a slightly enhanced tendency to detonation when struck by a bullet.

63. *Ibid.*, pp. 30-31. The "falling weight tests," involved dropping 58 lb. weights from various heights on small pieces of cordite of various shapes and thickness and on other explosives, such as black powder and dry guncotton. These are tabulated in Appendix XVIII: "Falling Weight Experiments," pp. 201-203.

64. See above, footnote 33, for memorandum of W.H. Noble and Abel to the Director of Artillery, 21/9/86.

65. *Ibid.*, p. 62. Wetteren small-arm powder, hornite, and picric acid mixtures had already been tested in larger guns starting in November, 1888.

66. *Ibid.*, p. 69. The air space in the cartridges was reduced by inserting rods, cylinders, blocks and linings of various woods into the cartridge case. No attempt was made to obtain a higher muzzle velocity here than that of black powder. This was a "Q.F." (quick firing) gun.

67. *Ibid.*, p. 71.

68. Preliminary tests and modifications were made by Andrew Noble at Elswick: the chamber's capacity was to be reduced from 1,500 cubic inches to 939 cubic inches. p. 75.

69. *Ibid.*, p. 76.

70. *Ibid.*, pp. 76-86. The Committee was unsuccessful in developing cordite suitable for the 8-inch RML (rifled muzzle loading) howitzer.

71. *Ibid.*, p. 139.

72. On March 7, 1892, the Secretary of State (Stanhope) spoke to Parliament about cordite in rather measured terms:

"I hope and believe that this powder will turn out to be satisfactory. But as every foreign nation has hitherto failed in attaining this much-desired object of a smokeless powder absolutely stable under all probable conditions, I speak with diffidence, and I do not venture to assert with

too great confidence that we have been successful." *Parliamentary Debates*, 4th series, Vol. 2 (4 March, 1892 – 25 March, 1892), 241 (7 March, 1892).

73. *Extracts from the Annual Report of the President, Ordnance Committee for the Year 1893* (London: Printed at the War Office, 1894), p. 70. Royal Artillery Institution Library MR 78.

74. *Explosives Committee*. Report No. 3, 31st October, 1901, pp. 2-10. Public Record Office WO32/9061. The committee consisted, in addition to Lord Rayleigh, Sir W.C. Roberts Austen, F.R.S., Sir William Crookes, F.R.S., and R.B. Haldane. Part of the concern over the keeping quality of the original cordite in hot climates had to do with the explosion on H.M.S. "Revenge." p. 9. Their recommendation was to reduce the proportion of nitroglycerine to 30% (from 58%).

75. Marshall, *Explosives*, I, p. 304. He went on to say: "for after a quarter of a century , during which it has been subjected to far more drastic treatment in all parts of the British Empire than the powder of any other Power, it is still giving satisfaction." He noted that the Germans ultimately adopted a powder similar to cordite for their naval guns.

76. Ken Alder, *Engineering the Revolution: Arms and Enlightenment in France, 1763-1815* (Princeton: Princeton University Press, 1997), p. 13. Alder applies the term to firearms and projectiles and uses "thick thing" to reflect the "resistance and obstinacy of matter" to ready denomination and determination by theoretical principles and mathematical laws.

77. *Final Report of President Explosives Committee*, p. 2.

78. Seymour H. Mauskopf, "Pellets, Pebbles and Prisms: Suiting Black Powder For Scaled-Up Guns In English Munitions, 1860-1880." Brenda Buchanan, ed., *Gunpowder, Explosives and the State: a Technological History* (in press).

79. Seymour H. Mauskopf, "Bridging Chemistry and Physics in the Experimental Study of Gunpowder," Frederic L. Holmes and Trevor H. Levere, ed., *Instruments and Experimentation in the History of Chemistry* [Dibner Institute Studies in the History of Science and Technology] (Cambridge: MIT Press, 2000), pp.335-365.

80. Royal Institution: James Dewar .DB1. General laboratory notes 1864-1923.DB1/5: *ca.* 1888-1901. Beginning on May 8, 1890, Dewar

delivered a course of six Thursday evening lectures at the Royal Institution on "Flames and Explosives," DB3/2: 1886-1906, pp. 58-61: Course of 6 lectures on "Flames and explosives," on Thursdays beginning 8 May 1890.

81. Public Record Office, SUPP 6/512: *Proceedings and Reports Committee on Explosives 1888 to 1891*. Minutes of the Proceedings of the Explosives Committee, 27th April, 1889: 314. Examination of the Nature of Explosives by means of the Spectroscope. p. 23.

82. Royal Institution: James Dewar DVIIa/27: Dewar – Duke of Northumberland, 18 May 1916.