Gunpowder Mills Study Group

NEWSLETTER 20, FEBRUARY 1997

MEETING AT THE INSTITUTE OF HISTORICAL RESEARCH, SENATE HOUSE, UNIVERSITY OF LONDON SATURDAY 24 MAY 1997

Please note that it was intended that this should be a field meeting. However it has not been possible to make the necessary arrangements so that a meeting at the Institute of Historical Research has been organised instead. At this meeting it will be decided whether we should have a further meeting at the Institute as planned on Saturday 11 October or make use of that date for a field meeting.

PROVISIONAL PROGRAMME

10.00-10.30 Assemble and Coffee in the Common Room on the Ground Floor

10.30-10.45 Chairman's Introductory Remarks
10.45-11.45 **Glenys Crocker and Keith Fairclough**, "The Introduction of Edge-Runner Incorporating Mills in the British Gunpowder Industry"
11.45-12.45 **David Jones**, "Early Gunpowder Mills at Regensburg"

12.45-14.00 Lunch. It is recommended that members bring a packed lunch which may be eaten in the Common Room where hot drinks can be purchased.

14.00-15.00 **Frederic Lee**, "The Gunpowder Trade Association, 1872-1902"
15.00-16.00 Members' Contributions and Discussion of Group Activities
16.00 Prepare to vacate room

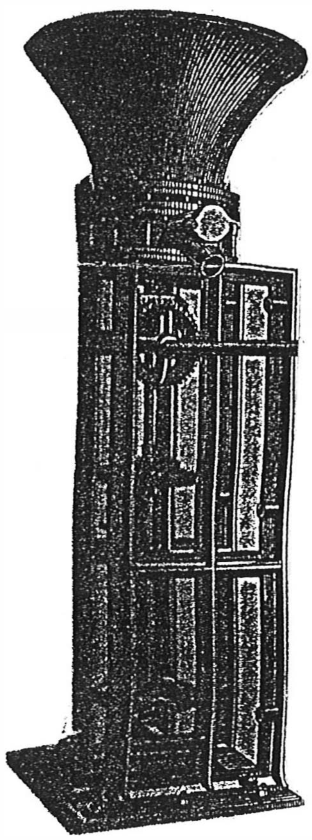
We shall be meeting in The International Relations Room on the second floor of Senate House. Goodge Street, Warren Street and Russell Square underground stations are nearby. Parking may be available in the University of London car park - entrance at NW corner of Russell Square. To cover administrative costs a fee of £2 will be collected.

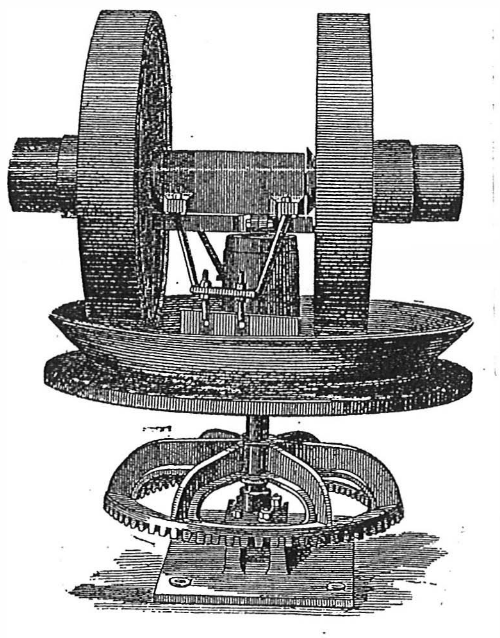
Please let Alan or Glenys Crocker know if you are coming and if you would like to make a member's contribution: 6 Burwood Close, Guildford, Surrey GU1 2SB; tel 01483 565821, fax 01483 259501; e-mail a.crocker@surrey.ac.uk

Please note that subscriptions for 1997-98 are now due. See enclosed form.

THE MANUFACTURE OF GUNPOWDER IN *ENGINEERING* 1878

Wayne Cocroft has sent us copies of the following articles on the manufacture of gunpowder which appeared in vol **25** of *Engineering* (1878). These were written by James A C Hay and include illustrations of machinery constructed by Messrs Taylor and Challen, engineers, Birmingham:
(i) Jan 4, pp 1-2. Introduction on the composition and the preparation and refining of the ingredients.
(ii) Jan 18, pp 37-8. Charcoal grinding mill; saltpetre and sulphur grinding apparatus; mixing machine incorporating mill
(iii) Feb 8, pp 95-6. Breaking down machine; hydraulic pressing apparatus.
(iv) Feb 22, pp 137-8. Granulating machine; dusting reels; glazing barrel.
(v) Mar 15, pp 197-8. Drying stove; pellet-powder machine.
(vi) Mar 29, pp 235-6. Pebble powder machine; densemeter.
It is proposed to publish the illustrations accompanying these articles with informative captions at appropriate places in the present and future GMSG Newsletters.





Machines for the manufacture of gunpowder, constructed by Messrs Taylor and Challen, Engineers, Birmingham, reproduced from *Engineering*, 1878.
1. Charcoal grinding mill, similar to a large-scale coffee mill. Charcoal is placed in the hopper at the top and ground by adjustable spiral teeth between a rotating cone and a fixed cylinder. *(From a poor quality original)*
2. Edge runners for grinding either saltpetre or sulphur. The rollers are 4 ft in diameter and weigh 30 cwt.

THE AUTUMN MEETING IN LONDON, 1996 — Keith Fairclough

This meeting, which was held on 12 October at the Institute for Historical Research, opened with a talk by Peter Guillery of the RCHME on Purfleet Gunpowder Magazine. Growing concern with safety meant that earlier government magazines at the Tower of London and at Greenwich had come to be considered unsuitable locations. In 1751 there had been recommendations that Purfleet would be a suitable site for a new magazine, and plans were presented in December 1754. However there was a war on, and nothing was done until 1760 when an Act authorised the construction of new and much larger magazine facilities at Purfleet. As early as 1763 the site was in use, but it was not until 1773 that the work was completed. Five magazine buildings were built, each capable of holding 10,400 barrels of powder. The facility at Purfleet became an example that was replicated at other magazines, and the site was long to remain the main government storage facility. It was not closed down until 1962, when many of the original buildings were still in use. Slides were shown of the original construction plans, of maps and photographs of the site when it was in use, and of the present day remains. Much of the site had been cleared in 1973, but one of the five magazines still remains. Of particular note was the construction of the magazine buildings. Eighteenth century engineers built them to withstand bombardment, and their mass and solidity was far greater than many magazines built later, which were smaller and lighter structures separated by earthworks. The Purfleet magazines also included one of the earliest known examples of an overhead mobile crane system. Further details of the Purfleet site can be found in an article published by Peter Guillery and Paul Pattison in the *Georgian Group Journal*, volume 6 (1996), 37-52.

Next there was a talk by Keith Fairclough on a little known aspect of the early career of Thomas Coram, the man whose efforts led to the setting up of the London Foundling Hospital in 1739. Details of his early career in America as a shipbuilder and his role as a merchant back in England are known, but between 1729 and 1732 he was a partner in the firm of Grueber & Coram that delivered gunpowder to the Ordnance. Little is known of this firm, but a notebook kept by Coram during the first months of 1729 gives details of the expenses he incurred in this business. It shows that he had no role in the manufacture of gunpowder at the sites at Chilworth and Faversham, this remained the responsibility of the Grueber family. But Coram was not a sleeping partner. He had a defined role in the management of the company and brought his previous expertise to bear. As he lived in London he was responsible for obtaining saltpetre from the Ordnance and the East India Company and dispatching it by water to the powder mills, he negotiated with Ordnance officials over contracts and passes to prevent bargemen being pressed, and he attended proofing of the company's powder by the Ordnance officials at Greenwich. There are also brief financial details that throw light upon the financial problems of the Grueber family and of the company's involvement in the private trade. But he also used his earlier training to supervise the construction of a powder cart and a powder barge to run between London and Guildford. The notebook also contains details of the expenses of four trips made by this powder barge up the River Wey, Coram himself making the maiden voyage to check that all was well. The notebook thus provides a unique insight into a little documented aspect of an eighteenth century gunpowder business.

Next there was a joint presentation by Brenda Buchanan and Wayne Cocroft on Oscar Guttmann whose major work on the history of gunpowder production was published just over 100 years ago. Buchanan provided details of his career in the industry and of his publications, and it is intended to publish her contribution in a later issue of thes Newsletter. Cocroft showed slides relevant to his work in England. He emphasised the continental influence that is apparent in his work as a consulting engineer and manager at Hayle in Cornwall, the split into clean and dirty areas within the site, and the construction of concrete magazines. Guttmann was also employed as a consulting engineer at Waltham Abbey and Woolwich, to set up acetone plants for the high explosives industry. He also showed examples of Guttmann's balls, clay balls used for packing acid towers.

The afternoon opened with a report from Brenda Buchanan on the gunpowder papers presented at the August 1996 ICOHTEC meeting in Budapest. Abstracts were available, and the papers will be published eventually. She also discussed the publishing and translation problems she faced when editing the papers that had been presented at the previous ICOHTEC meeting at Bath. This book had been published in time for the Budapest meeting, and was available for consultation or purchase by members at this meeting.

The last advertised talk was given by Alan Crocker, on a gunpowder mill at Tyddyn Gwladys, near Dolgellau in Wales. This was one of only two gunpowder manufactories to be set up after the 1875 Explosives Act. The mills were closely linked to the local gold mining industry, being built in 1887-88 by William Pritchard Morgan, "the Welsh Gold-King", shortly after he acquired the nearby Gwynfynydd gold mine. In 1890 his gold mining company went into liquidation and his powder mills were mortgaged. The latter were sold to a Liverpool merchant, Richard Cockburne Briscoe, who set up the North Wales Gunpowder Co to operate them. However this company went into liquidation in February 1892, and after that the mills were never used for gunpowder again. Shortly afterwards some of the buildings were converted into barracks for local miners and the incorporating mills were used for crushing gold ore. Slides were shown of contemporary maps and of present day remains. [This talk was based on a paper, published in *Melin*, the journal of The Welsh Mills Soc, vol **12**, pp 2-25, Nov 1996.]

Several shorter contributions were then made by members of the Group. Frederic Lee commented upon marketing arrangements in the United States of America during the operation of the Gunpowder Trade Association 1872-1902, and accepted an invitation to give a paper at next year's meeting. The contribution from Glenys Crocker appears elsewhere in this newsletter and that by Charles Trollope is discussed in an article on saltpetre by Brenda Buchanan. Gerry Moss then discussed street names such as Gunpowder Alley near present day Gunpowder Square off Fleet Street and Gunpowder Alley near the Tower if London that appeared on Rocque's maps of London. He then showed slides of the Group's May 1996 trip to Paris. At the close there was a short review of future business. There was discussion of proposed visits on 24 May 1997 to either Faversham, Weedon or Purfleet, and a report on the publication of Alice Palmer's thesis on Low Wood gunpowder mills, and the publication by the Faversham Society of key articles from earlier editions of the Group's newsletter.

GUNPOWDER MILLS STUDY GROUP - VISIT TO PARIS, MAY 1996

Wayne Cocroft

Paris: The Arsenal District

The Arsenal district lies between the Place de la Bastille and the River Seine bounded on its eastern side by the Quai d'Arsenal, a canal which formerly served the now demolished fortress of the Bastille and the Royal Arsenal. The Bastille was established by Charles V in 1370 and the area between it and the Seine to the south developed as an arsenal. Gunpowder production began in the middle ages and in one notorious explosion in 1534 one of the corner towers of the outer defences of the Bastille was demolished. The arsenal area was later important for the manufacture and storage of saltpetre. No remains of the arsenal buildings survive but its presence is commemorated in local street names and in the carved stone mortars incorporated into the parapet of the Bibliothèque de l'Arsenal. Recently a plaque had been unveiled to Antoine Lavoisier, Régisseur des Poudres et Salpêtres. Links with the manufacture of explosives is still maintained by the headquarters of the French national explosives company the Société National des Poudres et Explosives (SNPE). To the rear of this is Paul Vieille's laboratory where he carried out his important research into explosives in the late nineteenth century.

Corbeil Essonnes

Corbeil Essonnes is a small town 25km south of Paris which was chosen in the late seventeenth century as a powder manufactory to replace the Paris mills. The town linked to Paris by the river Esson via the Seine to the arsenal area. An illustration of one of the early powder mills at Essones is shown in figure 1.

In our brief tour of the town we saw little evidence of the gunpowder industry except for a few street names. With more time a careful inspection of the river running through its centre might reveal traces of former mill sites. The only standing building associated with powder manufacture was the chapel of St John which was commandeered during the revolutionary period for powder drying. Powder drying in France at this date was still carried out by sun drying, or as in this case by laying the powder out in trays for air drying.

Le Bouchet

The French government gunpowder mills at Le Bouchet were laid out between 1821 and 1824, partly in response to the concerns of the inhabitants of Essonnes of the threat from accidental explosions. Nevertheless it provided the government with the opportunity to establish a purpose-built and up-to-date manufactory. It is, for example, known that French engineers visited Britain to study the improvements made in gunpowder technology introduced in the previous decades. This building activity at Le Bouchet is in contrast to Britain, where military spending was reduced to a bare minimum after the end of the Napoleonic wars. This period of inactivity in the state factories at Woolwich, Enfield and Waltham Abbey was characterised by Hogg as 'The Doldrums' (1963, 602).

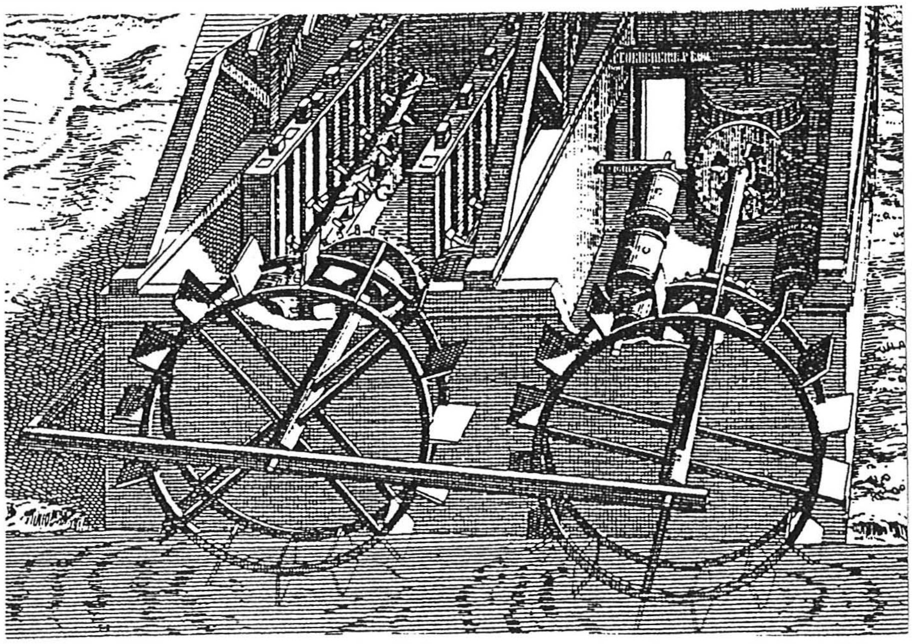


Figure 1. Seventeenth century gunpowder mill at Essonnes.

Our tour was reminiscent of early visits to Waltham Abbey where it was difficult to understand the layout and production flows on a site which has grown organically as new production processes were added. Le Bouchet was chosen for the proximity of a natural spring which gave the mills an assured water supply. In layout the mills appear to consist of two parallel leats, an upper mill race and a lower tail race. It now covers some 80 hectares much of which, typical of many powder works, is densely wooded. A number of the mill buildings survive on the site and many have been adapted to new uses. One mill remains with a central low breast shot wooden wheel with former machinery bays to either side. One bay retains its original form, and is stone built and rendered in cement on three sides with the fourth closed by low part-glazed doors. It is now roofed in corrugated asbestos, replacing an earlier covering. The other bay and the roof over the wheel appear to have been rebuilt and were covered by curved concrete roofs. The roofs were formed by narrow metal ribs with a mesh between, used to support the cement roof. This design is reminiscent of the 1935 Quinan Stove at Waltham Abbey which aimed to reduce the amount of flying debris in the event of an accidental explosion. The solidity of this mill is in contrast to the flimsy timber structures generally preferred in Britain.

Lammot Du Pont visited the Le Bouchet mills as part of his tour of European mills in 1858. In his journal he recorded features he considered to be out of the ordinary. At Le Bouchet he noted that the sulphur and charcoal were pulverised by gunmetal balls, in dust barrels larger than the ones used by Du Pont's. Ten stamp mills were in operation for making cannon powder and two rolling mills for making sporting powders (Wilkinson, 1975, 35). In 1868 in the *Quarterly Review* Smith noted that *moulins à pilons* and *moulins à tonneaux* were still used in France, but implied that they were gradually being superseded by edge runners (Smith 1868, 113).

As with Waltham Abbey the complexity of the Le Bouchet factory landscape is complicated by the juxtaposition of chemical explosives manufacture. Le Bouchet was one of the earliest factories in France which experimented with the production of guncotton in the 1840s. Manufacture was halted in 1847 after a devastating explosion in which seven died. The French apparently abandoned the manufacture of guncotton until the British War Department chemist Frederick Abel solved the problem of its instability by pulping and thorough washing to ensure the removal of the nitrating acids. In the 1880s the factory was extended to include the manufacture of smokeless powders and also the high explosive Melinite (picric acid, known in Britain as Lyddite). In parallel with developments at Waltham Abbey the site continued in use during the post-war period as a research centre, which included investigations into rocket propellants.

Sevran Livry - Nobel's house and the Poudrerie Nationale

On Sunday morning the group assembled at Sevran Livry, about 15km northwest of Paris. The town was home to the Poudrerie Nationale and during the 1880s to Alfred Nobel. We began our visit by walking to Nobel's former house, and passed what we were informed was a school house built for his employees' children. Nobel's house is now the town hall and its interior has been much altered. A notice on the wall stated that he had lived there from 1879 until 1889, although we were told he actually left in 1891. Behind the house was his laboratory. This is a single storey brick building, with a tiled roof and divided into eight bays, characteristic of many explosives-handling buildings. It was during his residence at Sevran Livry that he developed the chemical explosive propellant Ballistite, a mixture of nitroglycerine and nitrocellulose. It was unclear from our visit whether or not Nobel had a factory in the town.

We then headed for the former Poudrerie Nationale which is now a public park administered by the Office National des Forêts. Part of the site is being developed as an explosives museum led by the former director and our host René Amiable.

The plans for the new factory at Sevran Livry were drawn up by a young engineer, Gustave Maurouard, an employee of the government powder works at Metz. In conception the new powder works represented a complete break with previous practice and were to be entirely steam driven. Planning for the new factory began in 1867 but construction was interrupted by the Franco-Prussian War in 1870-71.

During that war a makeshift factory was established in Paris. Named the Phillipe Auguste Powder Works, it used locally available steam engines with leather belt-drives. In the last three months of the war to February 1871 it produced 300 tons of powder. Defeat in the war reinforced the necessity of erecting a new powder works, with the forced removal of the Metz powder works by the Prussians.

The powder works is split into two uneven halves by the Canal de l'Ourcq and the SNCF RER suburban railway line. As we entered the site from the north through the woods we passed a few scattered buildings of uncertain function. In this section of the factory, running parallel with the railway, were the earthwork embankments of the proof ranges and associated with them a small stone

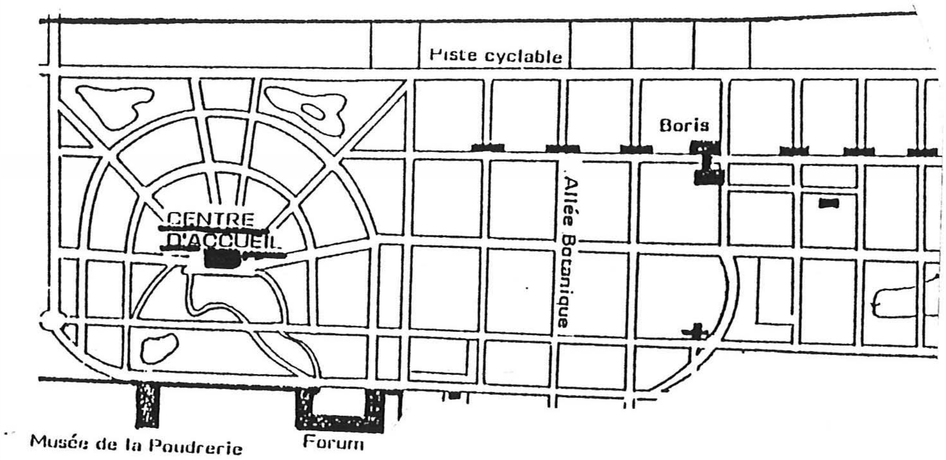


Figure 2. Plan of the Poudrerie Nationale at Sevran-Livry. The early works with radial cable drives from an engine house (Centre D'Accueil) were at the left and the later works with a linear cable drive from a central engine house (Boris) were at the right. The museum of powdermaking is at the bottom left.

magazine or 'laboratory', probably for the storage and assembly of charges for use on the ranges. Passing beneath the railway line we then entered the powder works proper.

In the plan of the works, which is shown in figure 2, we may distinguish the two principal construction phases. Architecturally the buildings of the Poudrerie Nationale are very impressive comparable to other imperial arsenals. To the west is the earliest part of the works laid out in the early 1870s. This consisted of a T shaped, two storey central engine house for two beam engines. These powered pulleys housed in the rear double-storey pulley room. This was semi-circular in shape, and from openings in its upper storey cable drives formerly radiated out to power the process buildings 110m away. Within the arc of buildings were all the processes necessary to manufacture gunpowder. This was perhaps an inefficient arrangement which limited the capacity of the works to the throughput of a single incorporating mill. The steam engines remained in use until after the Great War when they were replaced with an electric drive.

The powder works were, however, soon extended with the construction of a second boiler and engine house to the east. In this case the power transmission was along a straight row. The lines of the cables were marked by dated brick and sandstone faced piers which served to support the cables and to transfer the power to the individual process buildings.

The introduction of the cable-drive system in the 1870s raises some intriguing questions about the diffusion of this technology. Professor Rankine attributed this system to C F Hirn, and to a work published by him in France in 1862 (1880, 447-8). On the continent a postcard of the Bomlitz factory in Hanover shows a cable power transmission system in use during the early 1870s (Mussman 1996, 342). At the Du Pont mills by around 1880 it had also been adopted as a method of power transfer (Figure 3) (Williams 1974, 41). In Britain rope drives were commonly used in textile mills from the mid 1870s. It is suggested they were made possible by the development of durable cotton rope at this date (Giles & Goodall 1992, 160-3). Their use in the British gunpowder industry is, however, less

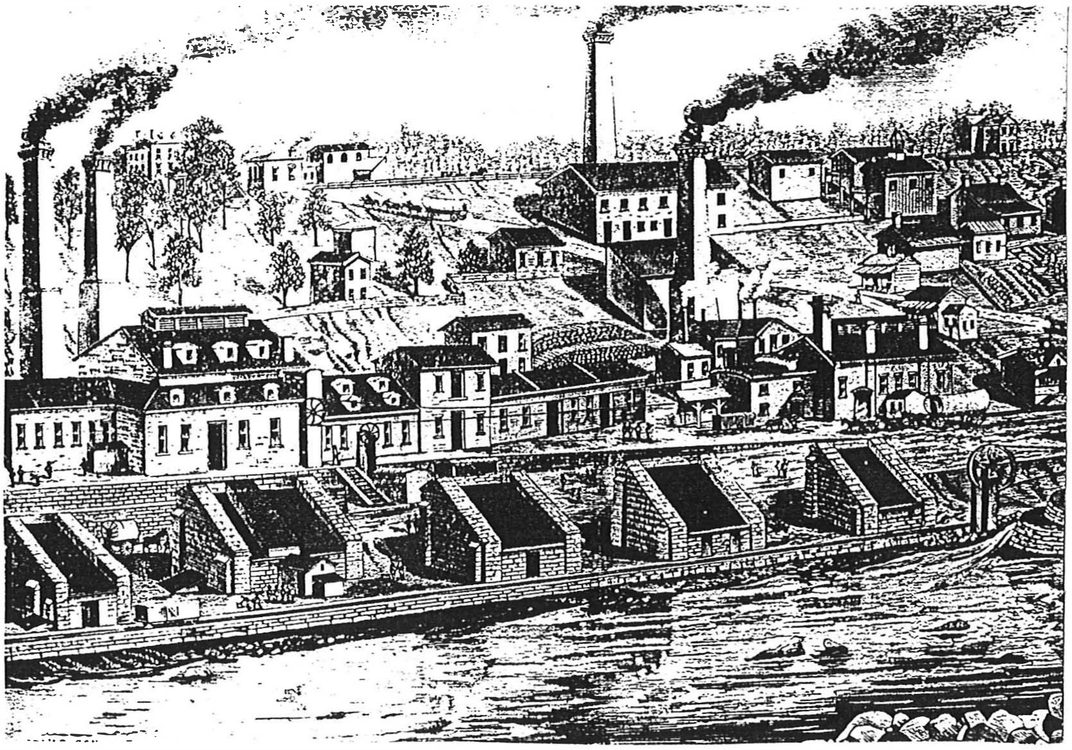


Figure 3. Cable drive being used at the Du Pont de Nemours & Co's Upper Brandywine Gunpowder Mills, near Wilmington, Delaware, around 1880 (Williams 1974, p 4). One large pulley wheel can be at the extreme right and two smaller ones just left of centre.

evident. One possible example may be the German-designed steam-driven powder mills erected at Chilworth in the 1880s, where there is no obvious method of power transmission between the detached engine house and the drive shaft mounted on the rear of the mills.

A considerable archive of original drawings also survives at Sevran Livry, which will considerably aid the interpretation and understanding of the site. An important collection of machinery and artefacts is also displayed in the small site museum. This includes items from the factory, artefacts associated with Nobel and machinery brought from other French factories.

Sevran Livry was also important in the history of the French chemical explosives industry. The manufacture of Poudre B (invented by Paul Vieille in 1884) began in 1885 and later Ballistite and Melinite were produced in the factory. It was unclear which section of the factory was involved in this work. However, adjacent to the museum were earthenware wolf bottles and a fascinating ceramic pump, probably used to move nitric acid.

The visit was very successful in raising awareness of the technological development of the French powder industry which hitherto has largely been closed to the English speaking world. It only remains to thank our International Secretary, Brenda Buchanan, and French hosts, Patrice Bret and René Amiable, for all their efforts in arranging these visits.

References

Hogg, O F G, 1963, *The Royal Arsenal,* OUP, London

Giles, C & Goodall, I H, 1992, *Yorkshire Textile Mills, 1770-1930,* HMSO, London

Mussman, O, 1996, Gunpowder production in the electorate and the Kingdom of Hanover, in Buchanan, B J, 1996, *Gunpowder: the history of an international technology,* Bath University Press, pp 329-50

Ranskine, W J M, 1880, *A manual of machinery and millwork,* London

Smith, F M, 1868, 'A short account of the improvements in gunpowder', *Quarterly Review,* **125**, pp 106-33

Wilkinson, N B, 1975, 'An American powdermaker in Europe: Lammot Du Pont's Journal, 1858', Science Museum manuscript MS412

Williams, T I, 1974, *Alfred Nobel Pioneer of High Explosives,* Priory Press Ltd, London

GUNPOWDER FOR THE WANLOCHEAD LEAD MINES

Richard L Hills

I discovered the following notes on gunpowder when studying, briefly, the Stirling of Garden papers at the Scottish Record Office, No 2362.

Bundle 107

10 Jan 1765. James Stirling must have complained about the quality of some gunpowder at Leadhills. Letter to Joseph Godfrey from Pigou & Andrews, London, 1 Jan 1765, saying their gunpowder has passed proof, and are sending 20 replacement barrels ... proofed at Greenwich.

7 Feb 1765. Jas Farquharson to James Stirling ... about the gunpowder being sent and Stirling to see if it is sufficiently good, "These gentlemen despair of being able to supply the Company with any better."

11 July 1765, from Ja Farquharson. "I have only to add that the 20 Barrels of Tower proof Gun powder last sent down cost £92.14.-"

12 Sept 1765 from Ja Farquharson. [Stirling has caught a bad cold travelling in an open post chaise to the mines during a severe storm. The Company eventually bought him a closed one!]

Bundle 108

26 June 1766, from Will Hamilton [who replaced Farquharson as Secretary]. "The Gentlemen are very much concern'd to find that the last Cargo of Gunpowder prov'd so very indifferent, & that you did not know it sooner, they are very apprehensive that some fraud is practis'd after the gunpowder is delivered, either during the voyage or at Leith: A new supply will be forthwith ordered, & every precaution taken, to guard against & detect this Roguery for which purpose a sample of the Gunpowder will be sent to you that it may be compared with the Barrels when they arrive."

THE LAST OF THE POWDER MAKERS

David Ashton

That fascinating source book, *The Rise of the British Explosives Industry*, published in 1909, lists somewhere between 25 and 30 manufacturers of explosives at that time. It is, of course, of the nature of the evolution of an industry that there should be amalgamations, as they were at one time called, and take-overs, as well as other forms of rationalization; and that a number, probably the greatest majority, of ideas should fall by the wayside and avenues of progress turn out to be culs-de-sac. As we know, the First World War and it aftermath was the occasion for many such mergers and closures, as was the rise to dominance of Nobel enterprises, later in this country to become part of Imperial Chemical Industries.

In the year that was important in my own case, 1947, there was, as far as I know, apart from Government factories and fireworks firms, only two explosives makers in this country: ICI and, in Essex, Explosives and Chemical Products, although also, in that part of the world, the British Xylonite Company still made nitrocellulose to be processed into the plastics material celluloid.

At that time I was 27 years old. At school chemistry had become my favourite subject, on the one hand because I was fascinated by the Periodic Table of the elements, and by the way the theory of valency explained chemical compounds, and on the other, in a thoroughly school-boyish way, because I loved flashes and bangs. Our chemistry masters were adept at producing spectacular and noisy displays, none of which, because of our current preoccupation with safety, would, I suspect, in these timorous days have been allowed. It was logical, therefore, that I should choose Chemistry as my principal sixth-form subject, and that I should elect to read Chemistry when I went up, in October 1938, to Liverpool University. Classes were small - there were only 14 of us in my year - and we divided for our Honours year into six reading Physical and eight reading Organic Chemistry.

The war was on with a vengeance. Dunkirk came and went, likewise the Battle of Britain and the May 1940 bombing of Liverpool. Conscription and direction of labour were universal. All fourteen of us were interviewed by an imposing civil servant who I later realized to have been C P Snow. He took the six specializing in physical chemistry for the infant radar programme. They received army commissions. From the remaining eight of us, the six men after graduating found ouselves in a very different sort of uniform, black serge trousers (if we could find any to fit us; otherwise our own), black jackets (again usually too small), devoid of insignia but with red edging or piping vaguely reminiscent, heavy boots, very heavy grey wool socks with trouser ends tucked in, our own hats - all young men wore hats in those days - and, as a sort of badge of office, second-hand red-framed bicycles, once again usually too small. We were distributed across the country: my location was the Royal Ordnance Factory Wrexham, ROF 35, and I had achieved my ambition: I was a plant chemist in an explosives factory. It is almost impossible to imagine what is entailed in organizing a great nation for a major war. Someone in the head office structure of the Royal Ordnance Factories must have conducted negotiations resulting in the GPO disgorging part of its stock of cast-off uniforms, jackets, trousers, and - bicycles.

These aids to locomotion were essential. Wrexham was a large factory, for safety reasons very dispersed, probably about 10 miles in circumference, employing 10,000 people, and with a rated capacity of 500 tons of cordite per week. But this is not the story of Wrexham, or of any war-time explosives production. I remained in the Ministry of Supply for most of the war, at Wrexham and at ROF Sellafield, which made TNT. Then came a period in a rather different branch of the war industries, but in 1947 I was looking for a change and answered an advertisement from, to me, an unknown company, Greenwood and Batley Ltd.

Greenwood and Batley were traditional engineers of the old school. They were skilled, straightforward, experienced in a number of directions, and generally successful. But they were different in that they had always been close to the munitions industries, and to an extent were very much part of them. In the American Civil War they had supplied a rifle plant to the Confererate Army. In the First World War they had made torpedoes. They had designed and supplied the machinery for extruding cordite, which had meant supplying and equipping factories in every corner of the British Empire. The same was true of the plant to make rifles and guns, and machines to make bullets and shells, and cartridge cases of all calibres, and machines to load and finish small arms cartridges and rounds for ordnance.

But additionally, they had been and still were, small arms ammunition makers, making cases and bullets, and operating the filling factories producing the finished rounds. During the war they had two case and bullet factories in Leeds, and filling factories at Abbey Wood near Woolwich Arsenal and at Farnham, outside Knaresborough in Yorkshire, making 303 ammunition but also 15 and 20mm cannon rounds. This factory was still operational, and this was where my job was to be.

ICI was of course the dominant presence in small-arms ammunition making, and by stages had rationalized the production of the Eley and the Kynoch groups, and of the Kings Norton Metal Company and others. The Vickers-Armstrong group had their own subsidiary filling shells for their guns, The Thames Ammunition Company, but whether or not this was still in production I do not know, although I believed that they had still kept their gun range at Bootle on the Cumberland coast, not far from Drigg and Sellafield, once TNT factories, and now part of the nuclear industry. And then at Grantham there was British Manufacture and Research (BMark) making 20mm cannon rounds.

Greenwood and Batley's problem was that the war had been won. No new threats to peace were discernable. Russia had been our ally and was our friend, the Berlin Air Lift and the Korean war were in the unimagined future, and the 'Cold War' was a yet-to be-invented phrase. No government contracts were available, and this state of affairs seemed likely to continue indefinitely.

The company's answer to this was the decision to make sporting ammunition, specifically 12-bore shot-gun cartridges. The cases would be made at the by this time completely idle cartridge department at G & B's works at Armley Rd, Leeds, the filling and finishing would be done at Farnham. But with great courage, the company also decided that it would make its own powder, and would make its own percussion caps.

The dominant force in shot-gun cartridge manufacture was, of course, ICI, trading under the very well established Eley-Kynoch name. The cartridges were made at their Witton, Birmingham, works. At that time they gave a choice of three powders, Smokeless Diamond, originally Curtis's and Harvey's successor to their Black Diamond, EC and Schultze. The first two were 33 grain powders, meaning that the standard charge for a 2½" 12-bore cartridge with a load of 11/16 oz of lead shot was 33 grains, while Schultze was 42 grain. It was thought that their production of 12-bore rounds was about a million a week. Greenwood and Batley were on reasonably good terms with ICI, traditionally buying from them part of their requirement of metal strip for case and bullet production, and all their 303 percussion cap requirements, and also some cordite for export. But G & B believed, probably correctly, that they could expect neither advice nor supplies from ICI for this new venture. Greenwood and Batley's field was general engineering. Both the managing director and his deputy were mechanical engineers of the old school, excellent men, skilled, fair and just, honest, and, as we have seen, not without courage. The department managers and the designers and draughtsmen were engineers, too. There was among the top handful, a degree, but at second- or third-hand, of familiarity with explosives, but what was entirely lacking was chemical knowledge.

But certain steps had already been taken. From some source, I never thought to enquire what, a trade directory probably, the directors had discovered a Mr Bagley. He stated his profession as being a consultant (quite possibly in other things also) in the manufacture of explosives. Bagley, I later learnt, was a gentleman of advanced years, but not necessarily the worse for that, and not without his eccentricities (but who is?). But he played his part, at least up to a point.

The plant, obviously, was to be on a small scale. Available were three buildings, redundant from the war-time production of 15mm (Oerlikon) and 20mm (Hispano-Suiza) ammunition, including the preparation of mixing of compounds for, and the filling of, incendiary and tracer shells. Of these three, two were a run of remote-control cubicles. These were sufficient to house all the plant for this new project. Bagley produced lay-out drawings for a minimum-size plant to make nitrocellulose, and this had already been installed.

The units were:

- A steam-heated oven for drying cotton.
- A standard earthenware pan, Nathan design, for dipping, that is, nitrating cotton and two 500 gallon stainless steel acid tanks with associated pipe-work and a compressed air system for moving the various acid mixtures.
- Two lead-lined wood vats for boiling (ie stabilizing) the gun-cotton.
- A beater as used in paper-making.
- A large vat for further stabilizing and blending the gun-cotton.
- A vertical centrifuge for taking the gun-cotton to the wet cake stage.

As regards the powder plant, he had opted for a semi-gelatinized powder, such as EC or Schultze, rather than a fully gelatinized type such as Smokeless Diamond or the various other rolled or extruded granular types. This was surely right, in that the plant was simpler and substantially less expensive. Mine consisted of an edge-runner for the wet mixing of the nitrocellulose with the other ingredients; two sieving units, both flat inclined sieves mechanically vibrated, one for the wet material from the edge runner and the other for the dry powder after surface gelatinization; and two 'sweetie pans', rotating turnip-shaped copper vessels with wide mouths, their axis at an inclination of about forty-five degrees, as used in the pharmaceutical and confectionary industries for the coating of pills and sweets.

At that stage Bagley had stopped. He had done what he had contracted. The plant was minimum capacity in that the beater and the centrifuge were the smallest each in their own range. The units were engineeringly sound, and everything from an explosives point of view was safe, of non-ferrous construction and with motors either flame-proof or sited outside the building, and so on.

But beyond that, he did not go. He provided no formula, recipe, or specification for the powder, no list of ingredients, no manufacturing procedures, no methods of testing and analysis, no proving and testing procedures or limits for the finished explosive.

When I joined it, Farnham factory was at a low ebb. In the war years it had produced about five million rounds of 303 ammunition a week and had employed several hundred, mainly women. Now it had less than a dozen, and subsisted mainly on breaking down surplus and out-of-date cartridges. There was a Works Manager and an ex-Woolwich Arsenal foreman. The factory occupied fourteen acres and was idyllically situated, apparently in the deepest countryside, but in fact less than two miles from the Knaresborough-Boroughbridge road.

There was much to be done. The Leeds factory was already producing shot-gun cases on a small scale and we were in trouble because of an incident of split rims. Also, it had been decided to move the first operation of forming (by rolling on a mandrel) the familiar orange cardboard tubes. As an interim stage, we started to import from Belgium both a powder and percussion caps. At Farnham, having sent the cardboard tubes to Leeds, we received them back complete with brass head. We inserted the caps and started to market the capped cases to independent loaders, with powder if they required it, and soon moved to loading and selling complete cartridges also.

It is not possible to do more than briefly refer to the commercial side of the enterprise. In addition to Eley-Kynoch, there were about half-a-dozen other firms of some note. Some, for example, the Hull Cartridge Company and The Pneumatic Cartridge Company (located in Edinburgh and associated with Sandeman's the port shippers) stated themselves to be cartridge makers. Some were distributors or wholesalers and/or importers. But additionally most of the larger gun makers loaded their own cartridges, or commissioned ICI to do this for them and this could extend right the way down to the sports shop or ironmongers in any small country town. Many shooters believed that they could obtain improved performance from their cartridges by ringing the changes in the components: case, powder, charge weight, wadding, shot size and charge weight. There was also feeling towards 'hand loading' and the two are reminiscent of 'hand tailoring' and 'made-to-measure'. ICI would, subject to a minimum quantity, print a customer's name and his cartridge's brand name on the case, and soon we equipped ourselves to do this. But a significant amount of my time began to be spent in obtaining orders, and I learnt what it was like to be a travelling salesman. I found a great deal of interest, and much goodwill. ICI were doing nothing wrong; their products were first rate. But people welcomed an alternative, even if they didn't always use it, and liked the additional variety.

The Belgian powder was called Clermonite. It was a soft-grained powder, similar to ICI's EC, that is, semi-gelatinized, and as has been said, it was for this type of powder that the Farnham plant had been designed. Clermonite had the fault of being too 'sharp' in its burning characteristics, that is, not sufficiently (a technical word) 'progressive', so that it had a rather high chamber pressure and a nasty 'kick'.

Our own experimental production had meanwhile started. We made perfectly satisfactory gun-cotton, and based on it a series of experimental powders using different proportions of the recognized additives. Gun-cotton is described as 'insoluble', which means in an alcohol/ether mixture, and therefore the hardening agent, to make the grains sufficiently robust, had to be acetone. Alas, the resulting powders were all too sharp and lively, more so than Clermonite, with unacceptably high pressure in the gun. I spent much time and effort attempting to moderate the powder, trying a variety of substances, including the explosive nitroguanidine, used in some types of cordite.

In parallel, we wished to develop our own percussion caps. Here, there was no difficulty as regards the plant. Greenwood and Batley had supplied many such plants all over the world, including a junior one, specially designed for the Kingdom of Nepal, so as to be portable on pack mules. Thus far did Pax Britannica run. It was simple to provide a similar production line for Farnham, a plate filling machine, a press, a blow-off cabinet, and a varnishing machine. Along with these was a unit for making mercury fulminate, a drying and sieving unit, and a jelly-mould mixer. In the standard units supplied, for example, to the Ordnance Factories, the plates held 1,000 caps. In the case of our 'baby' machines, it was, I think, 135.

Once again, the missing information was chemical, a reliable manufacturing specification for mercury fulminate. There was, of course, in the descriptive literature of explosives, accounts of how to make the first, and for a long time the only, prime explosive ingredient of reliably-performing detonating and initiating compositions, but obviously there was nowhere more than a vague reference to the proportions of the three chemicals. I was unwilling to start an experimental programme as I saw many difficulties in analysing the product and assessing its purity, its effectiveness, and its long-term stability.

As an interim step I decided to analyse the composition of the percussion caps that we were purchasing from Belgium, and this turned out to be quite simple. The two ingredients were potassium chlorate and lead thiocyanate. I was surprised that the recipe was so simple and that it included none of the primary initiating explosives, neither mercury fulminate nor the more modern lead azide/lead styphnate mixtures. Sensitivity testing of the Belgian caps showed a significant number of weak explosions, two or three per cent, but this did not seem to be reflected in the performance of the cartridges. I therefore took the decision to commence our own percussion cap manufacture using this mixture in the proportion of the oxygen balance of the two components.

Concluding this side of our shot-gun cartridge programme, but not telling it in chronological order, I did, in due course, find a reliable account of the strengths and proportions of the three chemicals for making mercury fulminate. The source, in a way, was a pretty obvious one, the Patent Office, although I did obtain confirmatory accounts elsewhere. So we started regular fulminate manufacture, and for the proportions of this and the other ingredients of the new mixture, I adopted those for the cap of the 303 cartridge.

In parenthesis, I would explain that my original job specification became heavily diluted due to two events. The first, on the international stage, was the Berlin Blockade followed by the Korean War. We received substantial 303 contracts, but with the very significant addition of Delegated Inspection and Packing. This required a labour force of approximately four times that for simply filling and finishing cartridges. Our production rose to about 600,000 rounds per week, and our total labour force to about 150 women and 20 men. The second event was the retirement of the Works Manager because of ill-health. I assumed his position while continuing the development work, although before long I recruited an assistant.

Coming back to the nitrocellulose programme, I eventually realized, from a variety of clues, that the nitrocellulose (strictly speaking gun-cotton) at 13.1% nitrogen, was too heavily nitrated, and that what was needed was a mixture of high- and low-nitrogen content NC, the insoluble (in ether/alcohol) 13.1% and the soluble 12.2%, blended 50:50 to give a figure of 12.65%. A small plant modification was needed. To accommodate the production of two nitrocelluloses, we installed a third acid storage and mixing tank and a third stabilising vat. We also upgraded our dry powder sieving by changing to a state-ot-the-art vibrating rotary unit. I also found, hidden among the Lancashire textile mills, but a substantial and impressive enterprise once discovered, the Chemical Cotton Company. Hitherto we had been using cotton purchased from the Ministry of Supply, as used for the manufacture of gun cotton for cordite. The Chemical Cotton Company was jointly owned by Courtaulds and ICI. It purified and processed cotton linters into a variety of grades designed for every use from explosives to plastics, lacquers and artificial silk and from food thickeners and slimming foods to wall paper adhesives. They were quite happy to sell us the two grades of chemical cotton that they had developed specially for ICI.

The results were immediately successful. We found that we had, from the point of view of the cartridge's user, a 'soft' powder, easy on the shoulder. The 1" chamber pressure had come down from 3.75 to 2.8 tons psi and the 6" figure had risen from 1.2 to 1.5 or 1.6. These are the marks of a 'progressive' powder. Velocity was improved and patterns were closer, both meaning that the killing range had been increased. It soon became apparent that the powder was particularly suitable for clay pigeon shooting.

Other problems were minor, and more in the nature of advances. The Bagley plant had no provision for blending the finished powder, essential to obtain a uniform product. I designed and we built a hopper blending unit, the principle being that a free-running powder, running from a conical hopper, forms a conical cavity within the hopper contents, grains being drawn downwards from the whole face of the cavity, causing mixing. The plant consisted of a stack of three hoppers, each holding 50 lbs. The powder was made in batches and stored in 5 lb tins marked with a batch number and a consecutive tin number. Tins were drawn from a number of batches according to a scheme and the top hopper filled. After mixing through the hoppers the powder was packed in a series of tins, once again numbered and carrying a Blend Number. A series of Blends was in this way built up. The process was repeated from Blends to give a series of Lots, and, a third time, from the Lots the final packing took place. The system and nomenclature were similar to the blending, lotting, and packing of cordite, with which I was familiar.

During the period between ROFs and Greenwood and Batley, I had been heavily involved in the quality control function of plastics and rubber processing, including chemical control and testing, and the quality control, including inspection and testing, of electric cables manufacture. This included the writing of specifications for raw materials, for testing methods for both chemical and electrical, and for manufacturing methods. At Farnham, as regards cartridge production, I could draw upon the very well-ordered and long-established systems of inspection and of proving ammunitioin for acceptance maintained and administered by the Chief Inspectorate of Armaments (CIA). I had adapted these to our shot-gun cartridge manufacture. For the powder manufacture, I could draw upon the CID (Chemical Inspection Department) specifications for cordite, which included the exact procedures for laboratory inspection and analysis. In parallel with the development programme, over a period, I set up a complete specification system under the headings Testing (including chemical), Firing Range Procedures, Raw Materials, Purchasing Specifications, Manufacturing Procedures, Finished Products (Chemical) and Finished Products (components and Ammunition). A laboratory was formed and the operatives trained. For some time we had an arrangement for the interchange of sample for stability testing with ROF Bishopton. The number of laboratory operatives varied between three and five, and their work was divided between the laboratory and the firing range.

One of our customers was a Mr Wheater, who lived in Hull, owning there a gun maker's and cartridge business. But also, he was the All England Clay Pigeon champion. Our powder was purple in colour - I had chosen the dye used in WM cordite - and I had a mind to call it Imperial Purple. But the directors thought that because of ICI this could not be. 'Greenbat' featured in Company trade marks and logos, and so the name was decided as Smokeless Powder Greenbat, which made me slightly regretful that I had not chosen green as its colour. Wheater liked the Greenbat powder very much, and adopted our cartridges, or alternatively, the powder. Greenbat became the preferred powder for the sport and was chosen by the British Olympics team.

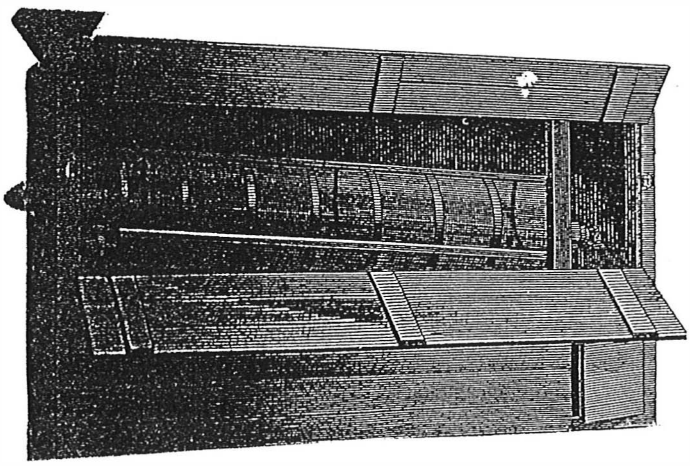
That is almost the end of the story. We purchased an automatic loading machine which produced very consistent cartridges. We had a satisfactory percussion cap based on a well-tried, if old-fashioned technology. Our sales were expanding, and had been boosted by a series of contracts from the Ministry of Agriculture for pest control.

My time was spent between the shot-gun and the military departments. There were at that time four factories producing the 303 round, Woolwich Arsenal (head stamp RL), ICI Witton (K), ROF Radwat Green (RG) and ourselves (CB). Besides Government contracts, there was an annual contract by the National Rifle Association for between one and two million rounds. This was given to the manufacturer whose cartridges the previous year had shown the best proof results. We won for three years running and received a heroes' welcome at Bisley itself.

What happened after that is anti-climax. On the shot-gun cartridge side, sales were badly hit by myxamatosis which almost eliminated the rabbit population. The decision was made to replace the 303 calibre with the new 7.62mm NATO round. As a company, we were not prepared to make the very substantial investment in new machinery, and similarly we declined involvement with ammunition for the 30mm Aden gun.

I made a number of suggestions, but the Company, for reasons that were no doubt perfectly logical, seemed to have decided that as an ammunition maker its day was nearly over. In the spring of 1956 I resigned, and moved into another industry. But for technical interest, these were the best years of my life.

[The above article is based on a paper presented by David Ashton at the GMSG meeting held in London in September 1993.]



3. Sifting reel for charcoal, saltpetre or sulphur constructed by Taylor and Challen of Birmingham, reproduced from *Engineering*, 1878. *(From a poor quality original)*

MATTERS RELATING TO SALTPETRE **Brenda Buchanan**

During Members' Contributions at the meeting of the Group on 12 October 1996, Charles Trollope raised a most important matter arising from the recently published book on *Gunpowder.*[1] He questioned the suggestion by Gerhard Kramer in his chapter on the Firework Book of the early fifteenth century, that the earliest form of saltpetre was of calcium rather than potassium nitrate, and his assertion that the process by which the former was converted to the latter by the addition of wood ashes or potash was first described by Biringuccio in 1540.[2] Charles cited the writings of Roger Bacon and Hassan al Rammah of the second-half of the thirteenth century in support of his contention that there was an earlier knowledge of this process, basing his claim on the quotations from their work to be found in the volume by Henry Hime, published in 1904.[3] As to the extremely deliquescent nature of lime, which was treated by this conversion, Charles produced dramatic evidence in the form of two small phials: in the first, kept airtight, were small dry crystals of lime; in the second, left open, the lime had become a viscous slowly pouring substance.

As editor of *Gunpowder*, I have interpreted my task as that of bringing together new material on the subject of gunpowder technology, so that novel ideas and writings which might not otherwise have been available to scholars may be opened up for discussion. By raising these important criticisms Charles Trollope is helping to fulfil this aim, and as such questions will be best answered by the authors concerned it is hoped that a long-term debate will ensue. In the meantime, and although it is not my aim to answer on their behalf, I am willing to share some of my preliminary reading, undertaken in order to understand more clearly the contents of each contribution.

It seems likely that Biringuccio gave the first clear description of the use of wood ashes. Hime, on whose work Charles Trollope relies, quoted Roger Bacon as providing earlier evidence, but it is the view of the respected authority on the history of chemistry J R Partington that this conclusion was only achieved by a selection of phrases from two chapters of Bacon's work, in what he calls "an arbitrary manipulation of a text" [4]. Similarly with the writings of Hasan al-Rammah, where there are particular problems of translation, especially as the Arabic term *bārūd* may mean saltpetre or gunpowder. In his contribution to *Gunpowder* Bert Hall describes Hasan al-Rammah's text as "plainly defective and its exact meaning .... argued by Arabists for some time".[5]

Interpreting texts is difficult enough, but the problem is even greater when we try to understand early chemical processes. It seems likely that the early form of saltpetre in Europe produced artificially in the pit or plantation method was rich in calcium nitrates.[6] Decaying nitrogenous matter dampened by urine or other liquids, and kept for about a year at a constant temperature enclosed in a dry area, yielded mixed nitrates and other salts which were then cleansed by boiling in a process to which wood ashes came to be added, perhaps initially as a detergent.[7] The addition of potassium-rich potash to the calcium-rich saltpetre in hot water, would cause the precipitation of calcium and magnesium carbonates and leave most of the nitrate in solution as potassium salt, to be formed by later boiling and crystallization into potassium nitrate saltpetre preferred by gunpowder makers and users, as being much less hygroscopic than calcium nitrate or lime saltpetre.[8]

These changes of practice may have become traditional because they worked, rather than because they were understood. The historian of chemistry Robert Multhauf has observed that not only was the reason for the addition of potash not known, but by the end of the eighteenth century it had become subject to different interpretations - did it remove fatty impurities, assist filtration, or encourage crystallization? Any notion of "progress" in this aspect of the history of technology falls at the evidence of the substitution of potash-free ash such as that from straw, or the failure to use potash altogether, in response to rising costs and scarcity as competition grew from industries such as glass and soap.[9]

As a further complication it should be noted that a distinction must be made between the artificially produced saltpetre described above, and that found as a natural product of the earth in warm climates. An instruction manual published in Paris in 1811 for example cites India, Southern Spain, Lower Languedoc, and Piedmont, as places where "the soils furnish the alkaline base without any mixture of vegetable nitrates".[10] As the earliest saltpetre used in Europe came from outside the continent, it may be that the addition of potash was at first a less important aspect of the refining of the product than it was later to become.

No explanations of these problems can be definitive, but they can indicate likely lines of change in areas of uncertainty. Biringuccio may provide the first clear account of the way in which potassium nitrate saltpetre was made, but this was probably a description of a process arrived at over many years. Charles Trollope's experiment with farm lime shows the hygroscopicity of that material from a modern source, but not necessarily the properties of the predominantly lime but probably impure calcium nitrate saltpetre of the middle ages, nor the effect of mixing with sulphur and charcoal. As to future developments, this subject, brought to our attention by the scientist Kramer and placed in historical context by Hall, has an importance beyond its novelty. In particular it raises questions about "corning", described by Kramer in terms of the "pulverknollen" or small lumps made by hand or mould, and placed by Hall within a more general scheme, whereby the creation of larger grains offering less surface for absorption was developed as one response to the problem of hygroscopicity.

Notes and References

1. Brenda J Buchanan ed, *Gunpowder: The History of an International Technology* (Bath University Press, 1996).

2. Gerhard W Kramer, "Das Feuerwerkbuch: its importance in the early history of black powder", ref 1, pp 45-56.

3. Henry W L Hime, *Gunpowder and Ammunition, their Origin and Progress* (London, 1904) pp 24-7. Charles Trollope has said that there is an earlier and fuller version of this book, published in the 1890s for army officers.

4. J R Partington, *A History of Greek Fire and Gunpowder* (Cambridge, 1960) pp 73-4, 201.

5. Bert S Hall, "The corning of gunpowder and the development of firearms in the Renaissance", ref 1, pp 87-120, see p 92.

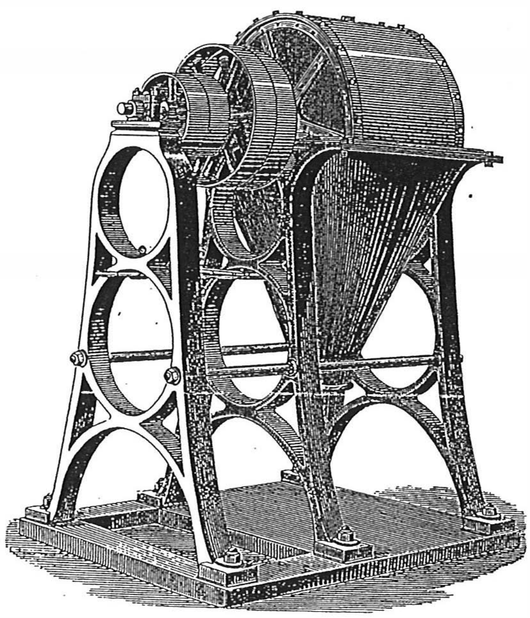
6. Kramer notes in his paper "On the history of saltpetre", presented on his behalf at the Budapest ICOHTEC Symposium in 1996, that animal remains and urine contain practically no potassium, whilst that of plants is not sufficient to form a pure potassium nitrate. Hall has observed (ref 5, p 90) that the yield of the saltpetre plantations was of mixed nitrates, some 95% being calcium and magnesium and 5% sodium and potassium. Since bacteria prefer an environment rich in the former, calcium was actually added to the pits in the form of plaster and ground seashells.

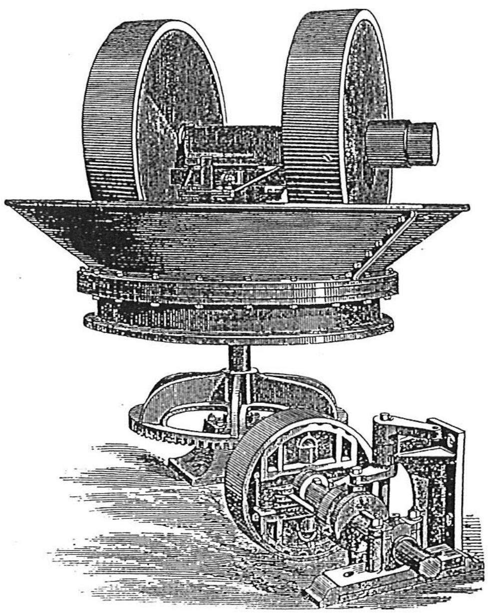
7. Partington, ref 4, p 201.

8. See Hall (ref 5, pp 90-2) for an account of the technique of boiling and its effect.

9. Robert P Multhauf, "The French crash programme for saltpeter production, 1776-94", *Technology and Culture*, vol **12** (1971) pp 163-81, see pp 177-9. Note also the complaints in the Republic of Venice in the second half of the eighteenth century about the scant use of wood ashes by saltpetre producers - see the paper presented by Walter Panciera at the Budapest Symposium, on "Saltpetre production in the Republic of Venice in the sixteenth to eighteenth century".

10. L Renaud, *Instruction on the Manufacture of Gunpowder...* (Paris, 1811), translated from the French by T & M Coulson and published in Philadelphia 1953.





4. Mixing machine with a 3 ft diameter copper drum containing 44 arms.
5. Incorporating mill with iron runners 6 ft 6 ins in diameter, weighing 4 tons. Constructed by Taylor & Challen of Birmingham; from *Engineering* of 1878.

ALFRED NOBEL: CENTENARY MEETING - SUMMARY OF PAPERS

December 1996 marked the centenary of the death of Alfred Nobel. The anniversary was commemorated in a joint meeting of the Historical Group of the Royal Society of Chemistry and The Society for the History of Alchemy and Chemistry held at University College London on 21 November 1996. We were saddened by the death of two of the speakers on the original programme. Sir Geoffrey Wilkinson was to have given the final presentation entitled The Road to Stockholm. In his place, Professor Bill Griffith gave a paper describing Wilkinson's life and work. Dr Trevor Williams also died a few weeks before the meeting. An appreciation of his work stressing his monumental contribution to the history of science and technology was given by Noel Coley. His place on the programme was taken by John Hudson.

The Life of Alfred Nobel by John Hudson (Anglia Polytechnic University)

Alfred Nobel is a difficult person to assess. He was intimate with no-one, and refused several requests to produce an autobiography. He responded to one such demand from his brother Ludvig with a terse paragraph ending with the claim that there had been no significant events in his life. A novel based on his life, written in 1947 by Sten Svderbergh, was entitled *The Man Nobody Knew*.

Alfred was born in 1833 in Stockholm. His father, Immanuel, was an architect-cum-builder. He also had a sideline as an inventor, and was bankrupt at the time of Alfred's birth. When Alfred was four years old, Immanuel left Stockholm to try and establish a business as an armaments manufacturer, first in Finland and then in Russia. By 1842, he was sufficiently prosperous for the family to join him in St. Petersburg. There Alfred received most of his education from private tutors, amongst whom was the Russian chemist Nicolai Zinin.

In his late teens, Alfred was sent on a lengthy trip abroad. He worked for a time in the Paris laboratory of the French chemist Pelouze, and travelled to New York where he met the emigré Swedish inventor John Ericsson. Soon after his return to Russia the Crimean War was started, and the family firm did good business in supplying arms to the Russian government. However when the war was over, the Russians cancelled their contracts with the Nobels, and Immanuel faced bankruptcy again.

Immanuel returned to Stockholm, where he was eventually joined by Alfred. They started to manufacture nitroglycerine for use as an explosive. Alfred's crucial invention was that of the detonator, which meant that nitroglycerine became a safe and reliable high explosive. However, its manufacture was (and still is) a hazardous process, and the Nobels' first factory was destroyed in an explosion in 1864 which killed Alfred's younger brother. This tragedy resulted in Immanuel suffering a stroke, and as a consequence Alfred found himself in sole charge of the business. From 1865 demand rose rapidly, as explosives were needed for the many major civil engineering projects being undertaken all over the world. By 1873 Alfred owned 13 factories in Europe and three in America.

Nobel introduced several other important innovations into explosives. Among these were dynamite, blasting gelatine, and ballistite. Apart from his work in explosives, Alfred was an extraordinarily prolific inventor, and took out over 350 patents. These ranged over fields such as rubber processing, artificial fibres, paints, sound reproduction, artificial gemstones, electric batteries, telephones, etc. He was also involved in several other business ventures. Foremost among these was the company founded with his two elder brothers to extract and refine crude oil from the oilfields near Baku on the Caspian Sea, and the Bofors-Gullspang Company. The latter was bankrupt when Alfred acquired it three years before he died, and he set about turning it into a major armaments manufacturer.

Paradoxically, Nobel was interested in the cause of world peace, and he supported the peace movement founded by Bertha von Suttner, who had briefly worked as his private secretary. He also had literary ambitions, and a play was on the point of publication at the time of his death.

Many obstacles had to be overcome before his will could be executed and the Nobel prizes established. The first awards were made in 1901, and a Nobel Prize continues to represent the peak of achievement. Although he remains a somewhat enigmatic and contradictory figure, Alfred Nobel is probably the best-known benefactor science has ever had.

Dynamite and Peace by J.E. Dolan (Nobel Explosives, ICI)

Alfred Bernhart Nobel is known to most people for the Nobel prizes, dynamite and nitroglycerine. His story is one of a man who, almost single-handedly, transformed mining, quarrying and civil engineering into a high technological industry without which modern civilisation could not exist.

Nitroglycerine was first produced, on the laboratory scale, by the Italian chemist Ascanio Sobrero at the Turin School of Mechanics and Applied Chemistry in 1846. Because of its extreme sensitivity and unpredictability nitroglycerine remained a chemical laboratory curiosity for 17 years until Alfred Nobel became obsessed with the idea of using the impressive power properties for constructive purposes to open up a new era in commercial blasting for peaceful purposes.

Nobel solved the problem of how to initiate nitroglycerine safely and reliably by inventing the detonator in 1863 which has been hailed as the greatest discovery ever made in both the principle and practice of explosives. On it the whole of the modern practice of blasting has been built and Nobel began to supply the world with his new system. However the extreme sensitivity of nitroglycerine to impact proved to be just too great a hazard for its continued practical use in the liquid form and Nobel realised that, if he were to make practical use of his ideas he had to give to nitroglycerine a similar degree of safety in handling as he had given to his initiating system. After many experiments with different absorbing materials, he finally tried Kieselguhr which has the ability to absorb four times it's own weight of nitroglycerine giving a red powder which was safe to handle and required the detonation from the blasting cap to initiate. Nobel called this mixture dynamite.

During the course of Nobel's lifetime he gathered a cadre of brilliant men around him and continued his experimental work replacing the original Guhr Dynamite first with Blasting Gelatine and then with a whole range of nitroglycerine explosives which revolutionised the whole of the mining, quarrying, civil engineering and construction industries.

Unlike most inventors Nobel combined technical creativity with commercial flair, both to a very high degree and within ten years founded an international group of Dynamite Companies in Sweden, Norway, Finland and Germany before turning his attention to the United States, Britain and the rest of Europe. Nobel found Great Britain most difficult. Because of the serious accidents with Blasting oil in different parts of the world, the British Government of the day had, in 1869, passed an Act of Parliament forbidding "the manufacture, import, sale and transport of nitroglycerine and any substance containing it within Great Britain". Nobel spent two very frustrating years before he obtained permission to establish his business on the west coast of Scotland at the mouth of the Clyde estuary - Ardeer. Helped by the Scottish Corporate principle of Limited Liability, he set up a Company in April 1871 with the rights to work Nobel's patents under the name The British Dynamite Company.

The first charge of nitroglycerine was produced at Ardeer on the 13 January 1873. The Company was an immediate success and within two years had cleared its capital outlay and in a further two established a very substantial profit. Nobel's ambition to establish himself in Great Britain was achieved. The Company prospered during the 1880s and developed an impressive overseas trade and Nobel lived to see his infant Company grow to become the biggest explosives company in the world supplying 10% of the total world's requirement of explosives. Nobel's business empire made him a very rich man indeed but he died a lonely man in St Remo, Italy, on the 10 December 1896 with only his doctor at his deathbed. He left his entire fortune to set up a trust to establish the Nobel prizes.

There is a tail to the Nobel story in that in 1879, seven years before Nobel died, a young man called Harry McGowan at the age of 15 joined the Company as office boy and rose to be its President and Chairman. In 1926, 33 years after Nobel's death, Harry McGowan persuaded the related industries of Brunner Mond, British Alkali and British Dyestuffs to come together with Nobel's Explosives as a single chemical corporate entity in the new chemical giant: Imperial Chemical Industries Ltd. The four companies publicly announced their intention to merge on 21 October 1926 and was fully operational by 1 January 1927.

The above account, which has been provided by ***Gerry Moss,*** *is based on a report in the newsletter of the Historical Group of the Royal Society of Chemistry.*

£6.5M from Heritage Lottery Fund for Waltham Abbey Project

This award was announced at the beginning of November and will help the Waltham Abbey Trust to restore the newly listed gunpowder buildings on the site.

BLACK GUNPOWDER: QUESTIONS OF TERMINOLOGY Brenda Buchanan

The question of selecting a title for the recently published *Gunpowder: The History of an International Technology,* which I edited, led me to consult widely on the origins of the term "black powder". The general tenor of the advice received was as set out by Bill Curtis, in his article in GMSG Newsletter **18**, p14. However his earliest date of 1868 is antedated, as pointed out by Tony Woolrich, by the reference to "ordinary black powder" in the Appendix of c.1864 to Charles Tomlinson's *Cyclopaedia of the Useful Arts and Manufactures.** In general however the term was adopted in the closing decades of the nineteenth century to distinguish what had hitherto been termed gunpowder, and the smokeless nitro-compounds then coming into use. For example in his *Manufacture of Explosives* (1895), Guttmann, after describing Vielle's "smokeless gunpowder" seeks to avoid confusion by referring to the older form as "black powder". Although histories of the DuPont Company may imply that the term "black powder" was customary, the use of "gunpowder" by Ellen DuPont in 1863 shows that amongst those with great familiarity with the materials, this was still the chosen name.

In the German speaking world "schwarzpulver" (black powder) was used from early times, perhaps as Bert Hall suggested, to distinguish black from red, yellow and blue powders used in fireworks. Heinz Walter Wild suggested that black powder may have had a particular connection with mining, as in a French document of 1617 relating to this, the term "poudre noir" is to be found. The term "schiesspulver" (gunpowder) was similarly of long standing, and may even have been used more popularly. A further possibility is suggested by the reference in the OED to potash as "black salts", for it was the introduction of wood ashes to calcium nitrate which produced potassium nitrate. Finally the ancient Chinese mixes given the name "huo yao" or fire drug may have influenced the early name by which this powder was known in northern Europe, giving rise to for example "kraut" (German), "krudt" (Danish), "krutt" (Norwegian), "kruid" (Dutch) and "kruyt" (Flemish).

I settled on "gunpowder" for the title of the book, as it represents the historical tradition of the country in which it was to be published, confident that the sub-title would indicate the international dimensions of the subject.

[*Page 394. Used to distinguish traditional gunpowder from a white gunpowder invented by the Frenchman Augendie, which was made from prussiate of potash, white sugar and chlorate of potash. See *Phil Mag,* Nov 1862. - Ed.]

An extended version of this article can be obtained on request from the editor.

Possible Restoration of an Incorporating Mill at Elterwater

The site of the former gunpowder mills at Elterwater in Cumbria is occupied by the Langdale Timeshare. Recently the lodge owners have purchased the site and this has provided an opportunity for discussions with the managing director about the possibility of restoring one of the derelict incorporating mills. This is at present being considered sympathetically.

A GUNPOWDER MILL AT RADCLIFFE NEAR NOTTINGHAM

We recently acquired a copy of Antonia Fraser's *The Gunpowder Plot,* Weidenfeld & Nicholson, 1996. I have not yet had a chance to read it but I have looked up all the references to "gunpowder" in the extensive index. Of particular interest is the following statement on pages 122-3.

"There was an enormous explosion on 27 April 1603 while the King was at Burghley. This took place at a powdermill at Radcliffe near Nottingham, not any miles away. Thirteen people were slain."

The sources of this information are given as: John Hale, *The Civilization of Europe in the Renaissance,* 1993, page 136, and John Stow, *Annales, or, A Generall Chronicle of England, Begun by John Stow. Continued by Edmund Howes,* 1631, page 819.

Radciffe-on-Trent is about 5 miles east of the centre of Nottingham and about 33 miles north-west of Burghley House. This is the only reference we have seen to a gunpowder mill having been located there and we would welcome further information on the site. We wonder for example whether it was a magazine and not a mill which exploded. There are in fact some detailed points in the book which are inaccurate, including the Long Ditton powder mills being said to be in Essex rather than Surrey. Incidentally the book claims that as a consequence of the Anglo-Spanish peace there was in 1605 something of a glut of gunpowder but there is no discussion about where the powder obtained by the Gunpowder Plot conspirators was manufactured.

Alan Crocker

THE DOGWOOD STORY

Jean Shelley, a keen local and industrial historian of Charlwood in Surrey, has sent us a copy of an interesting article with this title by Dot Meades, which was published in the Spring 1996 issue of *Ashdown Forest News.* It quotes from the 19th century reminiscences of H Walter of Nutley. At Fairwarp, which is about midway between Lewes and Tunbridge Wells, a trade was worked called dogwooding. Dogwood was much sought after, even sticks as small as a sixpence in diameter, and sold in bundles to a Mr Walter who had a property called The Dogwood Yard. The bundles were stacked up until wanted, thrown into ponds for a few days to rot the bark, taken out and the bark scraped off, bundled and stacked again until dry, loaded on to waggons and taken to the gunpowder mills at Faversham, Maresfield and elsewhere. Fairwarp is only 2 miles north of Maresfield, which had a short life as a gunpowder mill during the 1850s. The pay for scraping a bundle of sticks was 1s.0d to 1s.6d, depending on the size of the sticks and most of the work was done by women and children.

A pond formerly known as "the dogwood pond" has been located at a property known as Badgers Hollow at Fairwarp. Also buckthorn alder still grows on the western slopes of the valley between Fairwarp and Primrose Patch. However it is not very plentiful and in danger of being cleared away by those wishing to tidy-up the Forest.

BIRINGUCCIO'S EDGE-RUNNER INCORPORATING MILLS Glenys Crocker

Oscar Guttmann, in *The Manufacture of Explosives*, 1895, vol 1, pp.184-5, states 'The incorporating of black powder by means of incorporating-mills, which was formerly called the mill-stone method, was known as early as the year 1540. Biringuccio mentions that the incorporating-mills, which were imitations of olive-mills, were not much in use on account of their danger; nevertheless, they are now largely used in Germany, Great Britain, and Italy.' When Keith Fairclough and I were working on our forthcoming paper on the introduction of edge-runner incorporating mills in Britain, I decided to follow up this intriguing reference to Biringuccio's *Pirotechnia* (Venice, 1540). I began by looking for an English edition and found that the relevant passage (from Book x, ch 2) is different in the two different translations available.

C S Smith & M T Gnudi, (New York, 1943, rep.1959) translate the passage as follows (p.414): 'In ancient times, it was customary to grind it like flour with certain hand mills and millstones, but it was a very dangerous operation . . . . For this reason there are some who make it smaller and smash it in mills similar to a wine press. Some grind it with the usual water machine. Of all the methods this is the best and safest . . .'. Another translation appears, without reference to its source (and therefore is not listed under Biringuccio in the British Library Catalogue), in Peter Whitehorn's *Certain Waies for the Ordering of Souldiers in Battleray* (London, 1560): 'In olde time they were wonte to grinde gunpowder with certayne handmilles, as they use to grinde corne, but (besides the paine) it is a waye verie perillous . . . . Some grinde pouder in suche milles as they use to grinde crabbes or apples to make vargis or cider: and some hath it stamped in morters with a water mille or a horsemill, which waye is the beste of all other . . .'

The editions and the problems of translation are discussed by Smith & Gnudi, pp.xix-xxv. The Italian original reads as follows: '*Antichamente si soleva con* ***certi mulinetti & macine come le farine a braccia macinare****, ma era via molto pericolosa oltre la fadiga. Perchetal compositione con le pietre in sieme fregandosi di tal sorte riscaldava che vi producevano facilmente el fuocho & massime per essere materie tutte disposte a farlo, come ancho adviene fregando in sieme due vergelle di lauro secche con una pocha di violentia subbito v'aparisce. Et p questo alcuni sonno che tal poluare le digrossano & schiacciano con macine simile a quel del* ***uliviera****, & alcuni la pestano con il medesimo edificio a acqua che de tutti li modi questo e il migliore & piu sicuro, & che meglio & con mancho fastidio & spesa si pesti*'.

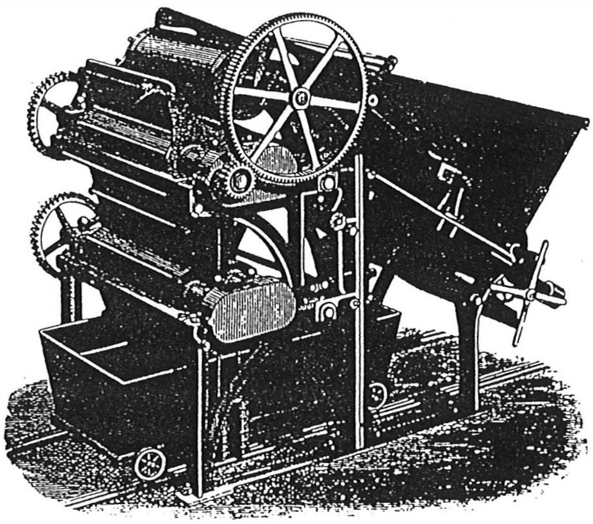
The equipment described by Biringuccio as particularly dangerous - *certi mulinetti & macine come le farine a braccia macinare* - is more suggestive of hand-operated horizontal millstones than of edge runners and the original implies that edge runners - machines similar to *uliviera* - were safer. Guttman's translation of *uliviera* seems more convincing that the other two quoted above - wine press or mill for cider apples - since *uliva* = olive. Whitehorn no doubt was using imagery which would have been familiar to his readers. The *uliviera* may have been an edge-runner mill similar to the *mola olearia* described by Columella (1st century AD), as shown in a reconstruction drawing in Singer's *History of Technology*, (Oxford, 1956), vol.2, pp.111-2.

GUNPOWDER VANS

John Horne of Southampton has sent us copies of pages 107 and 108 of Peter Tatlow's book *A Pictorial Record of LNER Wagons,* OPC, 1976, which illustrate several gunpowder vans. First is a photograph taken in about 1936 of a 6 ton "Powder B", seventeen of which were taken over by the LNER from the North Eastern Railway. There is also a close up view of its axleguard showing a wooden brake block. Then there are diagrams for a 7 ton "Powder J" of standard Railway Clearing House design. LNER had 5 built about 1928 and 20 constructed later. Finally there is a photograph of a North British Railway 7 ton gunpowder van built in 1904 and withdrawn from service in 1946. These vans were coded "Powder D" by the LNER and 21 remained at nationalisation. The notice on the door states "No person is allowed to enter this van without having put on the magazine boots which will be found inside of door."

John has also sent us a copy of a short article entitled "Gunpowder Van Livery" by Peter Bishop, which was published in the *Journal of the LNWR Society* in June 1995, page 228. This discusses whether gunpowder vans were painted red or grey as there are conflicting reports. In particular, using evidence from a contemporary model of a van it is argued that they were red both before and after the First World War. The model is illustrated and carries the notice "To carry not more than 100 barrels, each barrel to weigh not more than 100 lbs." This article prompted a response in a later issue (page 269) from Philip Millard, who in his *LNWR Liveries,* had claimed that pre-1912 vans were red and later ones grey. He confirms this view claiming that the model is probably unreliable. He also states that the Great Northern Railway gunpowder vans were painted white with brown underframes.

Earlier notes on gunpowder vans have appeared in GMSG Newsletters **1**, p6; **3**, p3; **4**, p12.



6. Breaking-down machine consisting of a hopper and two pairs of gun metal rollers. The crushed mill-cake falls via a spout into the wheeled box below. Constructed by Taylor & Challen of Birmingham; from *Engineering* of 1878.

REVIEWS

John E Dolan and Miles K Oglethorpe. *Explosives in the Service of Man: Ardeer and the Nobel Heritage,* Royal Commission on the Ancient and Historic Monuments of Scotland, Edinburgh, 1996. ISBN 0 7480 5811 7. A4, soft covers, 64 pages, 69 illus. £5 incl p&p (overseas £8), all cheques in Sterling, payable to RCAHMS, John Sinclair House, 16 Bernard Terrace, Edinburgh EH8 9NX.

This very attractive book was produced to co-incide with the conference, held in Glasgow, to commemorate the centenary of the death of Alfred Nobel on 10 December 1896. Its publication also co-incided with 125th anniversary of the foundation by Nobel of the Ardeer works, which was the UK's first dynamite factory, and the 70th anniversary of Imperial Chemical Industries. John Dolan is a chemist who worked for the Nobel Division of ICI for 37 years and GMSG member Miles Oglethorpe has worked for the RCHAMS since 1985. It was in 1990 that Miles first visited Ardeer on a GMSG tour of sites in Scotland and this led to him carrying out a detailed survey of the site which he spoke about at the Group meeting in October 1995.

Following a brief introduction (2pp), the book has chapters giving a brief introduction to explosives (4pp), an account of Nobel's life (1833-96) (2pp), the birth of Ardeer (6pp), the anatomy of Ardeer (26pp) and Ardeer and ICI (4pp). There is also a glossary (5pp), 25 references and a bibliography with 31 entries. The 69 illustrations, which occupy over half of the book, include 12 figures and 57 photographs and they all have informative captions. There are also two tables giving significant dates in explosives development and the dates when Nobel factories opened in 12 different countries (Sweden, Germany, Norway, Austria/Czechoslovakia, Finland, Scotland, France, Spain, Switzerland, Italy, Portugal and Hungary).

Naturally, most of the text concerns high explosives, as manufacturing gunpowder was a minor activity at the site and only undertaken between 1933 and 1977. However, there are photographs of a row of blackpowder incorporating mills, of a suspended edge-runner mill and of drying wheels in the safety fuse finishing department which our party saw in 1990. I also enjoyed seeing photographs of a corrugated-iron clad Chilworth mound, named after my local gunpowder mill in Surrey, the pulpers in the nitro-cotton pulping house made by James Bertram of Leith, well-known for manufacturing papermaking machinery, the industrial railways and tramways around the site, and a neat row of five pairs of safety shoes and overshoes at the entrance to a ballistite powder house.

However, for members with wider interests in explosives than just the gunpowder industry, the book provides a wealth of fascinating information and illustrations. Indeed, Miles and his colleague are to be congratulated on producing such an informative volume and I am sure that many members will wish to add it to their libraries.

Alan Crocker

Brenda Buchanan, 'The Technology of Gunpowder Making in the Eighteenth Century: Evidence from the Bristol Region', *Transactions Newcomen Society*, 67, pp 125-59, including discussion

This is the printed version of a paper which Brenda Buchanan presented to the Newcomen Society in London in March 1996. Brenda is of course the Group's International Secretary and her paper with Malcolm Tucker, another member of our Group, on the Woolley powder mills near Bath, published in *Ind Arch Review* in 1981, was one of the earliest detailed studies of a gunpowder mill site in Britain. Here Brenda tackles much wider issues, making use of information she has collected on the gunpowder industry worldwide. Indeed the title of the paper is rather misleading as a substantial part of the article is about the 17th century and earlier and much of the information relates not to the Bristol region but to other parts of Britain and to countries overseas. Some of the material included will of course be familiar to gunpowder historians but not to the general membership of the Newcomen Society, which is concerned with the study of the history of engineering and technology in general. However, there are lots of fascinating snippets of information which were new to me. For example, the illustrations include a 1593 plan of a saltpetre works belonging to an Ipswich powdermaker, a plan of the surviving earthworks at the site of a 16th century saltpetre house in Hampshire, and a map showing the path of a hurricane in 1729 near the Battle powder mills in Sussex. There are in fact 20 illustrations in all and it is unfortunate that several of these have been printed at too small a scale (I had to use a magnifying glass) whereas others, including a plan of a gunpowder windmill in Spain and of hand-operated stamps from a 15th century German manuscript are far too large.

The earliest known reference to a powdermaker in Bristol is to William Baber, who was active, but unlicensed, in 1619. He made powder for the king during the Civil War at both Oxford and Bristol and Brenda traces his progress from domestic production to what she assumes to be a substantial works known as Baber's tower, marked on a 1673 map of Bristol. However, this did not have water power and the alternative possibilities of human, animal and wind power are therefore explored, in a rather speculative way.

In 1722 the Woolley powder mills were established, with a limited amount of water power. Brenda deduces from a memorandum of 1747/9 and correspondence of 1760 that the mills had edge-runners from the start and therefore were introducing new technology before those of the London area. This statement was questioned at her lecture and I am aware that a paper by Glenys Crocker and Keith Fairclough showing conclusively that edge-runners were already being used in the South-East before the end of the 17th century is to be published in a forthcoming issue of *Ind Arch Review*. Indeed one of the exciting points which Brenda has discovered in Sir John Hope's diary of 1646 is a comparison of edge-runner oil mills in Zeeland and powder mills in Britain. Furthermore Brenda claims that because the powdermakers of the Bristol region did not supply the Ordnance but only the merchant trade they were not inhibited in introducing new technology. However mills in the South-East were also supplying private trade. For example, as early as 1621 at least one-third of the saltpetre delivered to the

Evelyn family, who held the monopoly of gunpowder manufacture, was for powder for merchant seamen and other private subjects (*VCH, Surrey,* **2**, 315).

The Littleton powder mills, about 6 miles south of Bristol, were established in 1749. One of Brenda's very exciting discoveries is that from the start they were supplied with cast-iron edge runners and beds by the Coalbrookdale Company. The Woolley mills soon followed suit and both mills also bought stoves from Coalbrookdale. This is earlier than any other known use of iron edge-runners and will provide a demanding challenge to enthusiasts of mills in the London area! However Brenda also claims that the Woolley mills were more imaginative than those of the south-east in using different recipes and grain sizes for different customers. This seems difficult to justify when one looks at the types of merchant powders being produced in the London area.

Brenda is primarily an economic historian and her approach to the development of the gunpowder industry is therefore to consider not just when things happened but why and how they were financed and by whom. This is a very stimulating approach and we should be grateful to her and to the Newcomen Society for providing us with this challenging, provocative paper, packed with fascinating information. It should be read by all members.

Alan Crocker

[J E King], *Weedon, Royal Ordnance Depot Revisited,* Weedon Bec History Society, 1996. ISBN 0-9528726-09, A4, 44 pp, 22 illus, £3 plus p&p, WBHS, 3 West St, Weedon Bec, Northampton NN7 4QU

This publication is a reprint of two articles by John King, who died in 1974 after spending the whole of his working life at the Weedon Royal Ordnance Depot near Northampton. The first article, written in 1965, is entitled "A Short History of the Technical Stores Depot, Weedon, 1804-1965". Members will be particularly interested in the chapter on "The Magazine". Originally this consisted of four brick buildings, each with two large barrel-vaulted chambers. A fifth building, with four chambers, was added some time after 1835. Between each of these magazine buildings is a massive traverse, consisting of another brick building filled with earth. The article has photographs, taken in 1995, of the exterior of the whole range of magazine buildings and the interior of one of them, a 1983 aerial photograph of the whole site with the magazines in the foreground and a reproduction of the 1900 Ordnance Survey 1:2500 map of the site.

The second article is entitled "The Weedon Small Arms Collection History" and was written in 1964 when this collection was dispersed. It consisted of pistols, revolvers, automatics, rifles, machine guns, breast plates, lances, swords, bayonets and knives.

After 1965 the Depot was occupied by Government departments for a further 18 years. The site is now in multiple occupancy.

Alan Crocker

***Gunpowder: the History of an International Technology,* Brenda J Buchanan, ed, Bath University Press, 1996. ISBN 0 86197 124 8. Hardback, £50, 400 pp, 150 maps, tables & illus. [Available through Drake International Services, Market House, Market Place, Deddington, Oxford OX15 OSE, tel 01869 338310.]**

This book is based upon papers presented at the Gunpowder Section of the 22nd Symposium of the International Committee for the History of Technology (ICOHTEC) held at Bath in 1994. The Section was convened by Brenda Buchanan, GMSG's International Secretary, and she is to be thanked for editing the papers, together with a few additional ones which could not be presented at the meeting, and arranging for them to be published in a very elegant hard-backed volume. There are 24 chapters, neatly divided into three equal groupings on "The evolution and early history of powder making", "The development and diffusion of gunpowder technology" and "powder making in its prime". The contents are truly international with papers from Australia (2), Canada (1), France (1), Germany (4), Hungary (1), India (1), Ireland (1), Norway (1), Spain (2), Sweden (1), UK (4) and USA (3).

Overall the quality of these papers and their presentation is high, most chapters containing new information and challenging interpretations which will be valuable to all those interested in the history and technology of gunpowder manufacture. There is also much related material on ordnance, the history of warfare and on mining. As the meeting was part of an ICOHTEC conference it is natural that several of the authors are academic historians of technology and interested in placing the development of gunpowder manufacture in a wide context and this is instructive. It is however also refreshing to read other contributions by amateur enthusiasts from a variety of backgrounds.

In her "Editor's Introduction", Brenda Buchanan draws out several themes, some of which, like the use of the term "black powder", have been discussed elsewhere in this and earlier Newsletters. Other points include tight control by various authorities over the manufacture of gunpowder, procuring saltpetre and sulphur, the slave trade and the use of powder in mining. Of the chapters, I particularly enjoyed Bert Hall's well-researched and well-documented "The corning of gunpowder and the development of firearms in the renaissance" (34 pp), which has a particularly logical and stimulating presentation. I also liked Björn Ivar Berg's "The production and consumption of gunpowder at the Kongberg silver mines 1734-1865" (18 pp), with excellent illustrations of this mill in Norway. The paper by Ignacio González Tascón *et al* on "The manufacture of gunpowder in Spain and Latin America from the 16th to the 18th centuries" (20 pp) is again outstanding (there was a mill in Mexico in 1555) but it is a pity that more of the beautiful illustrations shown at Bath could not have been included. This contrasts with the 17 full-page illustrations for Sarah Barter Bailey's short text (5 pp) on "The Royal Armouries 'Firework Book'", most of which have little to do with gunpowder but are great fun. These examples give a very inadequate indication of the wealth of information contained in the book and in conclusion I would like to congratulate Brenda for all her efforts in publishing it and urge all members of the GMSG to acquire a copy, which hopefully will help to ensure the publication of future conference sessions in this series.

Alan Crocker

Joyce Winfield, *The Gunpowder Mills of Fernilee*, published by the author, 1996, A5, 48pp, 21 illus, ISBN 0 9529864 0 X. From Joyce Winfield, 21 New Road, Whaley Bridge, High Peak, SK23 7JG, £4.99 plus 77p p&p (Europe £1.25, outside Europe £1.81, Australia and New Zealand £2.03).

The Fernilee gunpowder works, near Whaley Bridge, Derbyshire, were established by Thomas Williamson in 1801 to supply local mines. In 1888 the Williamson family sold the mills to the Chilworth Gunpowder Company, the subsidiary of *Vereinigte Rheinisch-Westphälische Pulverfabriken* which had acquired the Chilworth powder mills in 1885 to manufacture brown prismatic powder. Like Chilworth, the Fernilee works closed after the First World War and in 1937 the site was submerged beneath Stockport Water Board's Fernilee Reservoir, so that no archaeological remains are accessible.

This is an attractive book in A5-format which developed from the author's attendance at a WEA class on local history. It contains many details of people and events, illustrated by old photographs, which should ensure its success among the local readership for which it is primarily intended. The first chapter sets the scene in relation to present landmarks and water levels, with a sketch map showing the buildings and tramways. This is not dated but presumably relates to the period of the Chilworth Gunpowder Company which installed the tramways at Chilworth. The chapter continues with an account of the history of the business, the ownership of the mills and the forms of transport available - the Manchester to Buxton turnpike (1724), the Peak Forest Canal (1796) and the Cromford & High Peak (1831) and LNW (1857) Railways.

A chapter on the process of manufacture describes in particular the three incorporating mills, the corning house as described in reports of an explosion in 1909 and the manufacture of cartridges. There are also chapters outlining the history and development of the industry and on safety legislation, which provides a background to an account of accidents at the mills.

It is not clear from the book what products were being made at Fernilee in the later years. The Chilworth Gunpowder Company acquired the Surrey mills in 1885 to manufacture brown prismatic or 'cocoa' powder, using charcoal made from straw, but in 1892 built a new smokeless powder factory at Chilworth to manufacture high explosives. The Fernilee book states only that in 1893 new machinery was installed of the 'latest and approved type'. There is indeed much to be followed up and clarified and one hopes that the publication of this popular account will stimulate further research. It would have been helpful to this end if the author had provided a list of specific references, if only in the tiniest microscopic type, in addition to the general references to sources which she gives, narrative style, throughout the text (although this is, in itself, an excellent, informative way of presenting local history to the general public).

A chapter on gunpowder families notes that a number of workers migrated to Fernilee from other parts of the country. Several came from Surrey after the Chilworth take-over and others came from the Lake District and the west of Scotland.

The old photographs in the book are mainly of people, including group photographs of coopers and of powdermakers in their working clothes, and of vehicles - two workmen with a tram, a delivery van, a horse-drawn cart - and one is a view over part of the factory in 1911, showing a chimney stack and several process buildings [one of which may be a corning house?].

Finally there is a glossary which most of us would probably quibble with to some degree, as we would with some other details and matters of emphasis. But the book is a splendid piece of initiative and a much-needed start on the problem of this drowned powder mill. One hopes that the author will welcome a friendly approach from our Group.

Glenys Crocker

M R Bowditch & L Hayward, *A pictorial history of the Royal Cordite Factory Holton Heath*, Finial Publishing, Wareham, 1996. ISBN 1-900467-01-1. £15, incl p&p, cheques to Lesley Hayward, 115 East St, Corfe Castle, Wareham, Dorset BH20 5EG or from booksellers.

This is more than a pictorial history, and is in fact a detailed history of the factory based on Malcolm Bowditch's now unobtainable earlier history *Cordite Poole*, published by MOD in the 1980s. The present book is illustrated with 75 black and white photographs and nine figures. The majority of the photographs have been copied from the official factory albums dating from the first world war to the end of the second with a few more recent photographs of the surviving structures. The text includes much anecdotal history about the people and working conditions in the factory gathered over many years through local knowledge and talking to former employees. It also contains authoritative accounts of the manufacture of acids, guncotton, nitroglycerine, cordite tetryl and picrite. Of particular interest are the descriptions of the development of new methods for cordite manufacture which were copied by other second world war explosives factories at home and in the commonwealth. One criticism which may be levelled at the book is the lack of references to source material and a bibliography which will detract from its value to serious historians of explosives technology. It is nevertheless a valuable account of this important factory.

Wayne Cocroft

The Tonbridge Gunpowder Mills

David Hansell has discovered the following references to the Tonbridge mills in the *ICI Magazine*:
Oct 1929, p393. A drawing of the main gate of the factory featuring a guard, a clock tower, a wagon and a dog, together with congratulatory notes about an election to the Central Council and births of children to two workers.
June 1931, p648. A photograph of the press houses and mills on the riverside, showing two pairs of light-weight buildings parallel to the millstream separated by a further building perpendicular to it. There is a tram on a track along the bank and many trees in the background.
David also has a slide of an invoice dated 22 Feb 1844 with a heading elaborately engraved "Bought of William F Burton, Tonbridge Gunpowder Mill, Kent" and featuring vignettes of a country gentleman shooting and an army camp.

Eileen Gray, *Charcoals for use in Gunpowder*, PhD thesis, University of Newcastle upon Tyne, A4, 136pp plus 212 illus and 60 refs. March 1982

The main objective of the project reported in this thesis was to characterise the charcoals used in gunpowder and to specify the details of their preparation so that their specific requirements could be met. The approach is largely botanical but it is supplemented by surface chemistry, porosity and carbon gasification. There are 8 chapters: the history of gunpowder and the role of carbon in its manufacture; characterisation of porous solids; the formation, structure and reactivity of isotropic carbons; objectives of the study; materials used; experimental procedures; identification of wood and wood charcoals; the properties of charcoals and their affect on the gunpowder reaction.

Initially, alder buckthorn (dogwood), alder and beech charcoals provided by ICI were examined using a scanning electron microscope (SEM), with magnifications of up to x1000. Then, samples of these three hardwoods and also Douglas fir for comparative purposes were collected and used to produce charcoal in the laboratory. Alder buckthorn (formerly *Rhamnus frangula* but now *Frangula alnus*) is now rare but was obtained from Wicken Fen in Cambridgeshire. Several helpful coloured photographs are provided, one including the author and another her dog, which show some clear differences between leaves, sprigs, flowers, berries and shrubs of alder, alder buckthorn. and buckthorn. These charcoals were then analysed chemically, their porosity studied, their spontaneous ignition temperatures (SITs) determined, their reactivity with potassium nitrate studied and their microstrength measured.

Fractured individual grains of G7, G12, G20, G40 and SFG40 gunpowder were then examined in the SEM. Here the numbers define the grain size, G7 for example being powder which passes through a 1/7th inch sieve, and SF stands for sulphur free. Some of the G12 powder was incorporated at Waltham Abbey using a microniser or jet mill rather than traditional edge runners. This works by attrition and is a high speed continuous feed process. Finally charcoal extracted from British and Italian G12 gunpowder was examined.

The results of this work, including 123 SEM photographs, are presented in great detail and discussed in terms of the uses of gunpowder in the early 1980s. Alder buckthorn charcoal has a low carbon content (63.5-70%) which results in it igniting and burning at low atmospheric pressures so that it is ideal for fuses in anti-aircraft compositions. It also has high meso- and macroporosity and the charcoal fragments have a high aspect ratio which may also promote even burning. Alder charcoal has a higher carbon content (70-80%) and fuses and propellants containing it burn evenly at atmospheric pressure and above. It again has high macroporosity and fragment aspect ratio. It is used for most military purposes. Beech charcoal has a high carbon content (75-85%), relatively low porosity and low particle aspect ratio. It does not burn evenly and its use is restricted to propellants for rockets.

The conclusions of the thesis are as follows:

1. In all gunpowders the most essential requirement is reproducibility.

2. The carbonisation conditions to produce charcoals of the required characteristics have been established.
3. For ignition of fuses the Spontaneous Ignition Temperature (SIT) of the charcoal is most important.
4. For burning of fuses the shape of the charcoal and the reaction surface presented by the porosity are likely to be influential.
5. Ignition and propulsion may be influenced by SIT.
6. For propagation it is necessary to have a porous matrix which permits rapid flame spread.
7. Beech particles are equidimensional and pack closely. This inhibits flame spread.
8. The most important feature of gunpowder charcoal is SIT.
9. Macroporosity is important as it enables hot reactive gases to flow through the gunpowder.

Thanks to Tony Yoward for bringing this thesis to my attention and to Eileen Gray for allowing me to borrow a copy and to review it. *Alan Crocker*

SHORT NOTICES

Alan and Glenys Crocker, "The Gunpowder Mills at Tyddyn Gwladys near Dolgellau", Melin (Journal Welsh Mills Society) 12, 2-25, 1996.
An account of the history of these mills, a detailed survey of the surviving buildings and an analysis of their functions. It is illustrated with maps, survey drawings and, unfortunately, badly printed photographs. The mills were associated with the Gwynfynydd gold mines and operated from 1887 to 1892. AC

P Guillery & P Pattison, 'The powder magazines at Purfleet', *The Georgian Group Journal,* VI, 37-52.
An account of the government powder magazines detailing their development in the 1760s to their partial demolition in the 1970s. WC

Arthur Clark, *R.O.F. Kirby 1940-1946 - a photographic history,* Kirby Pastimes Publishing, 1995. £4.50, incl p&p, cheques to Kirby Pastimes, 2 North Mersey Business Centre, Woodland Rd, Kirby, Merseyside, L33 7UZ.
This 23cm x 19cm book is a collection of wartime photographs of ROF Kirby taken from an album of a former superintendent at the factory. Remarkably it is one of the few collections of photographs depicting the working and social life of a large second world war munitions factory which are publicly accessible. WC

B Elliot, 'The Royal Gunpowder Factory explosions', *After the Battle,* 93, 34-49.
An account of the two explosions which took place in the cordite mixing houses in January and April 1940, which resulted in the loss of ten lives and devastated large areas of north site. the article is based on the official reports in PRO Supply 5/752 and 5/753, although these are unacknowledged. WC

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GUNPOWDER MILLS STUDY GROUP

AUTUMN MEETING AT FAVERSHAM

24-26 OCTOBER 1997

The detailed programme for the meeting is printed on page 1 of GMSG Newsletter 21, August 1997. Essentially it consists of a meal and an introductory lecture on Faversham in a pub on the Friday evening, a meal and a background lecture on industrial archaeology in Kent in the same pub on the Saturday evening, specialised lectures about the Faversham gunpowder and explosives industry at the Fleur de Lis Heritage Centre on the Saturday morning, visits to sites on the Saturday afternoon and Sunday morning and a tour of the Fleur de Lis displays and a general discussion on Sunday afternoon.

If you are interested in attending please complete the form printed below. You will then be sent further details as soon as they become available. We shall need to know fairly accurately the number of people taking part. Therefore it will be necessary to register for the meeting in advance. It will probably be difficult to accommodate more than 35 people on the visits and more than about 40 or so at the lectures and evening meals. The registration fee, which will be used mainly to cover donations, and will not include any meals, refreshments or overnight accommodation, will be £10. The room for the evening lectures is being provided free of charge by a pub on the understanding that those attending will eat at the pub. Bed and breakfast accommodation in Faversham is recommended and a list of addresses, compiled by the Fleur de Lis Heritage Centre, can be supplied. There are many local places to have lunch.

To: Professor A G Crocker, Chairman GMSG, 6 Burwood Close, Guildford, Surrey GU1 2SB.
tel 01483 565821; fax 01483 259501; email A.Crocker@surrey.ac.uk

I would like to attend the Autumn Meeting of the Gunpowder Mills Study Group to be held at Faversham on 24-26 October 1997 and enclose a cheque for the registration fee of £10 made payable to The Gunpowder Mills Study Group.

If you would like details of bed & breakfast accommodation, please tick here ....

Name:.. Address...

Telephone... ....

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