The Royal Gunpowder Factory

1895

How Gunpowder is Made

ROYAL GUNPOWDER FACTORY WALTHAM ABBEY.

At the start of WW1 the factory at Waltham Abbey was producing 68 tonnes of gunpowder and cordite each week,and there was some production in private firms. Some TNT had been made at Ardwwr since 1907 but the total amount of high explosive available would have been laughable if the situation were not so serious. While the germans were actually firing off about 2,500 tonnes of TNT every week,the total production of both TNT and Lyddite in Britain was less than 20 tonnes per week. TNT had only recently being adopted as the principle high explosive and the production of Lyddite was being run down because the War Office had let it be known that it was to be superseded.

Immediately after the passing of the Defence of the realm Act on 27 November 1914,which gave the government power to take over factories,the Rainham Chemical Works on the Thames opposite Woolwich had been commandeered and was used to purify the few tonnes of TNT that were available. By January 1915 the first national factory,organized by Lord Moulton,was being built at Oldbury by Messrs Chance & Hunt. A big factort followed at Queen's Ferry for making guncotton,and one at Gretna in Scotland for making cordite. Only 440 tonnes of Lyddite and TNT were delivered,by Lord Moulton's department,in 1914 but this figure rose to 114,865 tonnes in 1916. Delivery of propellant explosives was 5,382 tonnes in 1914,rising to 208,085 tonnes in 1916. By the end of the war the total production had exceeded 275,000 tonnes of Lyddite and TNT,and 460,000 tons of propellant explosives.

All that effort would have been to little avail had it not been for help from across the Atlantic. The United States,like Great Britain,had been slow to begin manufacturing TNT,but within a few weeks of the outbreak of war,DuPonts had delivered very large quantities of it,and other explosives,to Great Britain,France and Russia. The value of this aid was acknowledged by Lord Moulton when he said that the British and French armies could not have held out during the early months of 1915

without it.

By the end of the war in 1918,DuPonts had shipped about 635,000 tonnes of military explosives to the Allies. They had also supplied over 355,000 tonnes of commercial explosives to their home industries,but when the United States entered the war on 16 April 1917 they even managed to step into a still higher gear to meet the vast,new demands of the American military machine. To do so,the company had expanded its workforce from around 6,000 just before the war started to a peak of 100,000,of whom,350 lost their lives in accidents.

Very considerable amounts of explosives also came from other American manufacturers and from Canada. South Africa also contributed in the shape of Kenneth Quinan,who was seconded at a moment's notice from his job as general manager of the Cape Explosive Works to become Lord Moulton's right-hand man. So valuable was his assistance that he was made a Companion of Honour and The Times wrote that 'it would be hard to point at anyone who did more to win the 1914-18 War for Britain than K.B.Quinan'.

CORDITE.

On July,10th,1888 the Secretary of State appointed a committee to consider questions relating to new explosive agents and to new applications of,or improvements in,the production and application of,known explosive agents. This committee,known as the Explosives Committee, had Sir Frederick Abel as its President with Professor J. Dewar and Dr.A.Dupre as its Members,the Secretary being Capt.J.H.Thomson,R.A. It was a committee which acted with remarkable speed and efficiency and interpreted its duties more widely than might have been expected.

Their first meeting was held within a week of appointment and on 20th August,1888 they wrote to the Director of Artillery,stating that their entry upon work necessitated early consideration of the following functions not specifically dealt with in the Circular of Instructions issued to them.

1. To examine into and report on the novelty and merits of explosive inventions.
2. To afford advice and assistance in connection with new applications or modifications of known explosives.
3. To watch the progress of invention and keep the authorities informed and advised with regard to recommended course of action in regard to fresh advances here or abroad.
4. To pursue experimental investigations having for their object the advancement of knowledge of explosives and the originating of improvements and inventions in their manufacture and use.

The Committee were of the opinion that No.4 represented their most important duty,but pointed out that any success they had would not be regarded with favour by the explosives makers,and that they would inevitably come under the stigma of not being impartial judges and of profiting by information imparted in confidence. They pointed out that no facilities or resources were being given them and that there was not even any possibility of secrecy,and that therefore they could only secure to the Government the practical results of their official investigations by taking out patents.

They stated that it was essential that regulations should be laid down under which all officials producing inventions bearing on service requirements would have the right to take out patents with the approval of the Government,securing them in the public interest,but giving the inventor the option of taking out foreign patents at his own expense in all cases in which the Government does not consider it necessary in the interests of the Service to secure secrecy.

To this very reasonable suggestion no reply was received,but there can be no doubt that the present procedure with regard to such patents is based on it.

There can be little doubt that one of the reasons for the appointment of this committee was the fact that in 1886 the French had brought out the first successful smokeless propellant,the famous "Poudre B". This was made by gelatinizing a mixture of guncotton and collodion cotton with alcohol and working up the paste to small squares of a dry horn-like material.
For some 30 years Abel and others had been trying to moderate the force of nitro-cellulose so as to apply it to ballistic purposes,but the French material was the first which gave good results. There can be little doubt that the Service Authorities in this country were seriously disturbed by this spectacular advance.

CORDITE.

The Committee examined all the many powders which were being hawked about and for which startling and totally unsubstantiated claims were being made. They turned down one after another after fair but rigorous trial. In December 1888,however,Nobel submitted two samples of an entirely new type which gave very promising results. These had been manufactured at Nobel's factory at Honfleur. They were,in fact,the first samples of "Ballistite" and consisted of a mixture of nitro-glycerine and soluble nitro-cellulose with camphor as a plasticizer. The material was not affected by damp,but evaporation of the volatile camphor on exposure to the air rapidly affected the ballistic results. In every other way the powder gave the sort of results the Committee was looking for. On receipt of a report to this effect on 25th April,1889 Nobel promised to submit samples in which camphor had been replaced by some substance not liable to evaporation. He did not do so,and,according to the Committee,did not appear to realize sufficiently the importance of what they had told him.

The Committee thereupon took steps to investigate experimently the production of a substitute containing no volatile ingredients. They used guncotton instead of soluble nitrocellulose and adopted a method of manufacture slightly different from Nobel's in that the ingredients were kneaded together with a solvent such as acetone,afterwards removed by stoving,instead of being worked between steam heated rollers without a solvent. They quickly obtained promising results and also hit on the idea of making up the charge in the form of a bundle of wires or rods of a length to occupy the whole of the powder space of the cartridge. The material was produced in this form by forcing the preparation while in a suitable plastic state through a die of the requisite diameter.

The mixture,numbered 128 in the original series,became "Cordite,Mark 1". It's composition was:-

Nitroglycerine	58
Trinitrocellulose	37.
Vaseline	5.

The name "Cordite" appears to have been first used in the Proceedings of the Committee for 5th June,1889. Before that the material had been referred to as "Cord Powder" or "The Committee's modification of Ballistite". On 27th March a meeting between the Director-General of Ordnance Factories,the Superintendent,R.G.P.F. and the President of the Explosives Committee had taken place to consider the manufacture at Waltham Abbey,and it may well be that the more convenient name had been suggested at that meeting.

Exactly how the work of the Committee was being financed is a matter of conjecture. The Director of Artillery on 4th April,1889 approved the further expenditure of £100 to cover expenses of manufacture at Waltham Abbey. When that was exhausted he would require a progress report and a statement of further requirements. The committee replied that progress was such that they anticipated the amount would be considerably exceeded in the current year,but they would report in due course. In June the President forwarded to D.of A. a letter from Messrs. Easton and Anderson (Engineers) describing in general terms the machinery they had designed for the manufacture of Cordite. The cost was to be about £100. This modest expenditure was forthwith approved and work proceeded.

In September Capt. Thomson,R.A. who had been Secretary of the Explosives Committee,was appointed Experimental Officer for Cordite,his duties being to carry out and record all experiments with Cordite required by D.G.O.F.,reporting the results to him. This appears to have been a further blow to the authority of the Superintendent as apparently he was not even to be informed of the results of experiments.

In spite of all difficulties and opposition the triumphant march of Cordite continued and on 6th October,1891 the Superintendent wrote a long minute to D.G.O.F. setting out his requirements to make 2 million pounds of cordire a year,only to be informed that "there is no doubt that half the supply of Cordite will be obtained from the trade." The equivalent of the make of black powder at Waltham would be half the quantity mentioned,and the Superintent was to supply details of modifications required to bring output up to that figure. The acquistion of additional land for this purpose (Cob Mead) was approved by the middle of October and by the end of the month the Superintendent was able to detail his requirements without,however,assigning positions to buildings until he knew just how much land it was proposed to acquire and until the results of a proposal to deliberately fire a cordite stove were known. It is clear that,although operations had been so bar carried through without accident,the dangerous nature of the manufacture was becoming clearly recognised and more detailed information on the risks involved demanded.

The general manufacture of Cordite by private firms,apparently imminent in 1891,did not commence until 1894,when the National Explosive Company and Kynoch Ltd. were each given a contract for 600 tons to be delivered over three years at a price of 2/10½d. a pound,although in 1891 Superintendent Waltham had reported his cost to be 2/- to 2/6 a pound and inprovements to reduce that figure considerably could be foreseen. The highest tender sent in was 4/3 and 2/10½ was the lowest so the bargain was perhaps not an unreasonable one.

The firms were also apparently allowed to sell Cordite elsewhere if they could and Kynochs were soon to supply the Japanese Navy with it. But when the contract was placed they had not as much as a hut or a fiels,let alone the plant for manufacture. The commenced by placing a contract with Nobels to supply the Cordite paste and only did extrusion,drying,and blending themselves,though apparently they soon started making nitroglycerine and guncotton for some part of their output. In 1900 they admitted at the enquiry of the Select Committee on War Office contracts that they were importing guncotton from Germany,and by that time the price was down to 1/10½.

Nobels had built a Cordite factory at Ardeer in 1893/4 and the loss of the sole contract must have been somthing of a blow to them,but they appear to have started exporting at an early date and,after the nitroglycerine explosion at Waltham in May 1894,Nobels and the others came to the assistance of the Government to produce between that date and June 1898,1000 more tons of Cordite than they would otherwise have done,but it was not until January 1899 that Nobels received another order for Cordite from the British Government,and it is hardly surprising to see that in 1900 they were not very enthusiastic when the Government started to press for greatly increased output and in their reply stated that they would want earl notice of requirements as they had to accept orders from Foreign Governments who were willing to pay higher prices. They would,however,if it were made worthwhile,decline such business and restrict their manufacture largely to the requirements of the British Navy and Army.

Cordite.

Abel and Dewar patented their invention of Cordite,,British Patents 5,614 and 11,664 of 1889. This is not the place to go into the involved story of the repercussions,but there were several patents which claimed to anticipate them; Nobel,s Ballistite patent,one by Engel,one by Maxim and lastly one (B.P. 13,308/1888) by Mr.A.Anderson of the Royal Laboratory,Woolwich,and Mr.I.M.T. Anderson of the New Explosives Co.,Ltd.,Stowmarket. The last seems to have been particularly annoying to Abel and Dewar. To quote from their report....."This patent was taken out in November 1888 by special permission of the War Office,upon the recommendation of the late Director General of Ordnance Factories (Dr.W.Anderson) and without any conditions being imposed,for the production of a smokeless powder from gun-cotton gelatinized by means of a solvent. The complete specification of this patent was lodged some time after the Committee had been engaged in experiments in the Arsenal on the production of Cordite,the nature of which could not but become known to Mr.Anderson in his official capacity in the Department where part of the Committee's work was carried on and it included a claim which was not indicated in the provisional specification,namely that of employing explosives generally in the form of threads,strips,cylinders and tubes produced by squirting materials through holes or slits in metal or other plates". Such a serious view of the possibilities of this specification was taken that the Cordite Patent was kept secret lest possible proceeding by the Anersons might have led to the disclosure of details of manufacture not enlarged upon in the specification

Opposition came,however,not from any of the surprisingly numerous Andersons,but from Alfred Nobel,who claimed that the Cordite Patents infringed his Ballistite patent (B.P.1471/1888) and that,in evidence he had given Abel's Committee,he had revealed manufacturing details of Ballistite that had been of great service to the Committee in evolving the manufacture of Cordite,but there seems to be no evidence that what he told them was of any real value to them. Although the War Office offered Nobel a joint interest in the discoveries of both sides,negotiations came to an end and the case eventually came before the Courts in the form of a friendly action. Nobel lost the case and Mr.Justice Romer said in his judgement that Abel and Dewar had solved the problem Nobel had left unsolved,that of making a good powder of insoluble nitrocellulose and nitroglycerine. It would be an unwarrantable extension of Nobel' patent to hold that it covered the use of guncotton when the patentee had expressly limited himself to the use of soluble nitrocellulose.

At this period of his life Nobel was involved in a series of misfortunes. Both his mother and his elder brother died,his own health,was bad,political and economic difficulties had assailed his French company and his neglected mistress was having a child by an Austrian Officer. Schuck and Sohlmann quote the judgement in the case in full and there seems no doubt that it was a just one,but Nobel bitterly resented it and carried the case to the Appeal Court and the House of Lords,thereby incurring costs to the tune of £28,000. Still indignant,he started to write a satirical play called "The Patent Baxillus",but he seems to have had little grounds for complaint as his company received orders from the Government for making cordite and were also allowed to make it for various foreign governments including the Japanese.

CORDITE.

Although one of the factors that had decided the Explosive Committee to standardize on the use of Mineral Jelly in cordite,was the lessening erosion and corrosion in guns,it was found in the Boer War that this was still serious and in 1901 Cordite M.D. was introduced to effect a further improvement. In this the proportions of guncotton and cordite were practically reversed,thus making the composition:-

Guncotton	65
Nitroglycerine	30
Mineral Jelly	5

This considerably reduced the temerature of explosion with greatly improved results as far as the expectation of life of guns was concerned,and M.D. remained the standard cordite until 1915 when circumstances compelled a further change.

When M.D. was introduced the output of the factory was considerably increased by increasing the guncotton plant and acquiring fresh land for the erection of cordite stoves to the south of Quinton Hill. These extensions were completed by 1906.

It was not very long after the introduction of Cordite M.D. that the first serious accident in cordite manufacture at R.G.P.F. took place. On 15th December,1902 an incorporating machine blew up,killing three men. No entirely satisfactory explanation was forthcoming,but the occurrence led to a further tightening up of regulations particularly as regards inspection and mixing of the paste and ingredients,and nothing of the sort ever took place again.

In 1901-2,two of the very remarkable team of Chemists then employed at the Factory under the inspiring leadership of Sir Frederick Nathan,Dr.R.Robertson and Mr.W.Rintoul,commenced experimenting on the recovery of acetone from the cordite stoves by the bisulphite process. It was not until 1906 that a plant on these lines was completed and put into operation. It proved very successful,saving about 50% of the acetone used and was in operation until 1918.

At the outbreak of the 1914-1918 War the output of cordite was 26 tons a week. This was stepped up immediately to 57 tons and by March 1915 had reached 64 tons. This was all done without any new plant,but in the Autumn of 1914 orders had been received to increase production of rifle cordite to 20 tons a week and cannon cordite to 120. This was completed within a year of the outbreak of the War. At this point,in August 1915,the factory was transferred to the Ministry of Munitions and by various extensions the capacity was incresed to 200 tons of Cordite M.D. About the end of 1916 the shortage of acetone compelled the new Cordite R.D.B. to be used for all large sizes. R.D.B. was a wartime development and consisted of 52% Collodion Cotton,42% Nitroglycerine and 6% Mineral Jelly,ether-alcohol being used as a solvent.

The years between the wars were years of depression at the R.G.P.F. but the small staff remaining there did a great deal of valuable work with the very limited means at their disposal. Not only was the plant maintained in good order but much investigational work was carried out. Solventless cordite and flashless cordite owe much to the early plant work that was carried out by the staff in those critical years,but perhaps the most outstanding feature was the development of "Cordite W". Between 1928 and 1932 guncotton was made with a mixture of 50% linters and 50% cotton waste. In 1932 it was found that cordite made from it gave corrosion spots on climatic trial which definitely shortened the life of the cordite. It was decided to revert to the use of cotton waste only but possible dangers had been shown up. The corrosion usually centred round foreign bodies and a new type of straining arrangement was designed which led to greater freedom from foreign matter in the cordite. It was also felt that a more efficient stabilizer than mineral jelly was required and as a result of experiments carried out by H.A.Phillips and P.G.Kmapman it was decided to use 6% of "carbamite" (diphenyl diethyl urea). This cordite was first produced in 1933,and proved very much superior to its predecessors as regards stability.

At the same time other qualities were being called for in cordite. Freedom from flash and smoke became of increasing importance as also did more rapid methods of manufacture which did not demand extended periods of stoving.

The first of these problems was solved by the use of "picrite" (nitroguanidine) which was suggested by the Research Department at Woolwich. A cordite containing 55% of this material was made at Waltham in 1928. Various compositions of this type were tried and eventually wartime manufacture settled down to compositions containing approximately:

55% Picrite
20% Guncotton.
20% Nitroglycerine
4.7% Carbamite.
0.3% Cryolite.

Such compositions are stable enough to allow the use of wood and straw cellulose in place of cotton and give almost complete freedom from flash and smoke.

The "solventless" process,by eliminating the use of volatile solvents such as acetone,does away with the necessity of stoving and the large ground area and many buildings required for it. The time occupied in drying cordite,particularly the large sizes,is very considerable and when production is urgent this can be a serious drawback. Compositions made in this way normally contain nitrocellulose (12.2% N2) and its gelatinization by nitroglycerine is enhanced by the presence of carbamite. A further advantage of the solventless process is the much greater safety resulting from the fact that a wet slurry of guncotton is mixed with nitroglycerine and thus the drying of guncotton and dry mixing are completely avoided.

In addition to its duties as a producing factory Waltham continued to do a great deal of experimental and pioneering work on various types of cordite right up to the time it closed in 1943.

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THE YEARS BETWEEN THE WARS.

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Small-arms repair work was exhausted by 1922 and it was ordered in April that the personnel at the RSAF was to be reduced by 600 to 1,350. The pre-war strength had been 1,800. At the RGF numbers were to be halved to a mere 250,compared with between 800 to 900 before the war. The Waltham Abbey Traders Association asked that the cuts be deferred,and organized a meeting,calling together representatives of the unions,the local councils and the Board of guardians. The Gazette spoke of a threatened calamity in eastern Enfield and complaned that the increase in local unemployment,made worse by the continued discharges at the RSAF and the RGF,was beginning to affect trade. Members of the Geddes Committee in May 1922 recommended the scrapping of the RGF,pointing out that the country had a ten-year supply of explosives. The consternation aroused locally by this proposal gave rise to a question in parliament from the Enfield member T.F.Hesketh. The Waltham Abbey factory remained open,but the great munitions factory at Gretna,which had cost £9 million to build during the war,was sold off piecemeal in January 1924; at this time there was scarcely any work going on at Waltham Abbey. The sacking of men continued and,by the end of May 1922, 530 men had left the RSAF while the RGF had been reduced to a nucleus of 230; only those most experienced in the manufacture of cordite were retained,these therefore included very few ex-servicemen. Most of the 200 factories built by the Ministry of Munitions during the First World War had by this time been closed. Private munitions factories continued to be wound up,Nobel's cartridge factory at Waltham Abbey closed in February 1925 with a loss of 1,500 jobs. The work was transferred to Birmingham.

THE MANUFACTURE OF CORDITE

AT
THE ROYAL GUN POWDER FACTORY

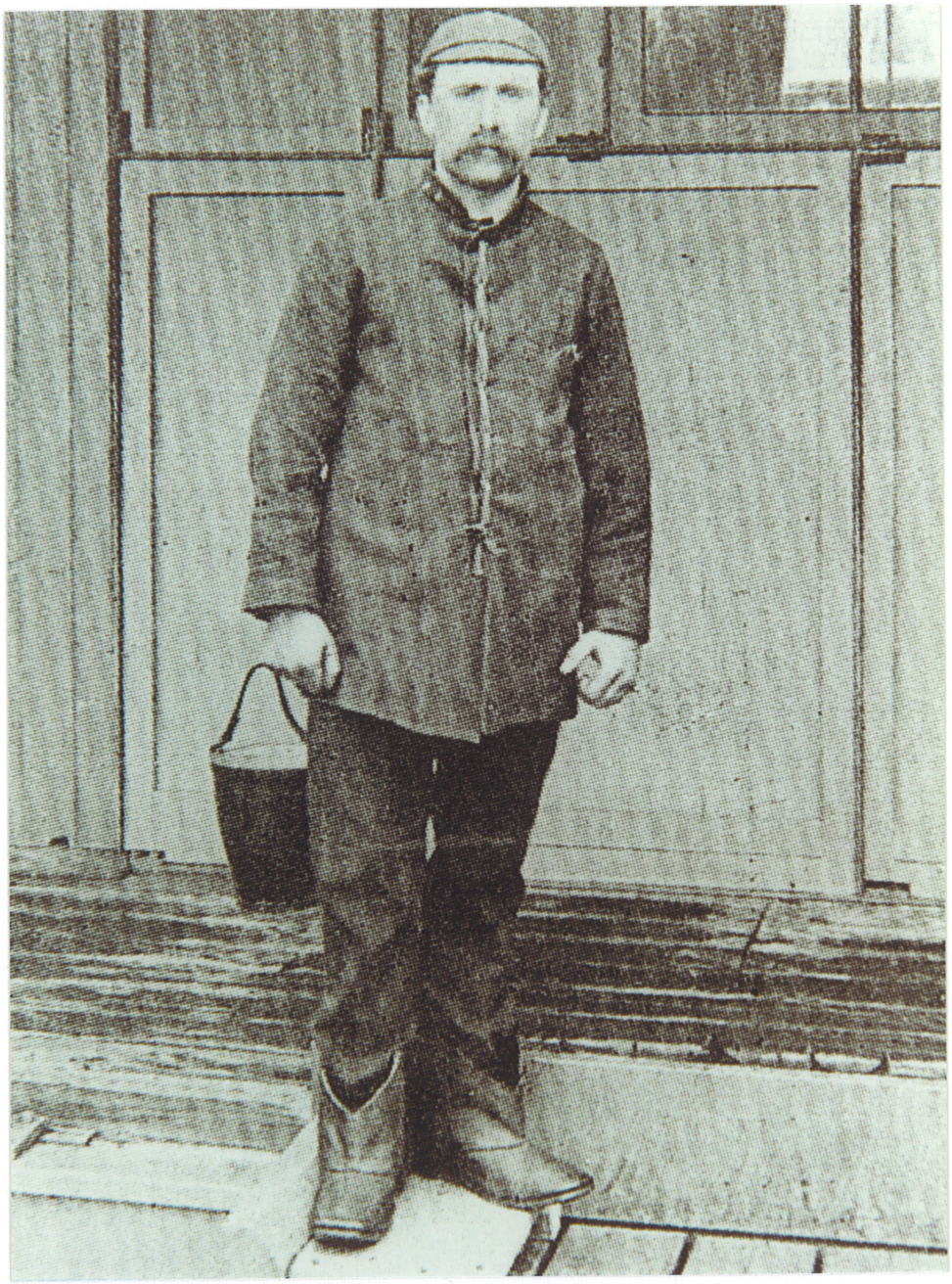
1895.

THE ROYAL GUN POWDER FACTORY.

All workers at the explosive factory were subject to the most stringent conditions which required daily physical searches for metal items or matches which might have caused a spark to ignite the contents of a workplace.

THE ROYAL GUN POWDER FACTORY.

Special clothing was worn by the workers without buttons and pull-on boots without nails were the order of the day.



THE ROYAL GUN POWDER FACTORY.

CORDITE.

A brown,cord-like substance,having as its base nitro-glycerine and gun cotton,forced into a mixture by the addition of acetone it was drawn out in a variety of sizes and shapes.

In the photograph,a number of these can be seen,from .01-inch in diameter,for use in pistol cartridges,up to the .5-inch rope used for the charge of of the 12-inch breech-loading Naval gun.

All the components for the production of cordite,with the exception of cotton and acetone were manufactured within the factory.

THE ROYAL GUN POWDER FACTORY.

GUN COTTON.

Gun cotton was produced by the action of nitric and sulphuric acid upon cotton and was in its own right,a powerful explosive.

COTTON.

Fine cotton waste from the textile factories of the North was carefully hand picked and shredded to remove foreign bodies before being placed in a vast oven. Here it was revolved on racks which passed constantly up and down through the drying area for twenty minutes in a temperature of 180-degrees.

THE ROYAL GUN POWDER FACTORY.

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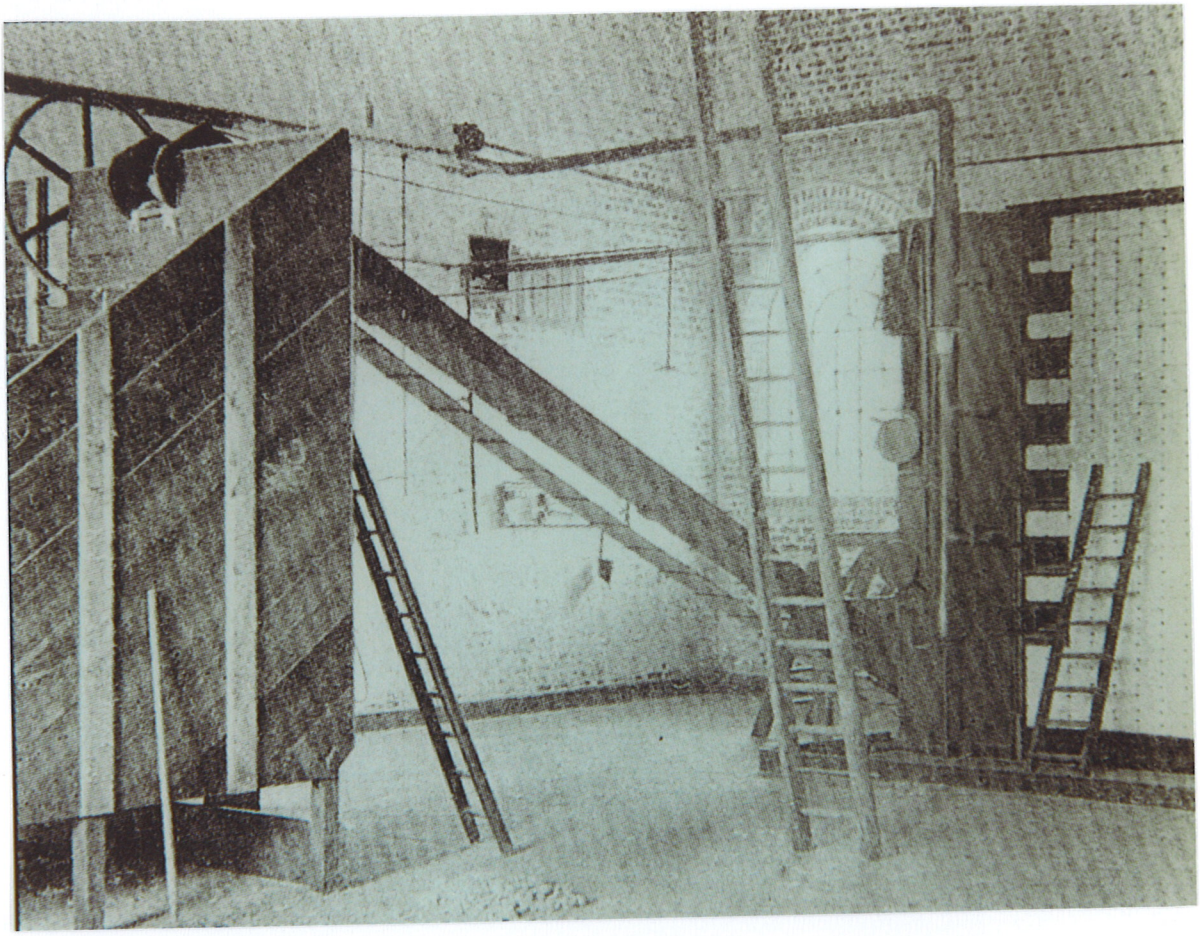
Here it was revolved on racks which passed constantly up and down through the drying area for twenty minutes in a temperature of 180 degrees.



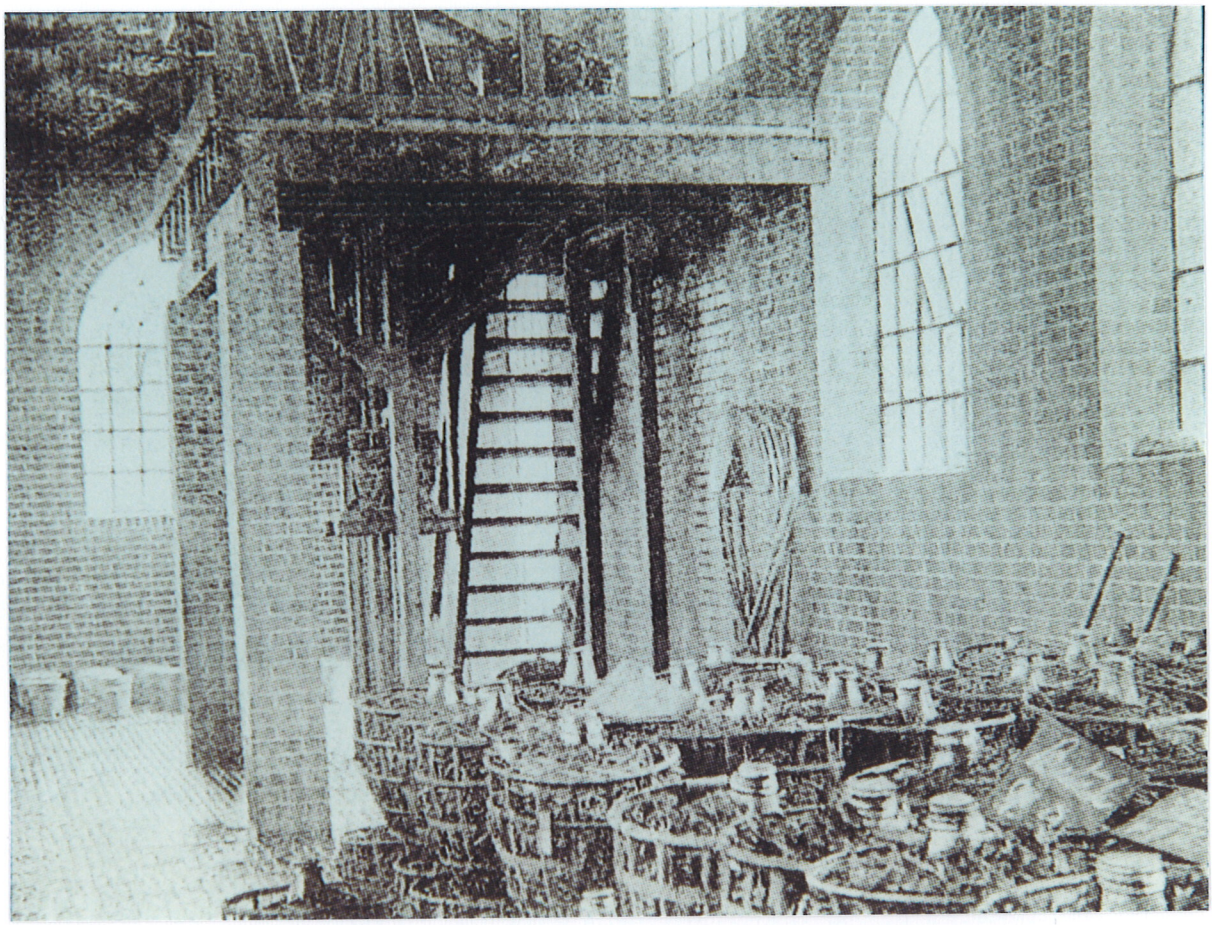
THE ROYAL GUN POWDER FACTORY.

GUNCOTTON.

On leaving the oven,packs weighing just over 1-lb were sent in bins to the nitrating plant where they were allowed to fall into baths of mixed acid.

Gun cotton was produced by the action of nitric and sulphuric acids upon cotton and was,in its own right a powerful explosive.

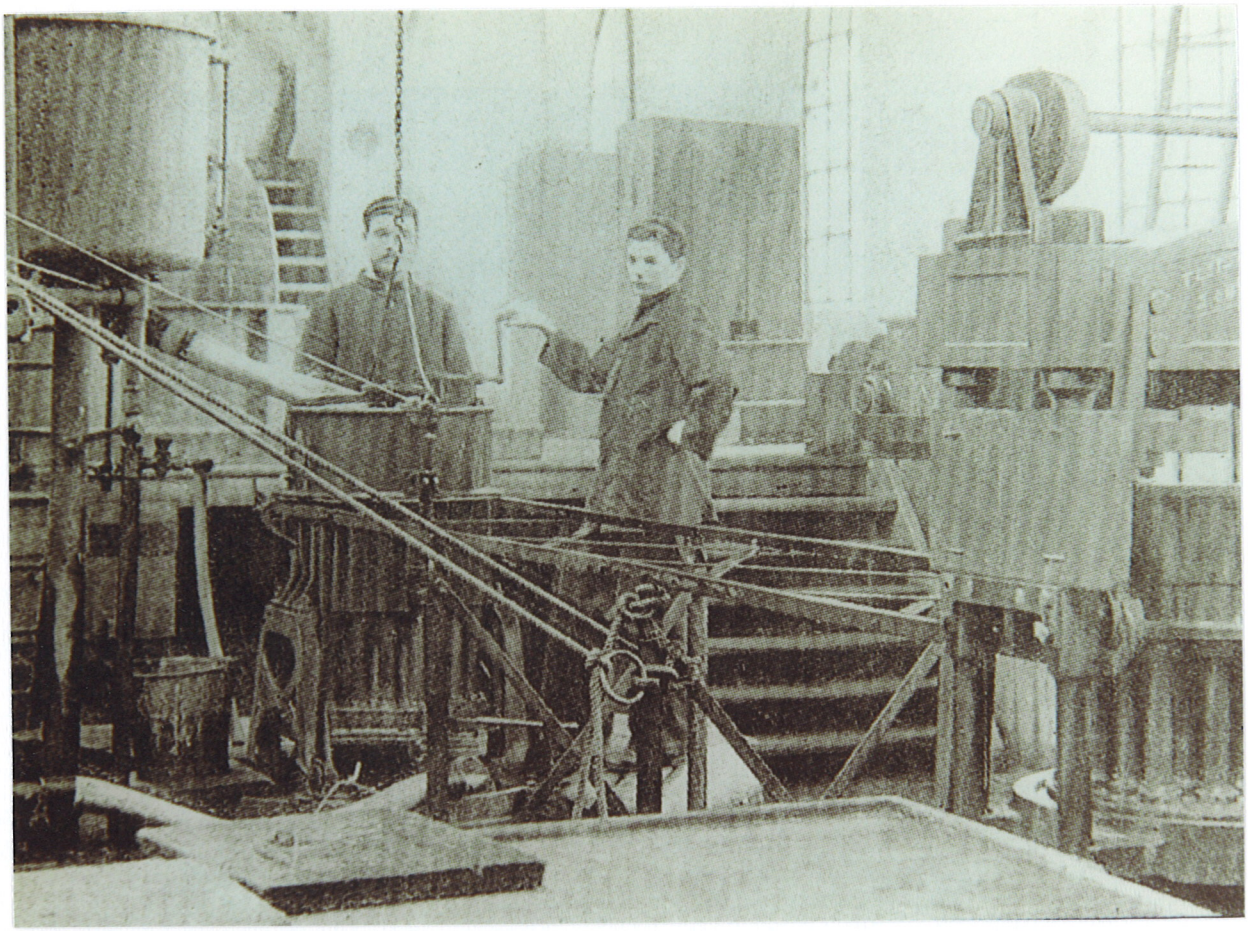
To make it,carboys of acid were positioned near to the mixing boilers. Hoisted some 10-feet above ground level,the contents were tipped through lead conduit,the nitric followed by the sulphuric,both flowing into cylindrical boilers. A jet of compressed air was used to ensure complete and even mixing of the two substances which was then drawn off into baths to receive the raw cotton.



THE ROYAL GUN POWDER FACTORY.

GUNCOTTON.

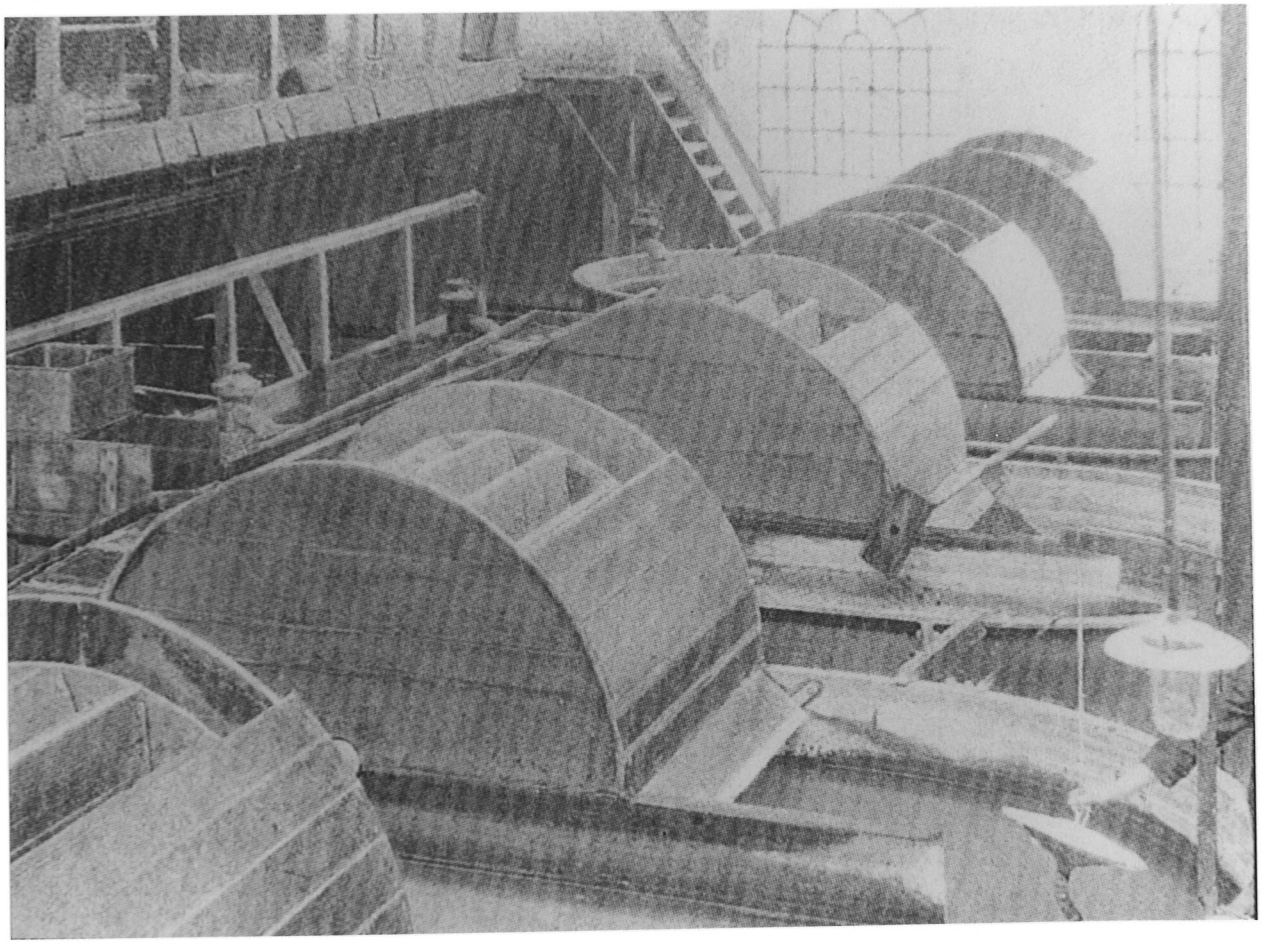
Each pack of dry cotton would soak up some 14-lbs of acid during a five minute immersion,after which the excess was removed in wringers. In this area the fumes given off by the acids were extremely corrosive- workmen being issued with free worn-out army clothing which soon fell to pieces in these processes.



THE ROYAL GUN POWDER FACTORY.

GUNCOTTON.

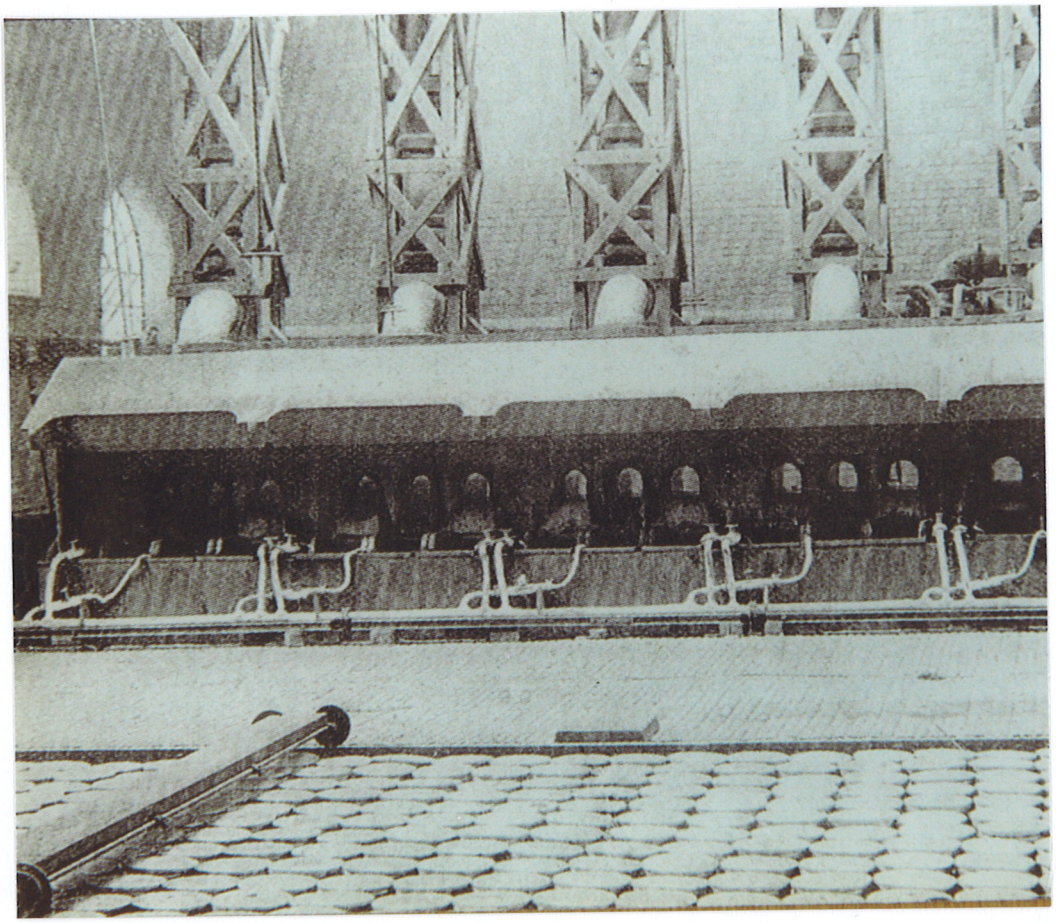
The cotton was then washed throroughly to remove all traces of acid and later boiled in huge vats for a period of 72 hours. After wringing out,the material was placed in bags and taken to the pulping room where it was minced and again thoroughly washed.



THE ROYAL GUN POWDER FACTORY.

GUNCOTTON.

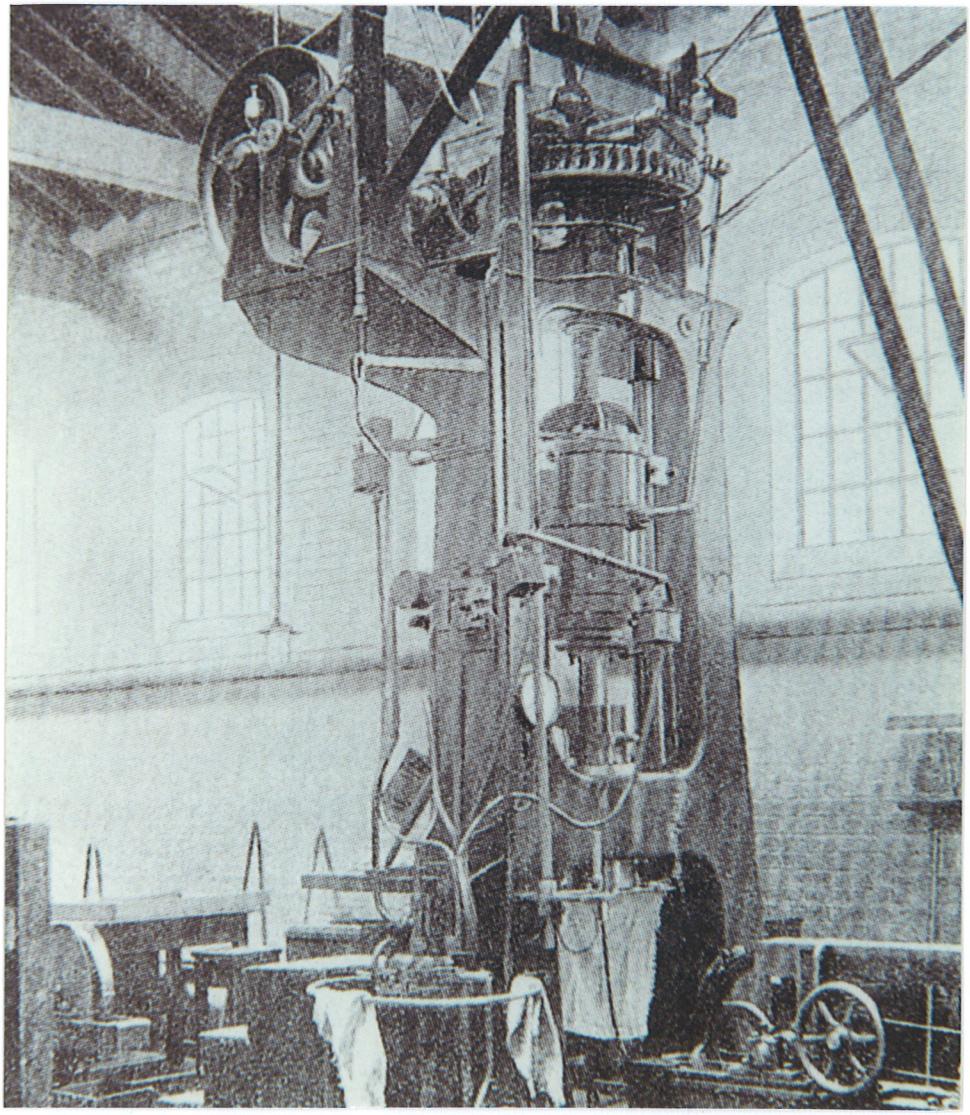
The excess water drawn off,the remaining cotton was transferred to a press and formed into discs.



THE ROYAL GUN POWDER FACTORY.

GUNCOTTON.

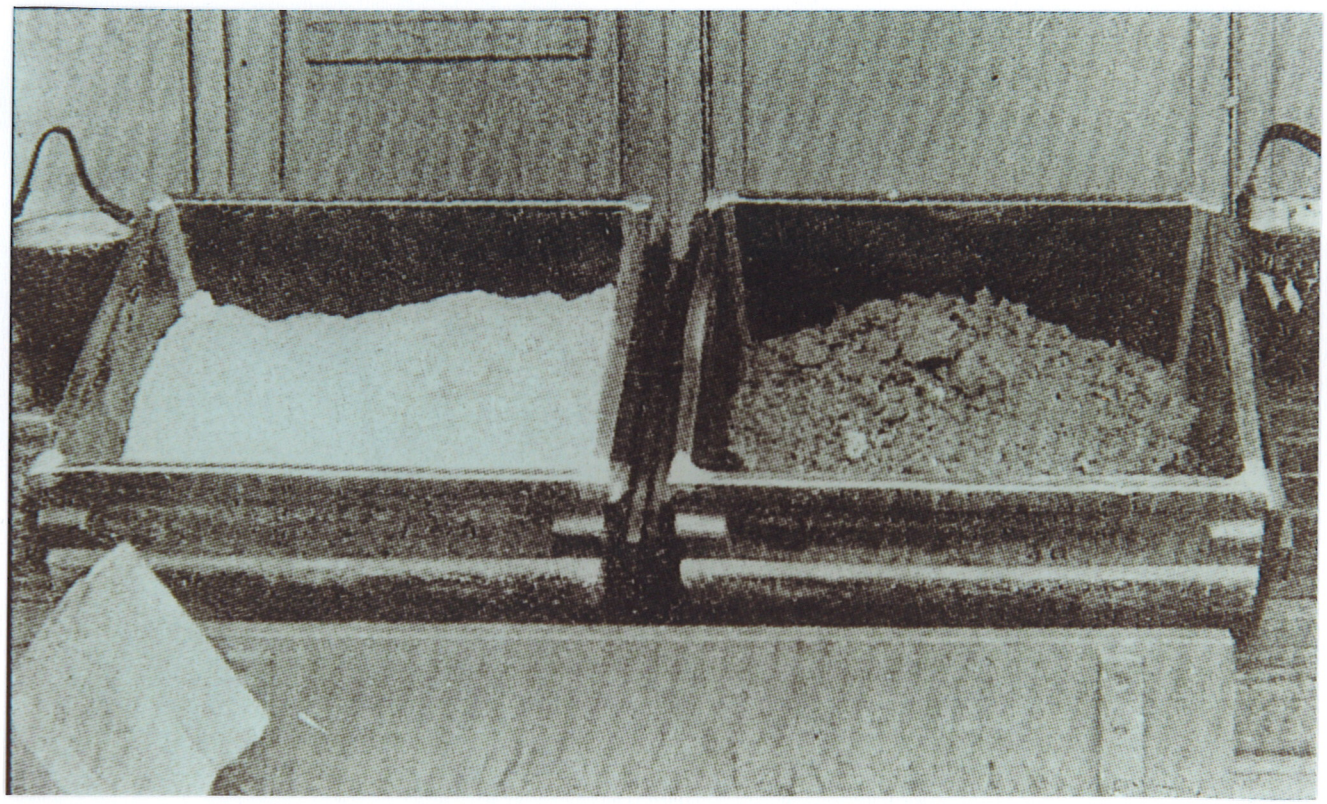
The cotton still having too much water content,these discs then passed through another press where they were subjected to pressure of 7-tons per square inch,reducing their size by half and water content to 14%.



THE ROYAL GUN POWDER FACTORY.

THE INCORPORATING MACHINE.

The correct quantities of dry gun cotton and nitroglycerine are first blended to some extent together by hand,and are then introduced into an incorporating machine.which consists of a covered metal box,in which a double worm revolves,giving a kneeding motion to the material in the mixer,together with the requisite quantity of acetone.
For the manufacture of Mk 1 about 23% and for MD about 40% is required.
After working for about three and a half hours,when most of the gun cotton has been gelatinized and blended with the nitroglycerine,the mineral jelly is added,and the working continued for an equal time.
The resulting mass,which has a dough-like consistency,is pressed through a die and formed into cords.



THE ROYAL GUN POWDER FACTORY.

The nitro-glycerine part of Cordite was obtained by the action of nitric and sulphuric acid on glycerine,resulting in a heavy,oily fluid,strawlike in colour. Nitro-glycerine is exceedingly sensitive to concussion. For ease of handling and to limit possible damage by explosion,relatively small quantities were dealt with in each of the factory buildings. 44-lbs of NG was mixed with 28-lbs of gun cotton,the resulting compound resembling damp china clay.

This was achieved by adding one substance to the other in a machine like a baker's dough mixer,containing a number of spiral knives which cut and mixed the material for three and a half hours.
At this point 15-lbs of acetone and 4-lbs of jelly were added and a further three hours of mixing took place.

THE ROYAL GUNPOWDER FACTORY.

CORDITE.

The component parts of cordite,are as follows: nitro-glycerine 57%,gun-cotton 38% and 5% of mineral jelly.

The mineral jelly is added three and a half hours after the dough or paste has been in the incorporation machine. Acetone is also added in quantities of 15-lb 10-oz. to every charge of 75-lb.

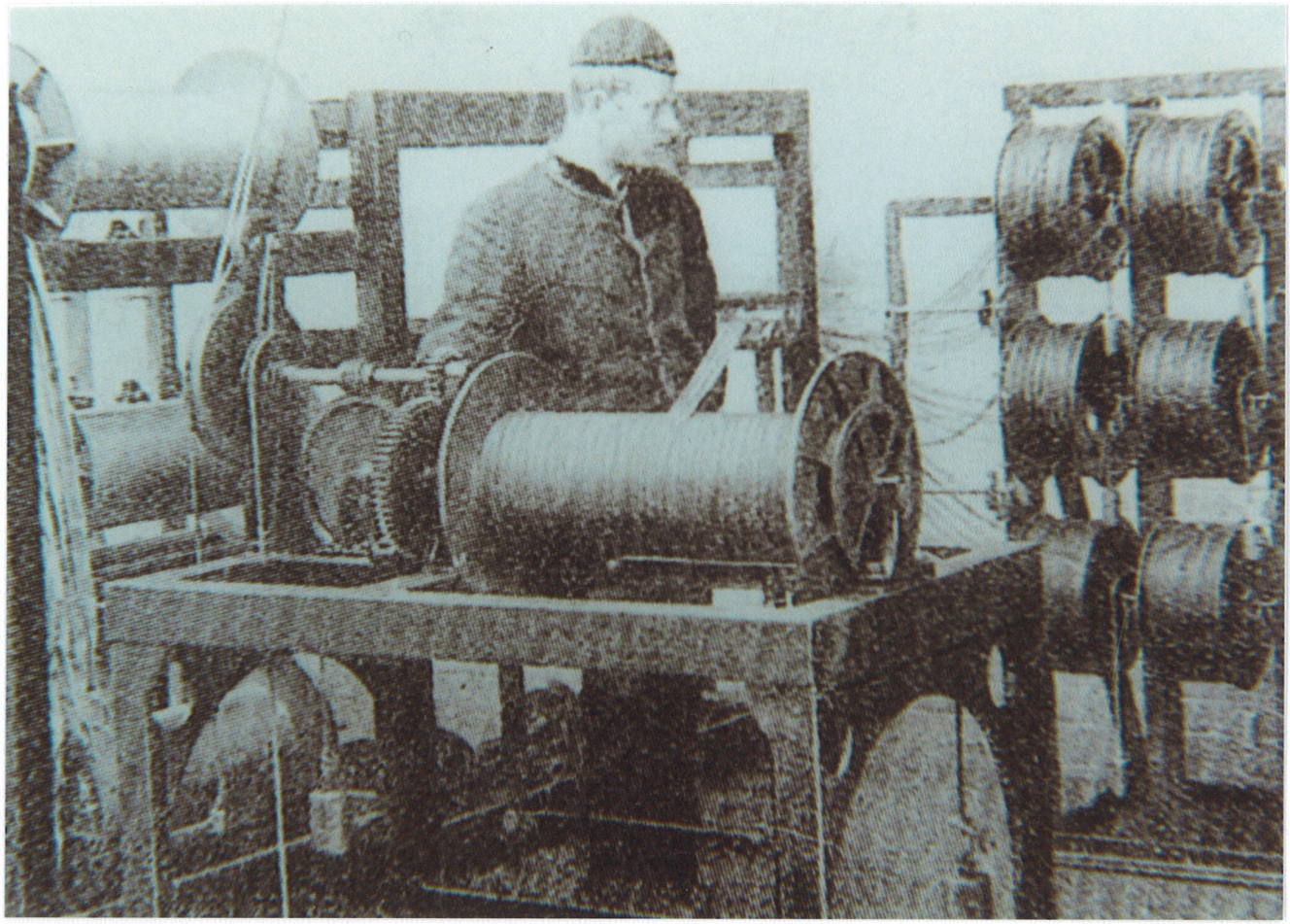
One of the final operations takes place in the moulding house. There one and a quarter pounds of cordite paste is pressed and moulded; the mould and its contents are then placed in another machine,and out comes 2,000-feet of what looks like brown twine,with a diameter of .0375-in. This is finished cordite,and it is wound upon a reel.

THE ROYAL GUNPOWDER FACTORY.

"TEN-STRANDING"

10 reels of cordite,just as they come from the machine,are fixed in a rack (the lad is shown in the picture about to fix this tenth reel) and are wound simultaneously on to a single reel the object being to secure uniformity of explosiveness. Furthermore,six "ten-stranded" reels are afterwards wound upon one,and the "sixty-stranded" reel is then ready to be sent away.

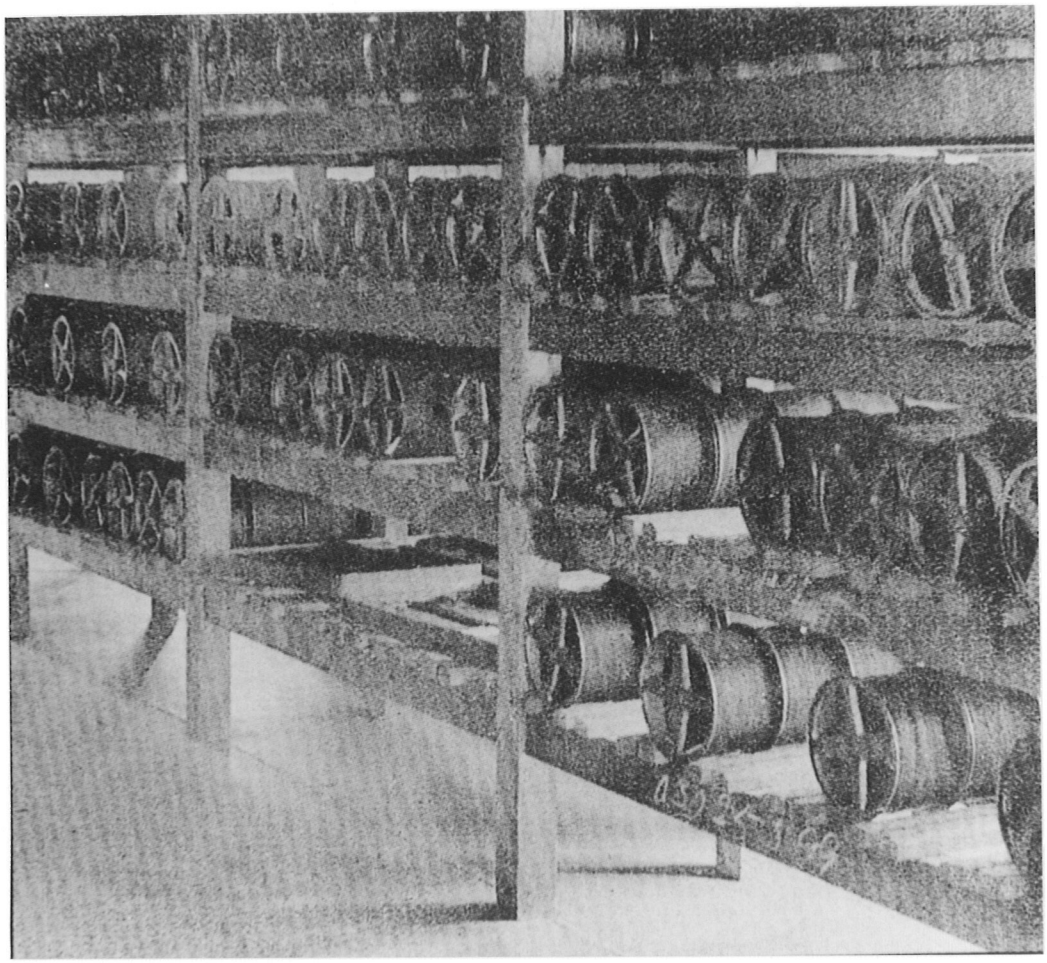
Minute details as to whom hands it has passed through accompany each reel; and the end of the thread is secured with a band of webbing.



THE ROYAL GUN POWDER FACTORY.

CORDITE DRYING ROOM.

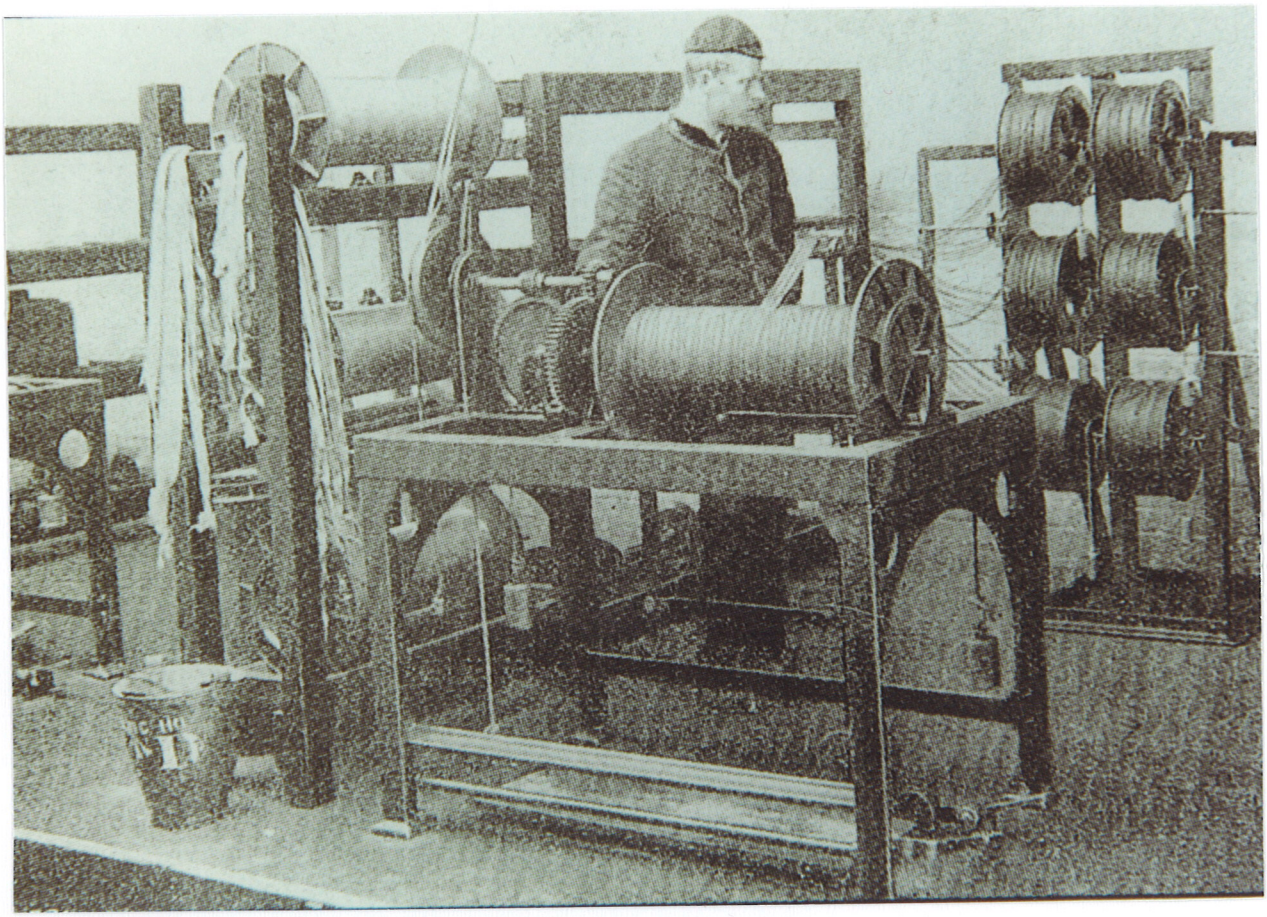
In order to remove excess acetone,the cordite was removed to a drying room and exposed to a heat of up to 100 degrees.



THE ROYAL GUN POWDER FACTORY.

Half-inch cordite required drying for 15 days,pistol and rifle cordite for 2 days.

On those drums destined for use in rifle and pistol cartridges,10 reels of the dried cordite were placed on a machine and ten strands,one from each reel were twisted and blended onto 1 new reel. 6 of the new reels were again blended,as in the illustration,into one rope,consisting of 60 separate cords.
When cut to one and quarter inch lengths,these charges formed the 30 grains of propellant for the .303-inch ball cartridge.
No cutting was carried out at Waltham,this was carried out at the cartridge loading factories.

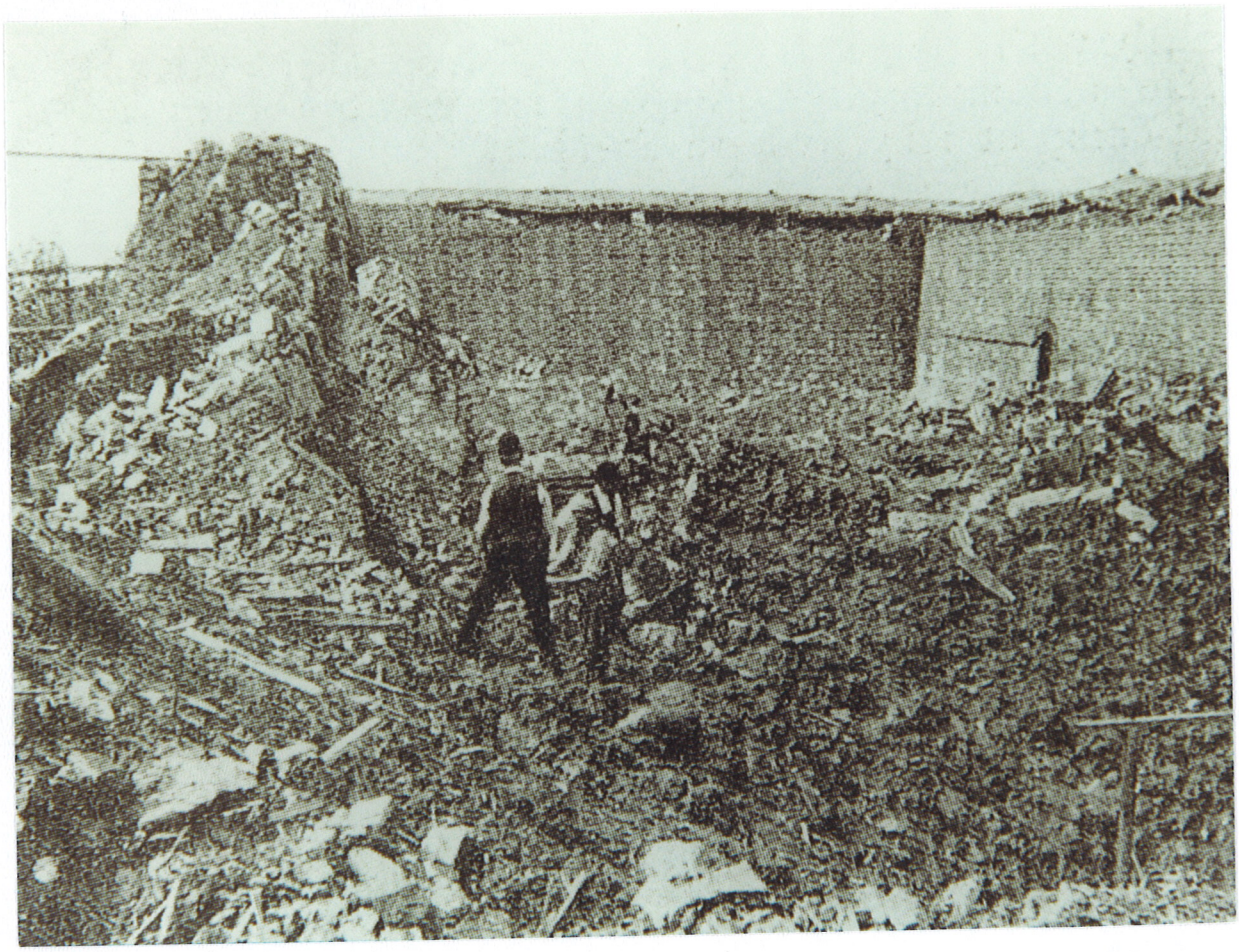


THE ROYAL GUN POWDER FACTORY.

Results of explosions at the factory.

THE ROYAL GUN POWDER FACTORY.

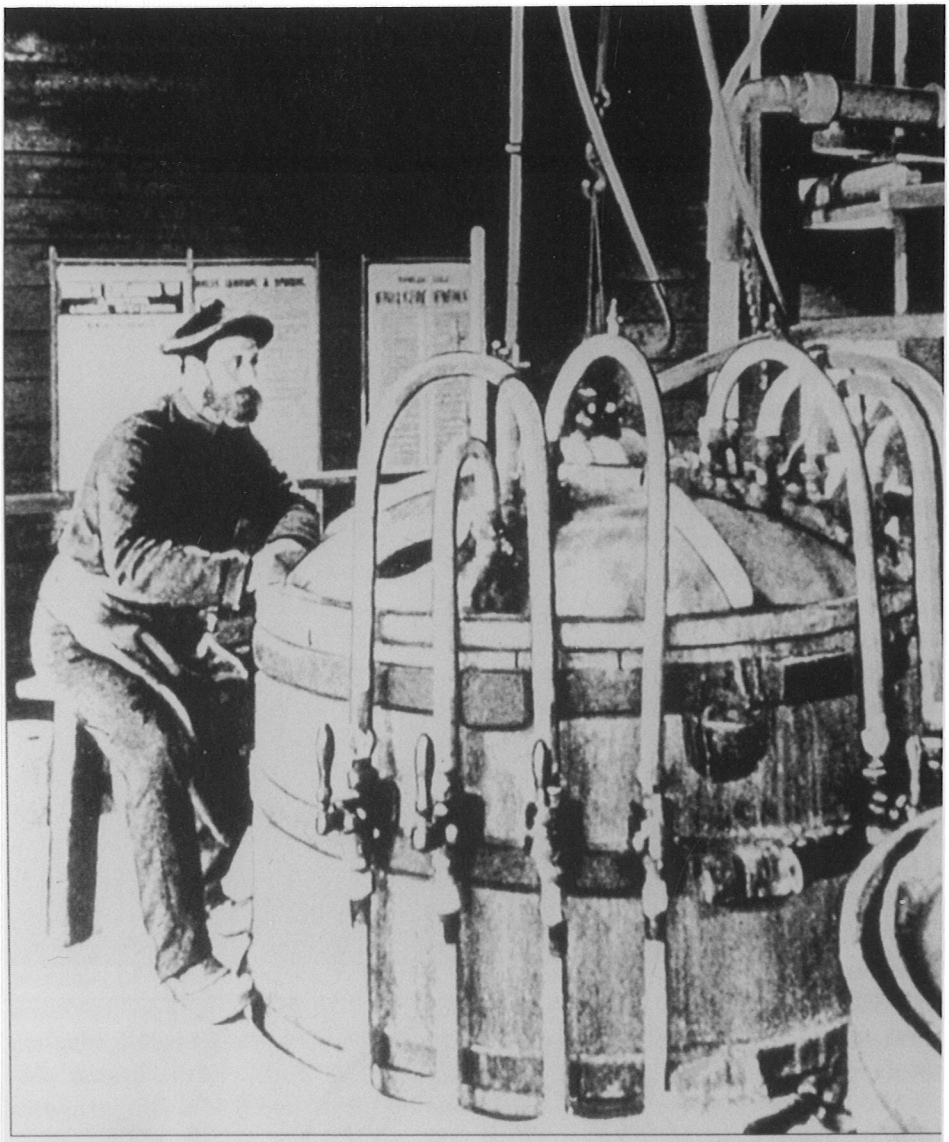
Results of explosions at the factory.



THE ROYAL GUN POWDER FACTORY
"NG STOOL"

The old way of making nitroglycerine.
Batch nitration consisted of spraying glycerol into a large vat of nitrating acid while stirring and cooling. the temperature has to be closely monitored and,if it rose above a predetermined level,the batch was 'drowned' by dunping into a large tank of water underneath.

The operator sat on a one-legged stool so that he would not fall asleep and let the mixture overheat.



The old method of making nitroglycerine. The operator sat on a one-legged stool so that he would not fall asleep and let the mixture overheat. (ICI)

THE MANUFACTURE OF CORDITE

AT
THE ROYAL GUN POWDER FACTORY

1899.

THE ROYAL GUN POWDER FACTORY.

GUN COTTON.

The cotton waste is picked carefully,in order that fragments of wood,rope,wire and rag may be removed. The cotton waste is then thrown on to a powerful teasing machine,which rends and tears its fibre; after this it is cut up by another machine,and then it passes on an endless band into a drying-room heated to 180 degrees.

The cotton is then weighed up into lots of 1-1/4-lb.,and each lot is placed in a tin cooling box.

After 24-hours,the lots,or charges,are ready for dipping. each dipping pan contains 220-lbs of mixed acids-three parts of sulphuric and one of nitric acid.

The operator throws the dry cotton into the acid and leaves it there for about five minutes during which time each charge of 1-1/4-lb. will have absorbed 13-1/2-lb of acid.

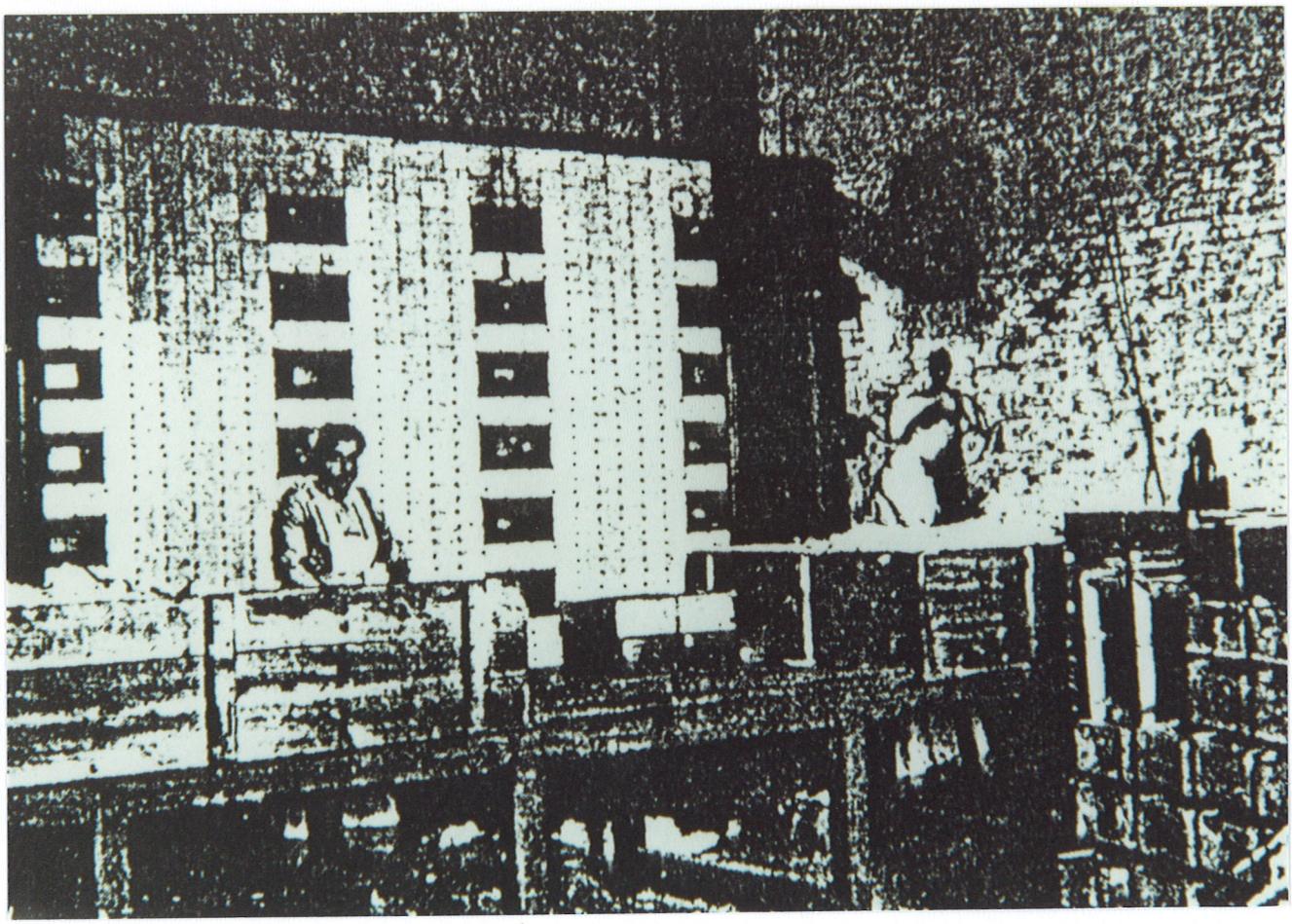
The workman now takes his implements from the cold water in which they are kept immersed,for fear that repeated contact with the acid should corrode them,and proceeds to remove the saturated cotton from the bath or pan,and puts it into a earthenware pot which is then placed in shallow water for some little time.

THE ROYAL GUN POWDER FACTORY.

GUN COTTON.

THE WEIGHING AND DRYING ROOM.

After the cotton waste is cut up by a machine,and passed on an endless band into a drying-room,the cotton is then weighed up into lots of 1-1/4-lb,and each lot is placed in a tin cooling box. After 24-hours,the lots,or charges,are ready for dipping.



THE ROYAL GUN POWDER FACTORY.

GUN COTTON.

DIPPING TANK.

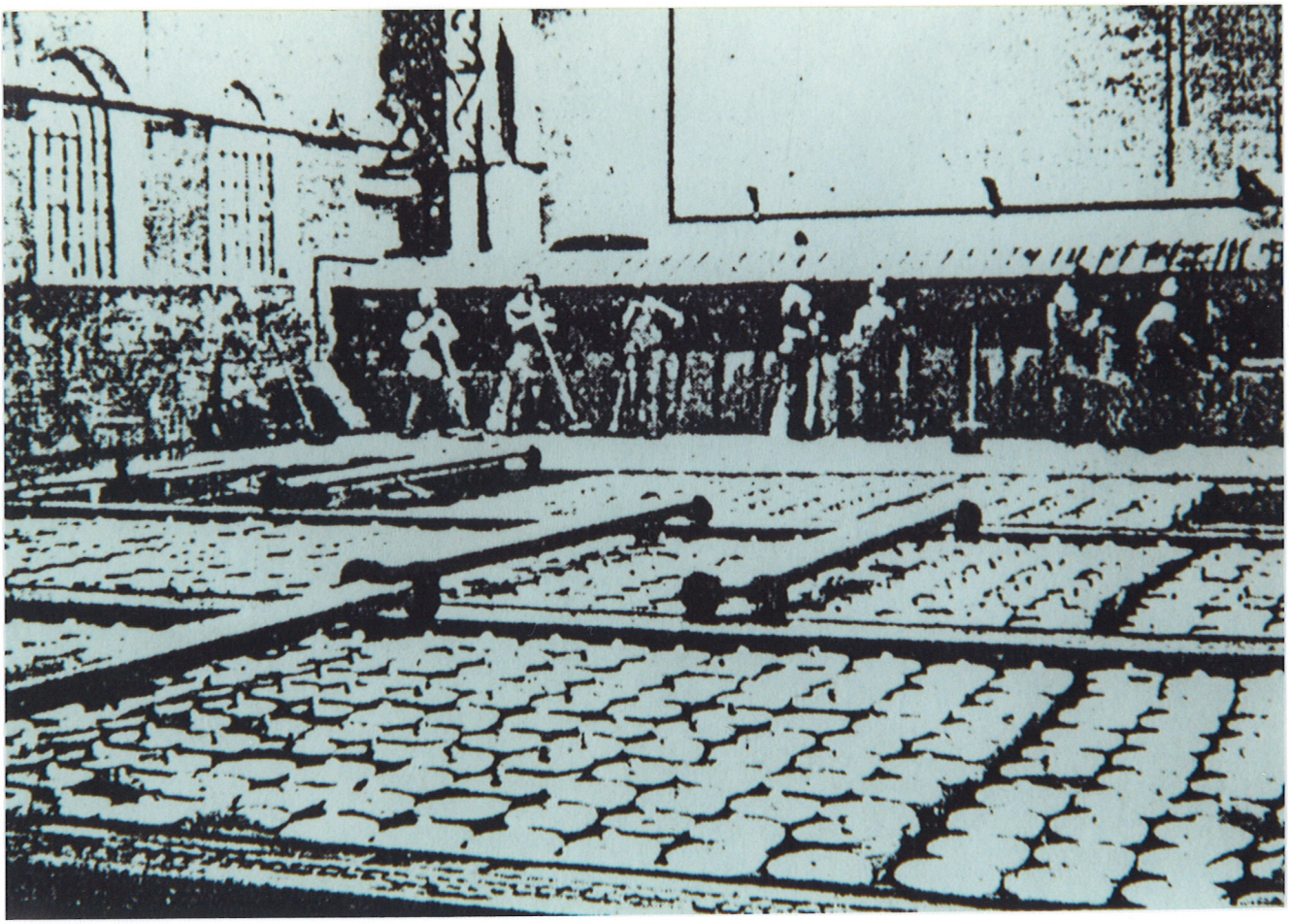
Workman placing cotton saturated with acids into earthenware vessel.

THE ROYAL GUN POWDER FACTORY.

GUN COTTON.

COOLING TANKS.

The earthenware pots full of gun-cotton are placed in here to cool.
Dipping baths are in the background.



THE ROYAL GUN POWDER FACTORY.

GUN COTTON.

From the earthenware vessel the cotton is shot into a centrifugal machine,whirling round at a speed of 1,200 revolutions a minute. In a very short time the cotton is comparatively dry; and the waste acid removed by the machine is allowed for by a contractor.

The next operation is the washing of the cotton in a wooden tank full of water,which is agitated by a revolving bladed wheel. When the foreman thinks this washing has gone on long enough,he tastes the cotton,and if no flavour of acid remains,it is taken out by a man who wades in in big boots. The water is wrung out and the cotton is then removed to the vat-house.

THE ROYAL GUN POWDER FACTORY.

GUN COTTON.

THE BOILING VATS.

The water is rung out of the cotton and then removed to the vat house.
It is boiled in monstrous vats for four or five days. Each vat holds about 18-cwt of cotton.

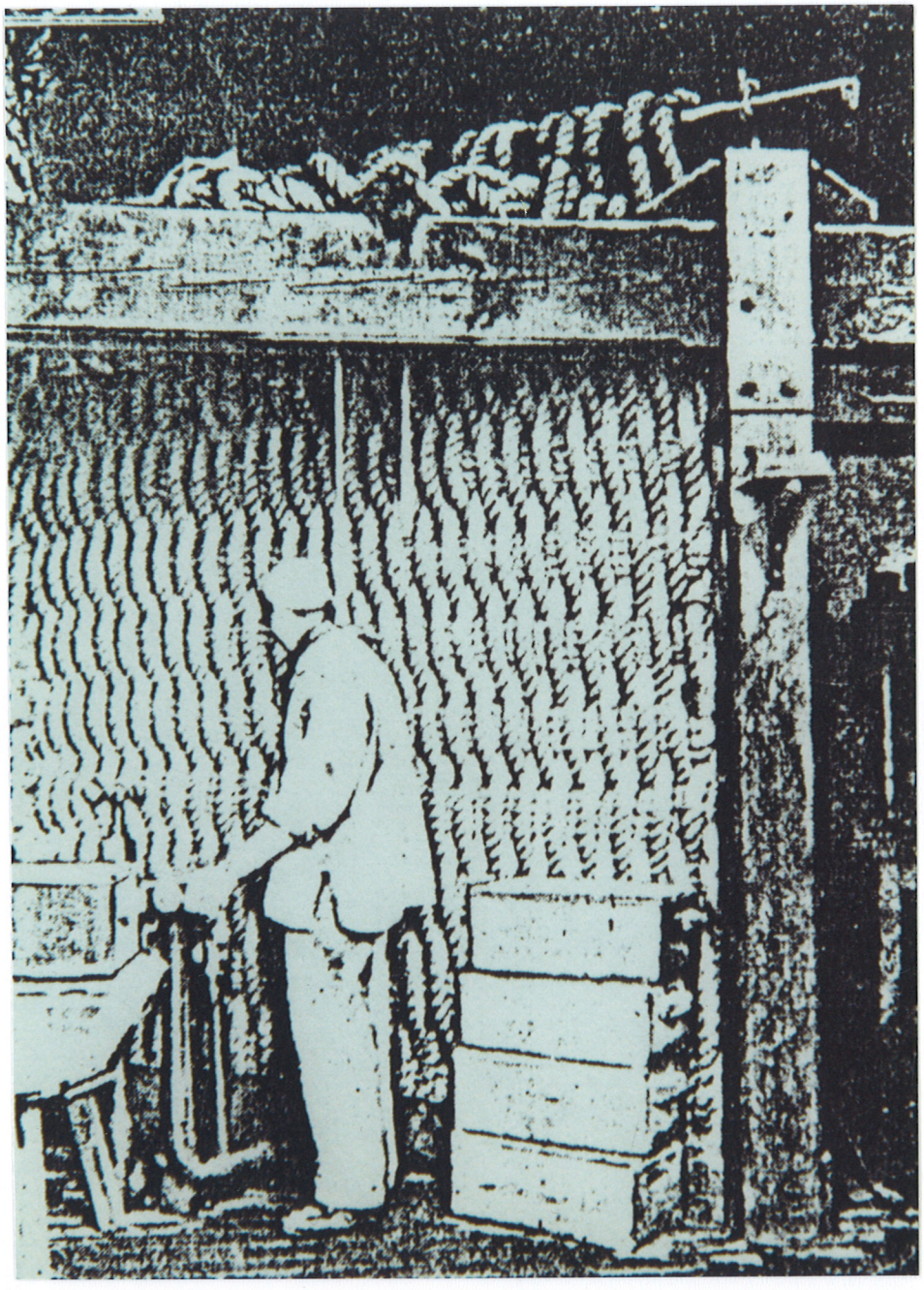
From the vats the long-suffering cotton comes out like wet oatmeal; then comes more churning and washing,until at length the moulding process is reached,and the cotton is pressed into big cubes of 2-1/2-lb. These cubes are veritable gun-cotton,and when pressed flat and furnished with a dry cylinder and a fulminate of mercury detonator,they are quite ready for torpedo work.

THE ROYAL GUN POWDER FACTORY.

GUN COTTON.

THE GUN COTTON PRESS HOUSE.

The press house is furnished with what is called a protective rope mantelet,or wall of rope,such as is used in fortifications.



THE ROYAL GUN POWDER FACTORY.

KNEADING HOUSE.

The dry gun-cotton,is taken to the nitro-glycerine house in boxes,and it is there saturated with nitro-glycerine,an almost colourless liquid.

The saturated gun-cotton is now called "cordite dough",and it is taken direct to the kneading house.

The men,as can be seen in the picture wear respirators as they bend over the sticky mass,which gives forth nauseous and deadly fumes. When thoroughly kneaded,the dough is sent to the incorporating-house and placed in drums,which have slow revolving screw blades; this mixing process goes on for seven hours.

THE ROYAL GUN POWDER FACTORY.

PROOF RANGE.

"The testing armoury and proof range are at Quinton Hill,but are within the boundaries of the factory. It is most interesting to behold the array of field artillery and naval quick-firers,all clean and bright and with a business-like appearance. On the occasion of our visit,a 6-inch quick-firing gun was mounted in a sort of cave formed of earth and masonry so as to minimize danger in case of the weapon bursting. Remember,the powder is being tested,and no one knows what may happen. When the gun is ready to be fired,every person leaves the vicinity; the electric switch is moved in the instrument room some distance away,and with a terrific roar,accentuated by the confined space,the gun hurls its projectile 17-ft. into the sand of the distant butt. A blank cartridge,by the way,is first fired so as to warm the gun. Standing here,listening to the roar of the Waltham quick-firers,which is answered by the sharp,crackling fusillade from the Maxims at the Enfield Small Arms Factory close by,it is not difficult to imagine that a modern battle is in progress".

THE ROYAL GUN POWDER FACTORY.

THE SETTLING POND.

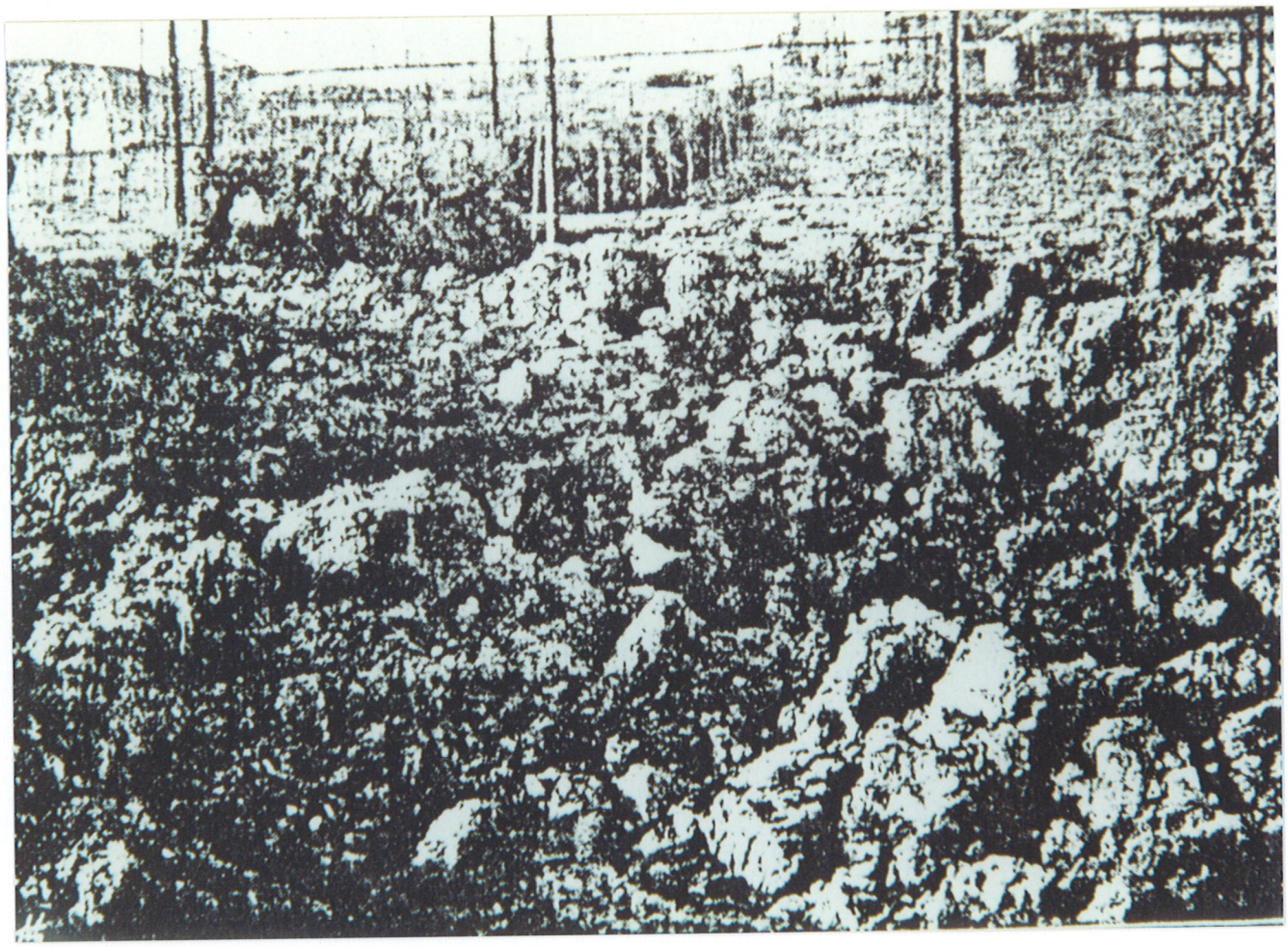
Into this pond all water from the various nitro-glycerine houses is carefully drained,since such water contains a certain quantity of nitro-glycerine.

Every Saturday this pool is blown up by means of a dynamite cartridge to get rid of the explosive matter it contains.

THE ROYAL GUN POWDER FACTORY.

THE SETTLING POND.

After an explosion in the nitro-glycerine house on the 7th of may,1894 when four men were killed,such a large quantity of nitro-glycerine had accumulated in the pond,that when it came to be blown up,the explosion blew holes 20-feet deep around the pond.



CORDITE.

England had firmly settled on Cordite and the early patterns of the .303-inch rifle cartridge were designed for,and used,a charge of 31½- grains of Cordite Mk.1 extruded as solid cords or rods and cut to an overall length to suit the inside dimensions of the cartridge case- about 60 such strands making one charge. The official designation of this propellant was 'Cordite Nk1,size 3-3/4; which signified that the material was Cordite Mk1 and that it had been extruded as a solid cord through a die of .0375-inch diameter. The final size of the cord was somewhat smaller due to shrinkage when the solvent was later removed during the final drying process.

The chemical composition of this material was 58% NG,37% NC and 5% Mineral Jelly which proportions had been designed to give a propellant in which the oxygen and the fuel had been fully balanced,ie,one with the highest possible energy content. This had the desired effect of keeping the required charge weights very low,but it also had the undesirable side effect of making the flame temperature very high,typically 2800 degrees C,which proved to be rather more than the barrel steels of the day could comfortably withstand. Erosion of the throat and at the commencement of the rifling was noticed in Metford rifles after as few as 500 rounds,which was quite unacceptable from both the economic and strategic points of view. The change to the deeper Enfield form of rifling some seven years later reduced this problem to more manageable proportions,but it did not really get at the root cause- the high flame temperature of the propellant.

In 1910 a new form of Cordite was introduced for small arms,designated Cordite MD (ie MoDified),in which the NG content had been reduced to 30%,the NC content increased accordingly and with the Mineral Jelly content remaining at 5%. This new material was considerably less energetic than its predecessor as the flame temperature was now a mere 2200 degrees C,thus the charge weight had to be increased to a nominal 37 grains rather than the earlier 31½ grains. Of itself this caused no immediate problems for there was plenty of spare space in the .303-inch case to accommodate the extra propellant.

An unlooked- for result of this reformulation however was that the burning rate had also been significantly decreased,thus a greater surface area of propellant was needed to maintain the necessary rate of gas evolution during firing. After a series of calculations and firings,it was demonstrated that the new grain shape would have to be hollow tube rather than a solid cord and that the dimensions would need to be .050-inches outside diameter,by .020-inches inside diameter with the length as before,that of the cartridge case. This new propellant was named 'Cordite MDT,5-2' to signify that it was the Modified formulation,extruded as a Tube with,respectively,the outside and inside dimensions of the extrusion die being given in hundreds of an inch.

This altered grain geometry caused no worries in the propellant factories; quite the reverse in fact the new material with its lower liquid content was much stiffer and easier to handle. It

did however cause perpetual troubles in the ammunition factories where it was discovered that although there was plenty of room inside the case to accommodate either charge,the bundle of the new tubes was so much larger than the original bundle of rods,that it would no longer fit through the neck of the case during loading.

A number of options were thus available,with various factories choosing the most suitable for them; either the bundle could be pushed into the neck of the case in two or more increments, or the whole bundle could be pushed into the neck of a partly formed case and the and the final necking operation performed on a loaded case.
Some factories fixed on one or the other of these processes and stayed with it through thick or thin,while others switched between them as circumstances dictated,but it all seemed to make little or no difference where it really counted-in the final performance of the ammunition.

This 'This Cordite MDT' proved to be such an efficient propellant for small arms that the armed services could see no overwhelming technical need to change; thus it remained in general service for over 50 years and is still being produced in some countries.

In all those years there was in fact only one other variation in the small arms field.
Cordite CDT,in which part,usually ½% of the Mineral Jelly was replaced by Carbamite,a more efficient stabiliser which had the added feature of easing several of the steps during production. This CDT however officially remained an alternative to MDT rather than a successor,although in later years it was the more usual product. Cordite Mk 1 remained in limited use for many more years in a few special applications such as proof rounds,and thus may well have set a hard to beat record for length of service.

THE ROYAL GUN POWDER FACTORY

CORDITE.

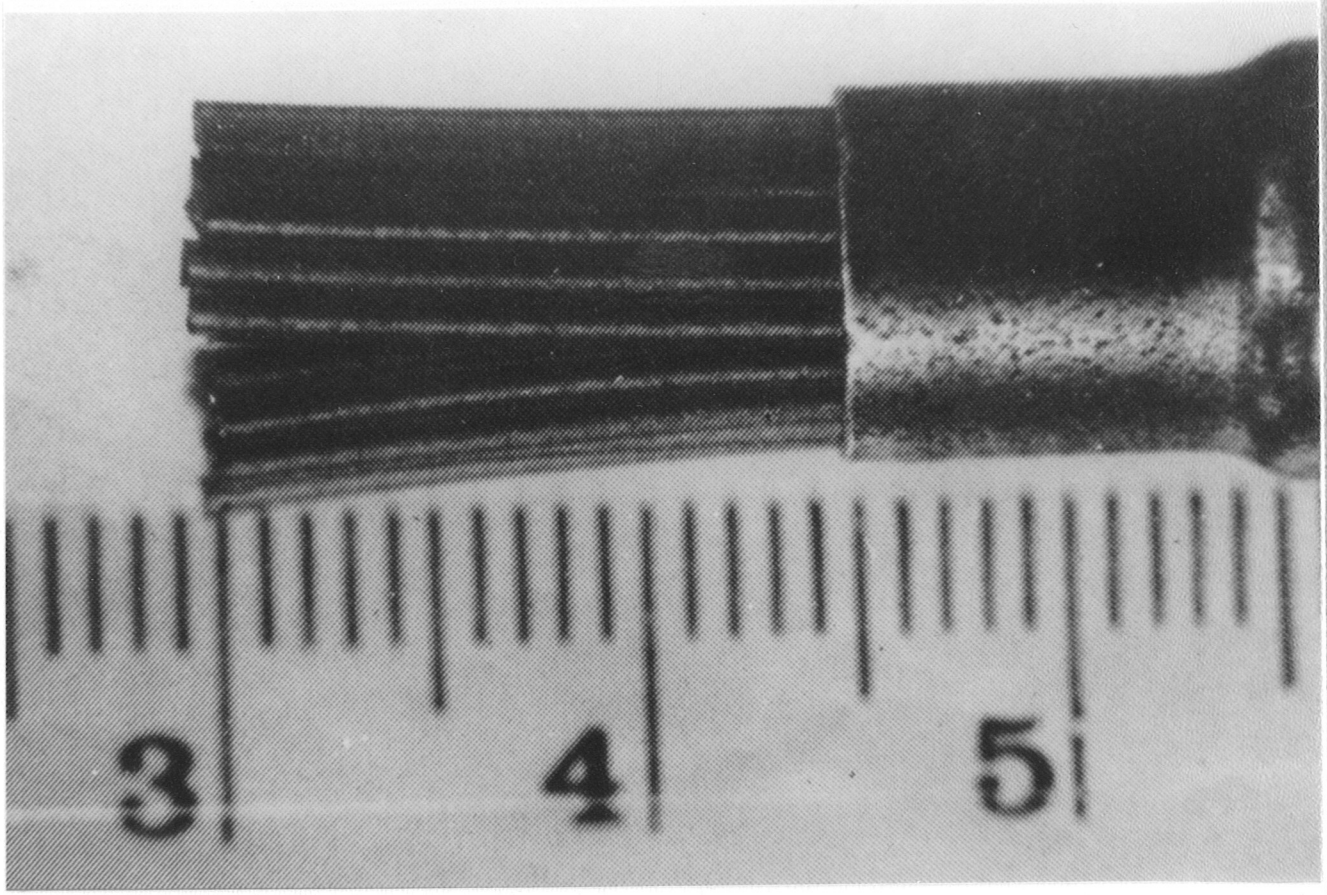
Two main types of Cordite for the .303-inch cartridge.
LEFT: The original Cordite Mk 1 solid rods of 0.0375-inch diameter.

RIGHT: Later type,Cordite MDT-2,single perforated rods of outside diameter 0.050-inch,and inside diameter 0.020-inch.

THE ROYAL GUN POWDER FACTORY

CORDITE.

A bundle of Cordite Mk 1 size 3-3/4,31 grains in weight and consisting of 60-sticks which make up the full charge for a .303-inch Mk2 cartridge.



CORDITE.

In peace time it had been considered quite acceptable when making Cordite to add as a solvent a large quantity of acetone to the dough of nitro cellulose and nitro-glycerine to speed up the gelatinisation of the NC,despite the fact that it was then necessary to stove the grains at about 50 degrees C for very long periods to get the solvent out again; for small arms propellant taking three days,and cannon powders up to five weeks.

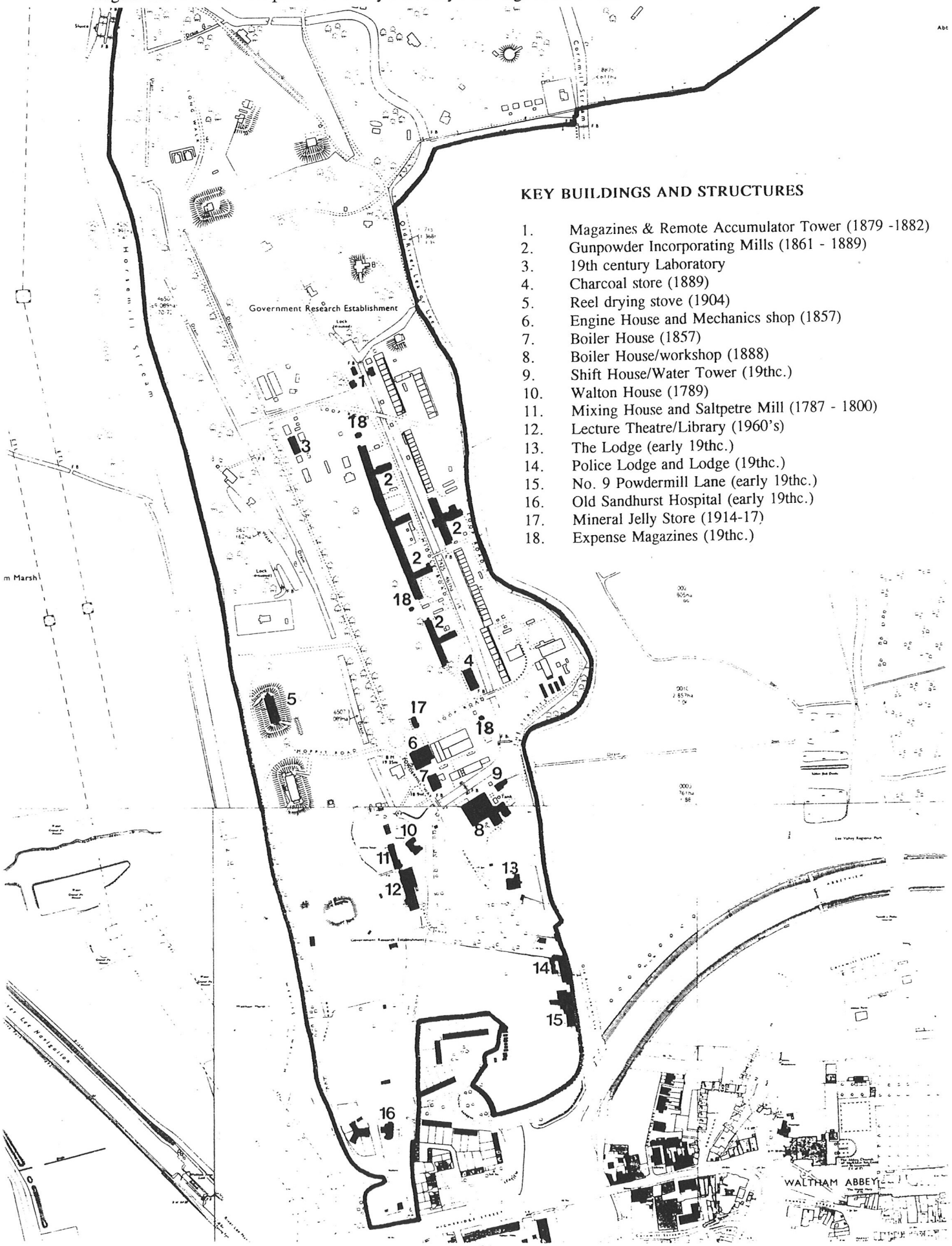
In wartime this delay was completely unacceptable,for not only did it slow down the rate of production,but it represented a significant hazard with several hundred tons of propellant exposed at any given time. The alternatives were equally unattractive. The solvent could not simply be omitted,as the mixing operation then became too slow and too variable,nor could it be left inside the grains as it slowly evaporated anyway,changing the shape of the grains and their ballistics as it did so. Furthermore the solvent,like most other chemicals,was in short supply and full recovery was essential if production was to be maintained. The chemists settled down to study the whole process of gelatinisation to see if they could find ways of circumventing these and other problems.

It was,for instance,known that highly nitrated nitro cellulose as used in making the existing Cordite was soluble only in acetone whereas the lower grades could be dissolved in the more readily available solvents ether and alcohol. A new family of Cordite were thus introduced using this new solvent process and having an increased nitro-glycerine content to offset the lower energy content of the lower grade nitro-cellulose. Such powders were named RDB (Research Department formula B) and were very widely used,being almost completely interchangeable with Cordite Mk 1 in larger guns.

But discontinued after war as did not store too well.

Further research at Waltham Abbey,the original home of government powders some 150 years earlier,led to yet another family of Cordites making use of the newly developed stabiliser 'caebamite' (ethyl centralite) in place of the traditional mineral

Figure 11: Former Gunpowder Factory Site: Key Buildings and Structures.



KEY BUILDINGS AND STRUCTURES

1. Magazines & Remote Accumulator Tower (1879 -1882)
2. Gunpowder Incorporating Mills (1861 - 1889)
3. 19th century Laboratory
4. Charcoal store (1889)
5. Reel drying stove (1904)
6. Engine House and Mechanics shop (1857)
7. Boiler House (1857)
8. Boiler House/workshop (1888)
9. Shift House/Water Tower (19thc.)
10. Walton House (1789)
11. Mixing House and Saltpetre Mill (1787 - 1800)
12. Lecture Theatre/Library (1960's)
13. The Lodge (early 19thc.)
14. Police Lodge and Lodge (19thc.)
15. No. 9 Powdermill Lane (early 19thc.)
16. Old Sandhurst Hospital (early 19thc.)
17. Mineral Jelly Store (1914-17)
18. Expense Magazines (19thc.)

GUNPOWDER.

A contemporary recipe for gunpowder,rediscovered in the West 1320,laid down.

12-lbs of live sulphur.
2-lbs of willow charcoal,
6-lbs of saltpetre,

THE ROYAL GUN-POWDER FACTORY.

"A mill for making of gunpowder'there,
And water. flows amazing and more rare;
Which from a model on river's took
Of worthy Walton's works (whose soul cant Brooke
With thing that's mean; but like a generous heart
Encourages all learning,honesty,and art)."
Local Poet 1735.

GUNPOWDER.

A contemporary recipe for gunpowder,rediscovered in the West 1320,laid down.

12-lbs of live sulphur.
2-lbs of willow charcoal,
6-lbs of saltpetre,

If they be well ground on a slab of marble,then sift the powder through a fine kerchief.

THE ROYAL GUN POWDER FACTORY

"Waltham is a pretty town;and,as one turns off from the main street into the lane leading to the principle entrance of the Royal Gunpowder Factory,one cannot help admiring the pastoral scenes of woodland and meadow,which render it difficult to believe that the most dangerous industry in the world is carried on within a few hundred yards.

Passing in at the gate we beheld an avenue of stately populars,at the end of which the Union Jack floated proudly from a flag-staff".

by William G. FitzGerald 1895.

THE ROYAL GUN POWDER FACTORY

900 men were employed in 1895,the wage bill coming to £70,000.
1,400 tons of saltpetre were stocked,and 100 tons of sulphur.
Enough wood was stocked to make 40,000 barrels of powder.
The annual consumption of coal ranged from 8,000 to 10,000 tons.

Gunpowder.

Compound,also known as black powder. It is a mechanical mixture of potassium nitrate,charcoal and sulphur in the proportions 70:15:10,though these proportions have varied during it's history.

The materials are ground separately into fine powder,then mixed in the wet state,the resulting 'cake' is dried and then crushed,and the grains are run through sieves to classify the powder according to size.

The size of the grain effects the burning speed,the smallest grains producing the fastest burning. The finest grade,meated powder,is used in the manufacture of pyrotechnics,in fuze compositions and ignition devices.

The granular powder is classed from FFFFg (grains measuring about 0.017-in. across) to Fg (about 0.069-in. across),the smallest grains being used in pistol ammunition,the largest in rifle,shotgun and cannon ammunition.

It's principle defect,as a propellant for firearms is that it generates a large volume of white smoke and the solid combustion products are desposited in the barrel as a sticky fouling.

THE ROYAL GUN POWDER FACTORY.

The Royal Gun Powder Factory before 1872,viewed from the bridge over the Lee Navigation.

The buildings from the left to the centre were originally part of the saltpetre refinery; after 1872 they were used for the production of guncotton,and turned out 250-tons per year.

THE ROYAL GUN POWDER FACTORY.

Engraving of the 'POWDER MILLS' by E.Watford 1898.

THE MANUFACTURE OF GUN POWDER

AT

THE ROYAL GUNPOWDER FACTORY

1895.

THE ROYAL GUN POWDER FACTORY.

"Waltham is a pretty town;and,as one turns off from the main street into the lane leading to the principal entrance of the factory,one cannot help admiring the pastoral scenes of woodland and meadow,which render it difficult to believe that the most dangerous industry in the world is carried on within a few hundred yards.

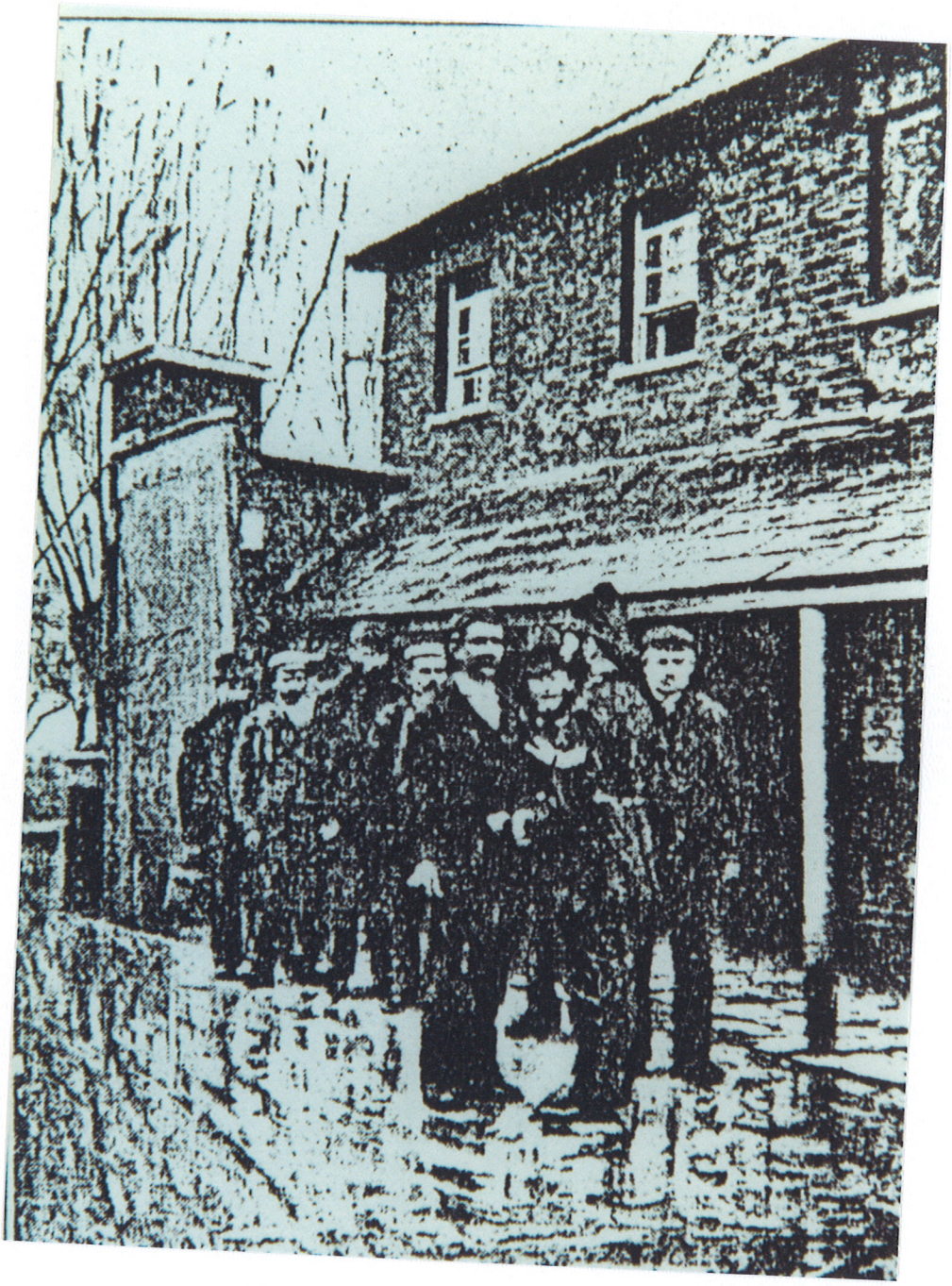
Passing in at the gate we beheld an avenue of stately poplars,at the end of which the Union Jack floated proudly from a flagstaff. This gave rise to a train of thought from which we were rudely aroused by a sharp challenge from the inspector of police. We were then requested to enter the police quarters,where we were plied with questions as to our business,and whether we possessed any matches,pipes,or steel implements. Then we turned out our pockets,just as Lord Sandhurst had to do when he visited the factory for the purpose of opening the hospital. In fact,all comers,from the Prince of Wales down to the humblest factory lad,are interrogated by the police at the gate with a strict regard for duty that remined us of certain anecdotes in our school-books".

by William G. FitzGerald. 1895.

THE ROYAL GUN POWDER FACTORY.

'ANY MATCHES.'

"Then we turned out our pockets- all comers from the Prince of Wales down to the humblest factory lad,are interrogated by the Police".



THE ROYAL GUN POWDER FACTORY.

The quadrangle near the office of the Superintendent. A sundial stands there surrounded by 6 big shells.

THE ROYAL GUN POWDER FACTORY.

SALTPETRE.

The saltpetre comes from Sind in India in bags of 100-lb and in this state it contains about 5% of impurities. It is dissolved in large quantities in water heated to 230 degrees,and,after careful skimming,the solution is pumped into coolers.

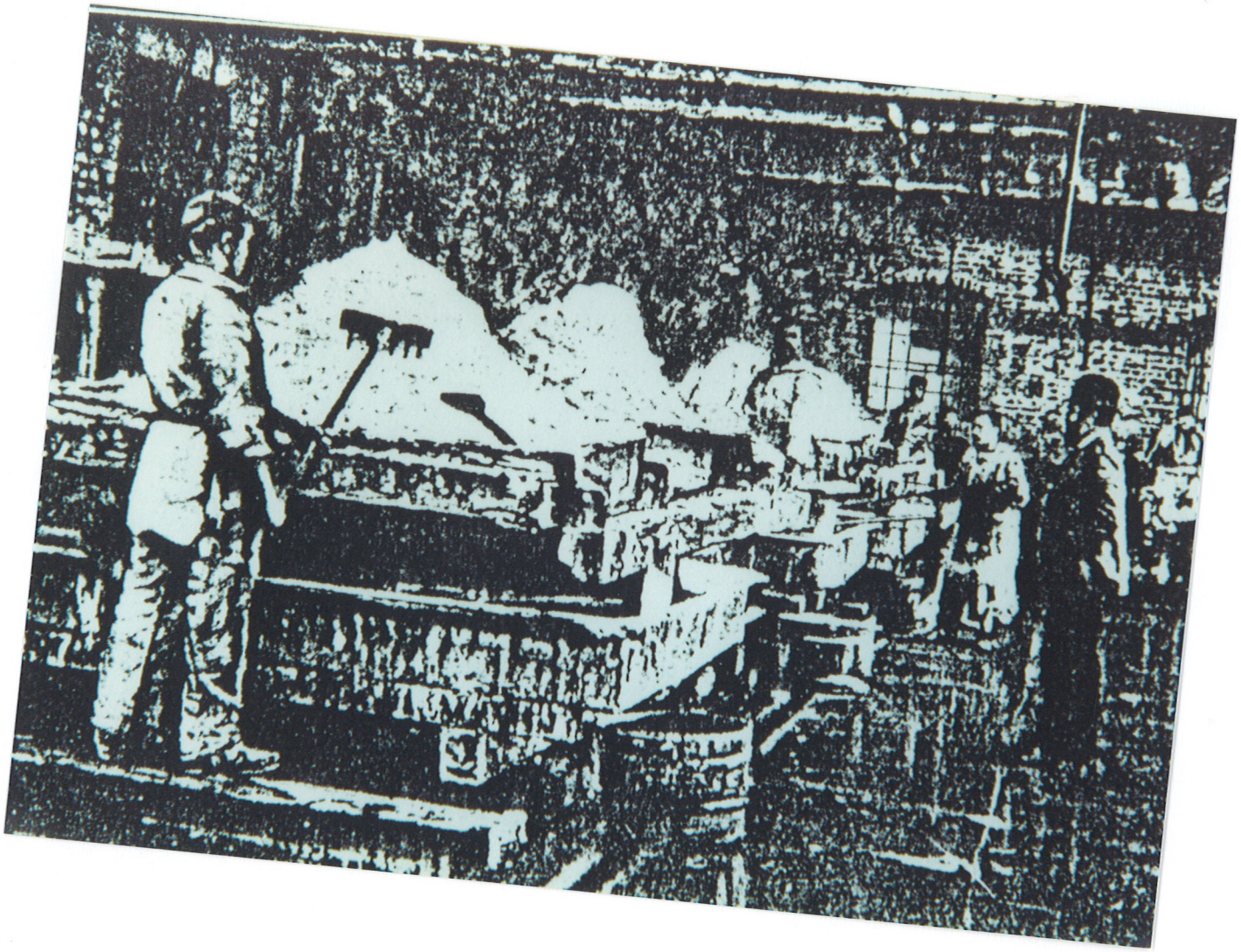
The saltpetre crystallizes in in the coolers,and is then raked from the bottom in the form of wet snow,which is piled up,and subsequently undergoes a washing process by means of a continuous stream of water.

There are four refining coppers and seven evaporating pots in the refining room. The saltpetre is ultimately sent to the mixing-house in barrels,with a certificate showing that it contains between 3 and 6% of water. The saltpetre refuse is bought by farmers for from 8-to 12-shillings per ton.

THE ROYAL GUN POWDER FACTORY.

THE SALTPETRE REFINERY.

To the right of the picture is Mr.Knowler,the "father of the factory",as he is called from the fact of his 43 years service.



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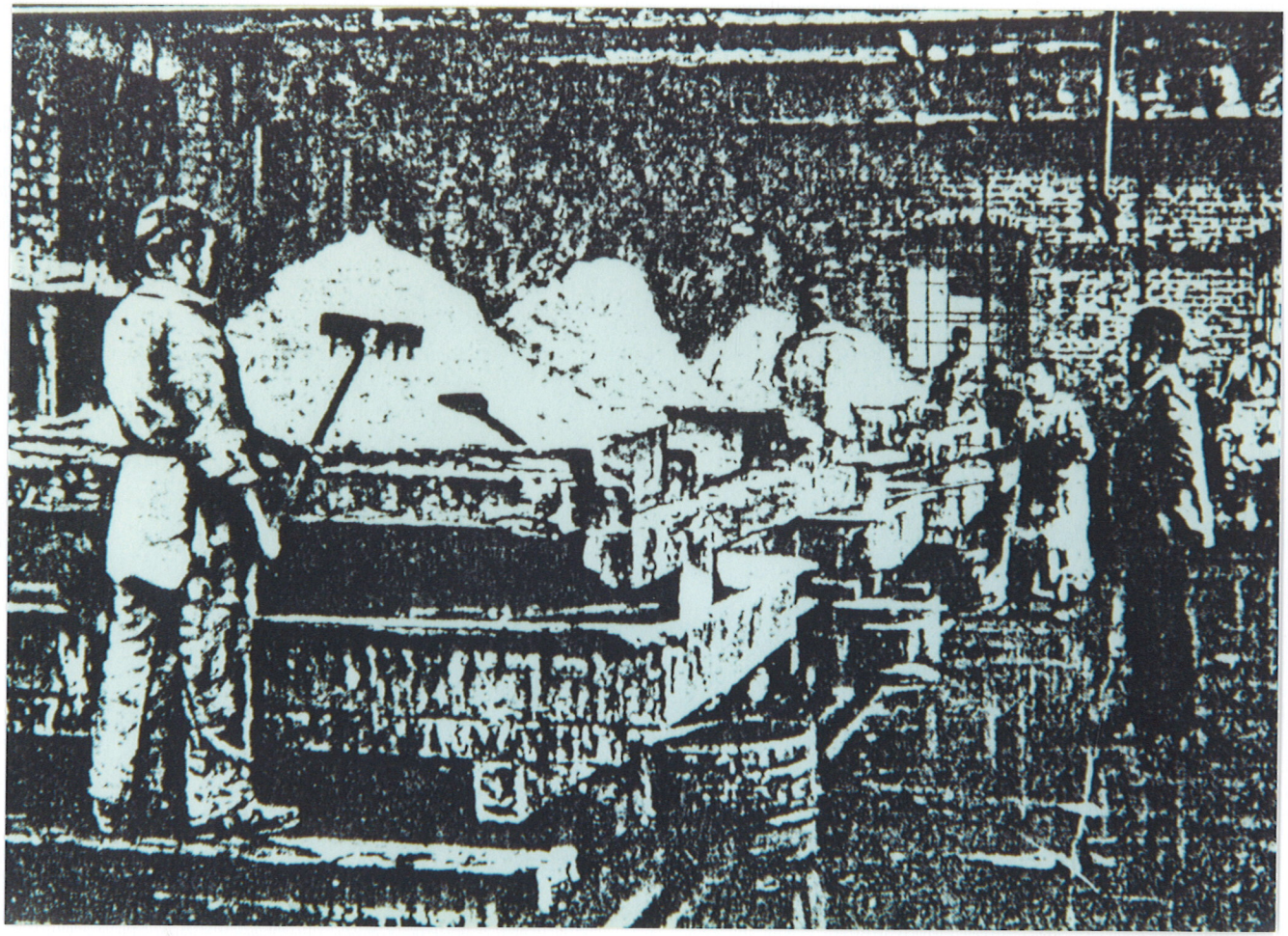

THE ROYAL GUN POWDER FACTORY

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THE ROYAL GUN POWDER FACTORY.
CHARCOAL.

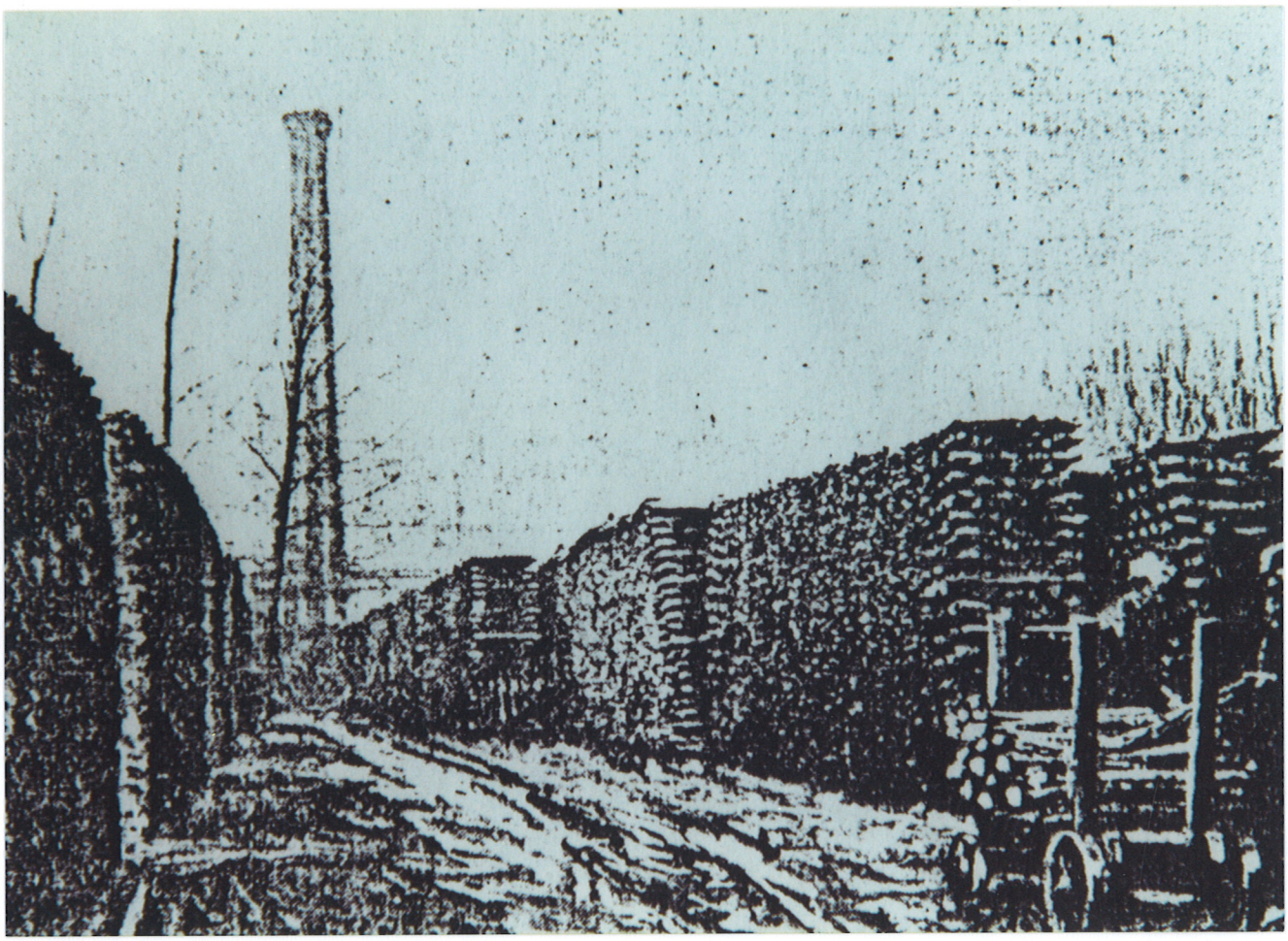
An important part of the gunpowder manufacture was the production of charcoal. Alder,willow or black dogwood in 3 to 4-ft lengths were stacked as shown,then covered with straw or ferns kept in position by earth or sand to retain the heat and control air intake. The results of such firing were uneven.

About 1830 this method was replaced by horizontal iron cylinders into which the wood was stacked,in a way similar to modern coking methods; the resulting acid liquor by-product was collected in casks and the gas allowed to escape to assist the firing.

THE ROYAL GUN POWDER FACTORY.

THE WOOD STACKS.

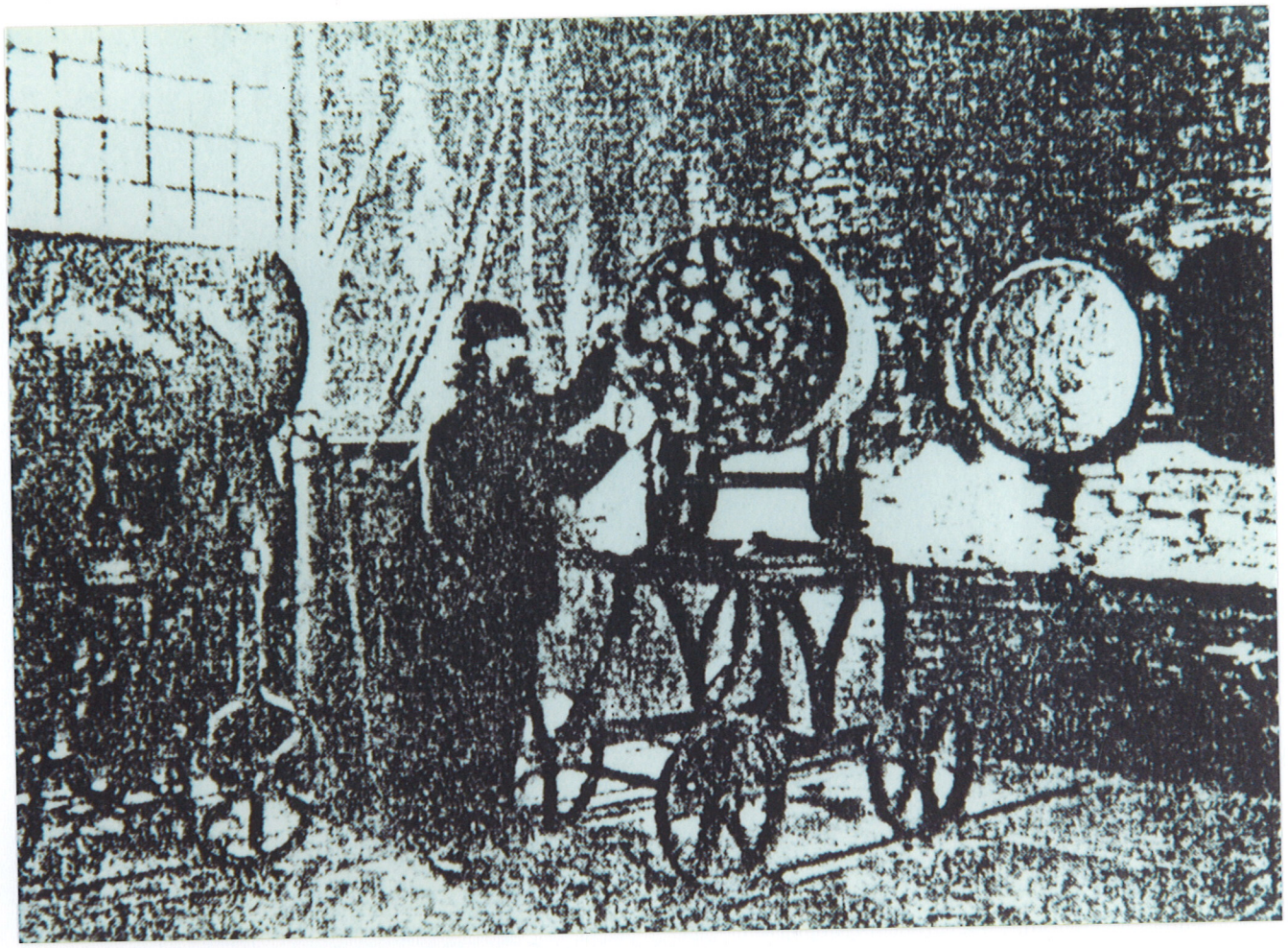
View of the wood stacks,many of which are from three to ten years old.



THE ROYAL GUN POWDER FACTORY.

MAKING CHARCOAL.

The charcoal-room.The wood is placed in the cylindrical drums and the latter are then run into furnaces shaped to receive them,by means of travelling cranes.



THE ROYAL GUNPOWDER FACTORY.

CHARCOAL.

There are groves and forests in the factory grounds of willow,dog-wood,and alder. This wood is coverted into charcoal. Many of the stacks of wood can be from 3 to 10 years old.

In the charcoal room the wood is placed in cylindrical drums,and the latter are then run into furnaces shaped to receive them,by means of travelling cranes. After from three to eight hours of very great heat,during which time the gases of the burning wood are utilzed as fuel in the furnaces below,the drums are withdrawn and their contents shot into air-tight iron vessels to cool for 4 hours. The charcoal is subsequently removed to smaller coolers,where it remains another 12 hours,after which it is taken by boat to the store. Here it remains for a day or two before being picked over by hand,in order to see that there are no nails or pieces of iron in it.

The charcoal is passed through a mesh 32 to the inch.

THE ROYAL GUN POWDER FACTORY

SULPHUR.

The sulphur refinery was stated as a smelly place.

Six hundredweight and a half of sicilian sulphur is shot into the retort,and after it has remained there about three hours it passed in vapour from the retort through cold water jacketed pipes,into the receiving pot,where it arrives in a treacly mass. It is then ladled into casting tubs where it is left for about 18 hours. next morning the tubs are emptied,and out of each comes 200-cwt of purified sulphur,which resembles a monstrous custard. This goes to the mixing room,after having been ground in the sulphur mill. The sulphur is ground so as to pass through a sieve having 36 openings to the square inch.

THE ROYAL GUN POWDER FACTORY.

THE SULPHUR REFINERY.

"We found it almost impossible to breathe within its evil-smelling precincts. Our friend is seen ladling this viscous matter into the casting tubs."

THE ROYAL GUN POWDER FACTORY

THE SULPHUR REFINERY.

"We next called at the sulphur refinery but found it almost impossible to breathe within its evil-smelling precincts.

As regards the worthy man we found there,he was as unconcerned as though he were inhaling the ozone on Brighton Pier; more,he proceeded to give us,out of the fulness of his twenty-six years' experience,a few details concerning his own department in quite a graphic manner.

Six hundredweight and a half of Sicilian sulphur is shot into the retort,and after it has remained thereabout three hours it passes in vapour from the retort,through cold-water jacketed pipes,into the receiving-pot,where it arrives in a treacly mass.

This viscous matter is ladled into casting tubs in which it is left for about 18 hours.

Next morning these tubs are emptied,and out of each comes two hundredweight of purified sulphur,which resembles a monstrous custard. This also goes to the mixing-room,after having been ground in the sulphur mill".

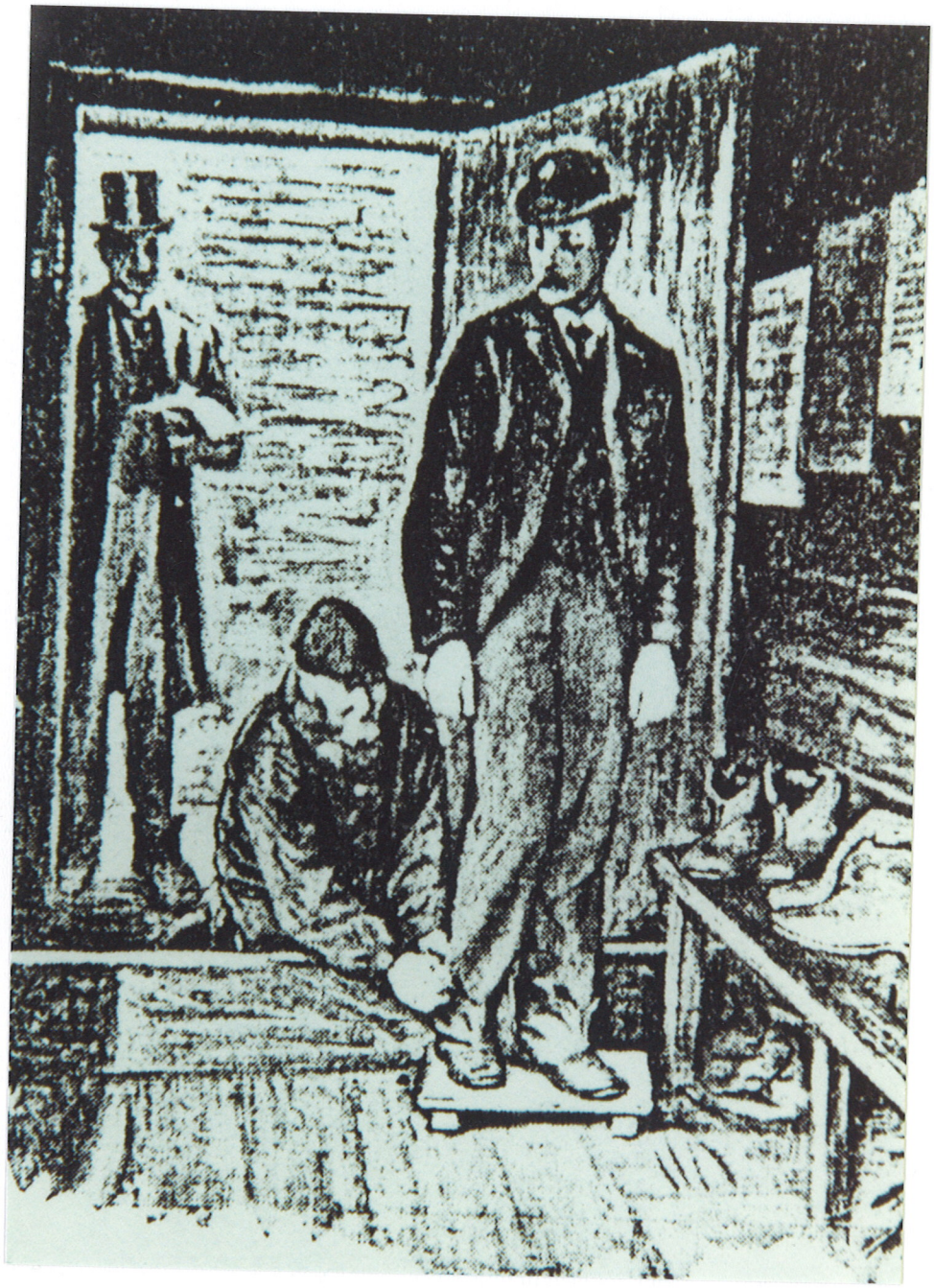
THE ROYAL GUNPOWDER FACTORY.

PRESS HOUSE.

"All sorts of fearsome notices and cautions abound in the retiring-room of the Press House. A rigorous line of demarcation is formed by an upright board,before passing which every visitor,from the Government inspector downwards,is compelled to put on a pair of enormous boots over his own".

Note: This precaution is taken in order that no gritty particles may be introduced on to the soft leather floor of the danger buildings.

Picture: The Chief Foreman is seen putting on safety boots..



THE ROYAL GUNPOWDER FACTORY.

THE MIXING ROOM.

"of this place it was impossible to obtain a photograph owing to the darkness that prevailed. Grimy men flitted through an almost tangible gloom; and in one corner an expert was weighing up the saltpetre,sulphur,and charcoal in parts of 75,10,and 15 respectively. For powder for big guns,however,the proportions are 79,3 and 18. These constituents were shot into a revolving drum fitted with blades inside. The mixture is afterwards packed in half-charge sasks of 60-lb. and sent to the incorporating mill-the first of the -danger mills'."

THE ROYAL GUN POWDER FACTORY.

The cleaning gang at the turn of the century. Once the gunpowder ingredients have been mixed the powder or 'green charge' is explosive. The danger is minimized by sweeping up and cleaning with wet mops.

THE ROYAL GUNPOWDER FACTORY.

PRESS HOUSE.

"The Press House is the parting of the ways,so to speak,of the various kinds of powder,which are made from press-cake treated in different ways.

For pebble powder the press-cake which resembles thick black slate- is cut into strips and these strips are further cut into '5/8 cubes'. The rest of the cake is reduced to coarse powder by three pairs of graduated rollers".

THE ROYAL GUNPOWDER FACTORY.

PRESS HOUSE.

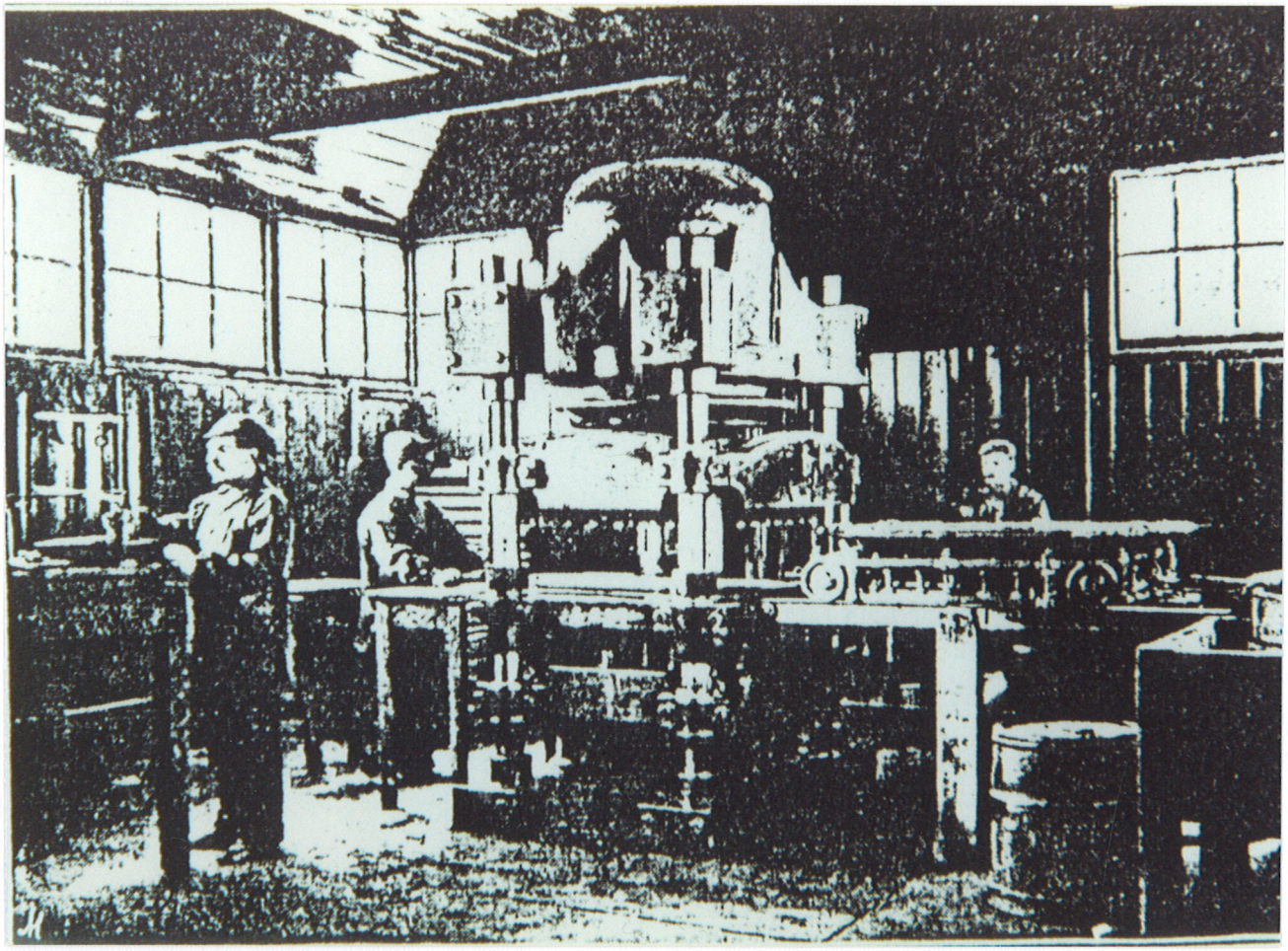
The glazed and granulated powder (the dust from which has been removed by another process and sent back to the incorporating mills) is now ready for moulding into prisms for the built-up charges used in big guns.

Coarse-grained powder is fed into the compartments of the wheeled tray to the right,and is then pushed under the hydraulic press,which has corresponding plungers. The hexagonal prisms emerge in batches of 64,or 13,000 per day.

THE ROYAL GUN POWDER FACTORY.

THE MOULDING ROOM.

"To the left of the picture a skilled workman is seen weighing out a specimen from each batch in air and mercury. And "if the scale do turn (literally) but in the estimation of a hair" the whole batch is rejected."



THE ROYAL GUN POWDER FACTORY

SANDHURST HOSPITAL.

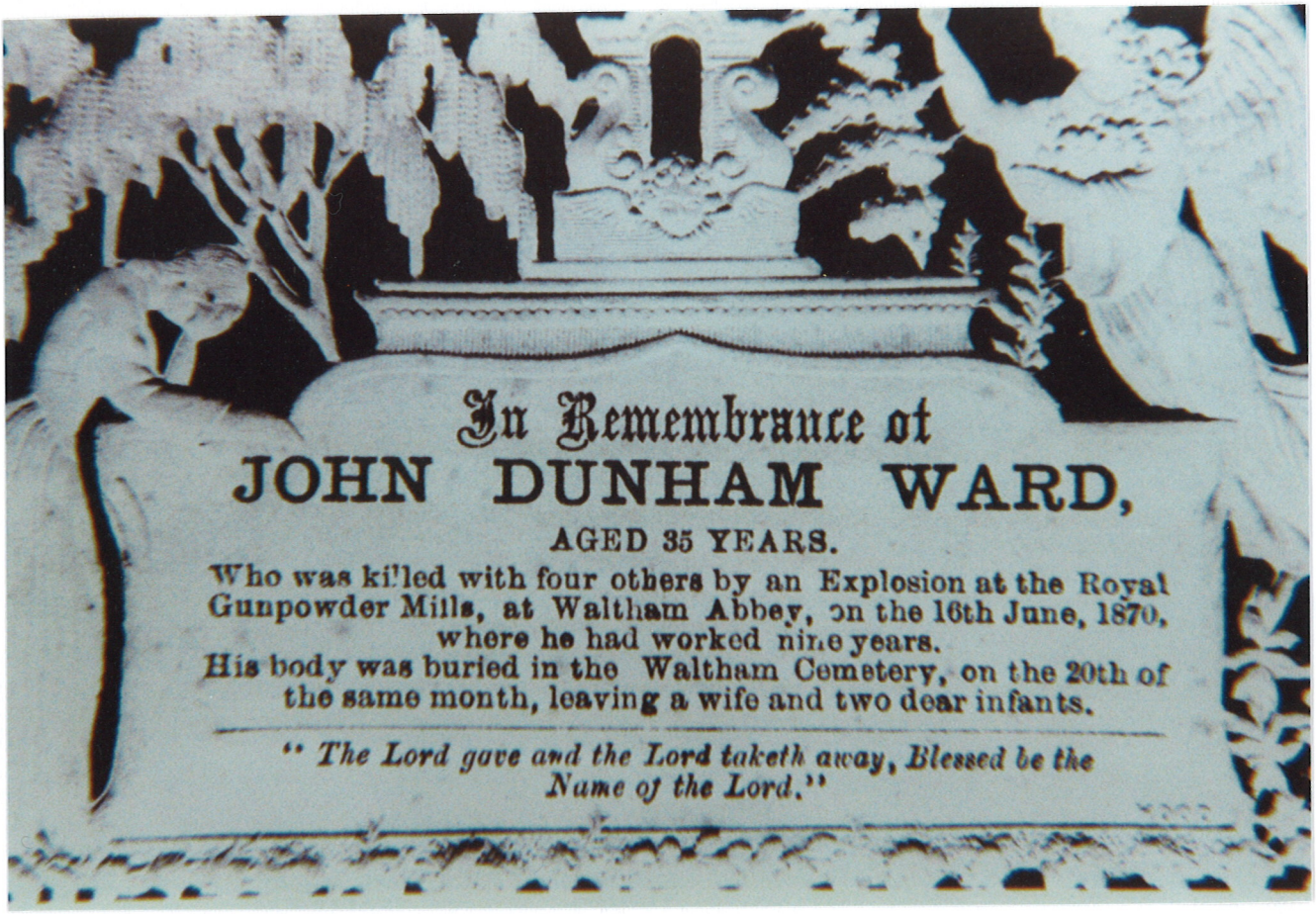
The factory has its own hospital,opened by Lord Sandhurst in 1895.

THE ROYAL GUN POWDER FACTORY.

The funeral at the Abbey Church of the men killed in the 1843 explosion. In some cases,weighted coffins were used to conceal the absence of a body.

THE ROYAL GUN POWDER FACTORY.

A memorial card issued after an explosion in 1870. One of the 'two dear infants' is Phoebe Ward.



THE ROYAL GUNPOWDER FACTORY.

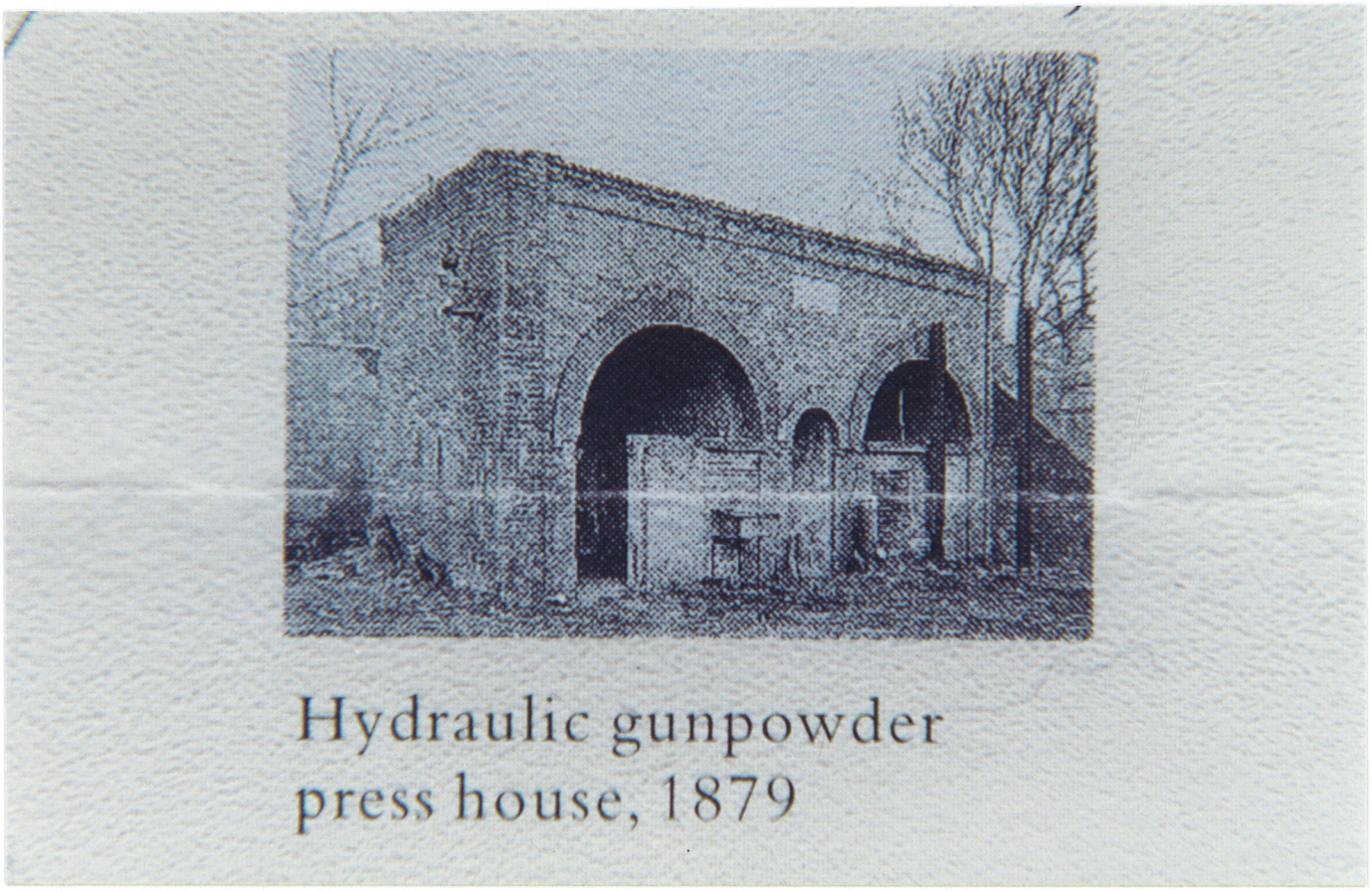
THE PRESS HOUSE.

The next department is the Press House,and in here one of the most dangerous operations take place.

Copper plates are fixed in a rack in a huge iron box,and about 750-lb of meal powder is strewn between them. A hydraulic ram of between 63 to 500-tons pressure is then brought to bear upon the plates for half an hour.

A bell rings when the pressure gauge reaches a certain point,and the men then return to the machine-room and remove the 'press-cake',as it is now called,from the plates.

Regulations caution the men against 'undue haste' in removing the cake,and wells outside each danger building,into which men who have been badly burnt may plunge. No more than 900-lb of powder was allowed to be kept in the press-house at one time.

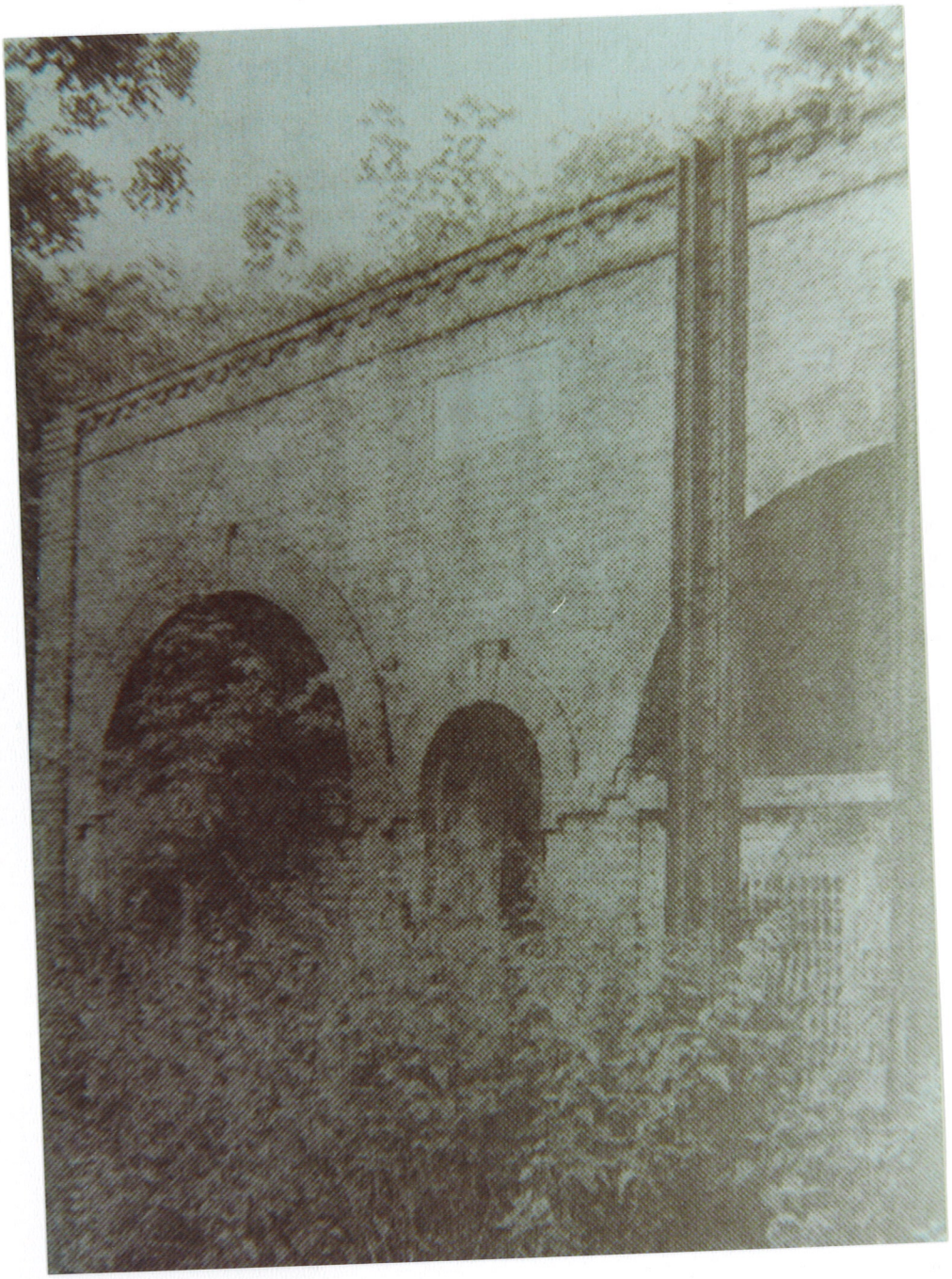


Hydraulic gunpowder press house, 1879

THE ROYAL GUN POWDER FACTORY.

PRESS HOUSE.

Used to make gunpowder pellets,was built in 1894.



THE ROYAL GUN POWDER FACTORY.

OLD GUNPOWDER PRESS.

THE ROYAL GUN POWDER FACTORY.

DRYING ROOMS.

Ordinary grain powder is left for 1 to 3 hours; pebble powder takes from 24 to 40 hours to dry and S.B.C. (slow burning cocoa) for 110-ton guns,about sixty hours, the last-mentioned powder is proved in 11-inch guns with a charge of 360-lb.,and gives a muzzle velocity of from 2,010 to 2,050-fps.

Finished powder of all sorts is sent to the splendidly fitted laboratory to undergo various tests; it is then proved in the guns at the butts attached to the establishment. Finally,large quantities of each kind are blended so as to give uniformity,and the powder is then conveyed to Purfleet and Woolwich in special barges.

THE ROYAL GUN POWDER FACTORY.

INCORPORATING MILL.

Exterior View.

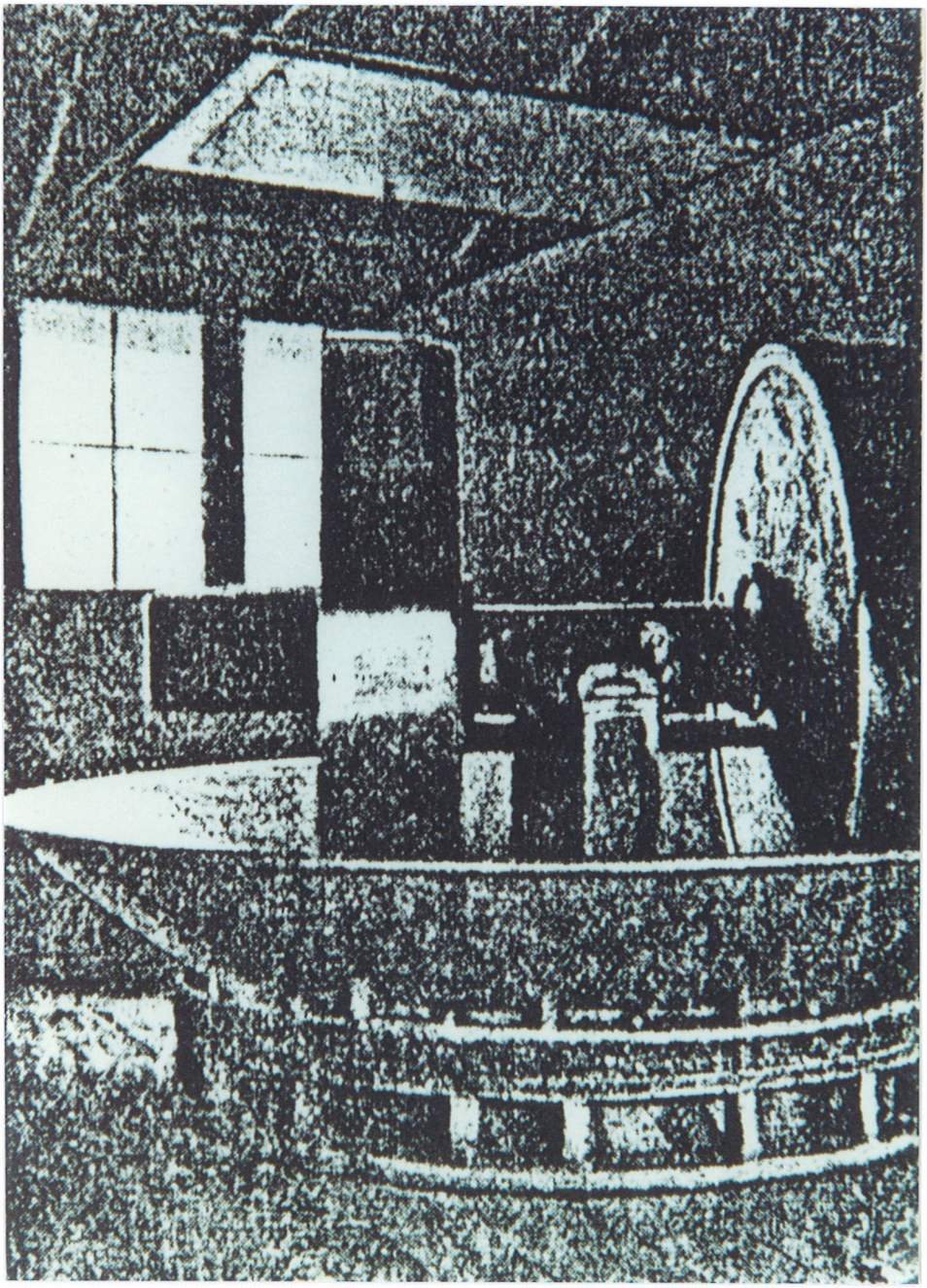
A set of incorporating mills,which are built in groups of six,and are worked by independent machinery.

THE ROYAL GUN POWDER FACTORY.

INCORPORATING MILL.

Interior View.

In this building there is a big,circular iron bed,round which revolve two enormous wheels,each weighing four tons.



INCORPORATING MILL.

Incorporating mills,which are built in groups of six,and are worked by independant machinery. Except for the division walls,these mills are constructed of the flimsiest material possible,the roof being of wood,and the fromts of canvas,buttoned on to a slight iron framework; this is in order that no resistance may be offered to a possible explosion. If the arms of the danger signals are raised,in order to show that the mills are working; no barrow or truck-load of powder,in any stage whatsoever,is allowed to pass by the mills.

In the mill is a big circular iron bed,rouns which revolve two enormous wheels,each weighing four tons.

Into this bed is shot the contents of the half-charge sack brought from the mixing house. A wooden 'plough' is then fixed from the centre,so as to keep the powder continually under the rollers,and then all is ready for starting the machinery.

Even in this stage the mixture is highly inflammable,and there lies a flash board over the bed. In the event of an explosion,either through the wheels meeting with gritty particles in the mixture,or from other causes,this board would be violenty thrown up on hinges,and in its decent backwards would automatically overturn tanks of water,not merely on to its own bed,but also the beds of its working neighbours,who might also explode.

Owing to the risk,when starting the incorporating mill,the operator draws down the flaps of his cloth helmet,puts on his gauntlets,retires outside. The operator is clothed in a suit of 'lasting' a leathery material,that has no pockets,and the buttons are of bone; no powder adheres to this material. The men are even forbidden to cultivate long beards,less they contain particules of grit.

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INCORPORATING MILL.

The aftermath of an explosion on 21 October 1890 in the incorporating mills.

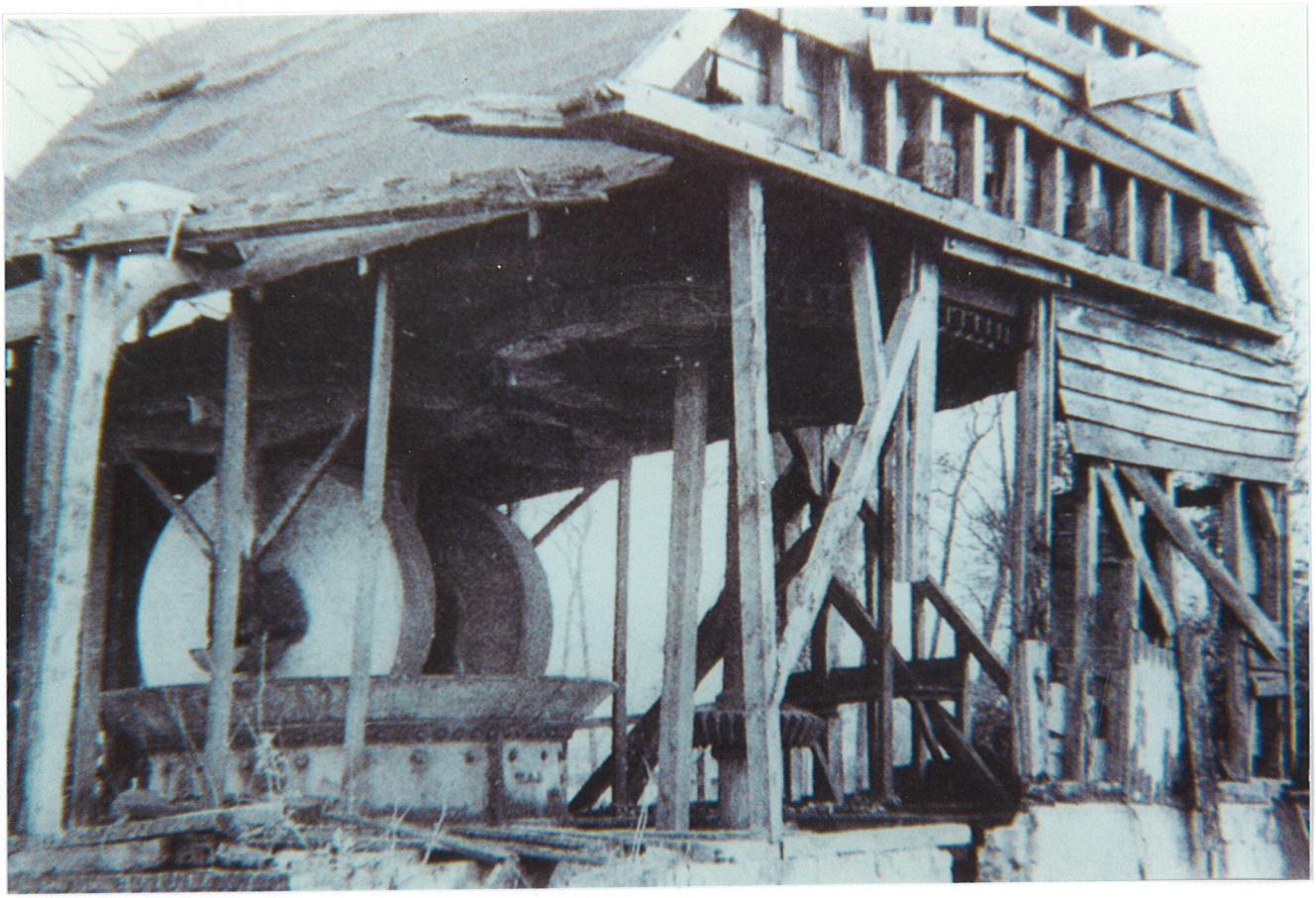
This photograph shows iron runners or rollers and the overturned drenching pan above.
Iron runners superseded stone wheels,as they could be smaller and were safer.

INCORPORATING MILL.

The last of the gunpowder incorporating mills,at the Royal Gun Powder Factory,the result of neglect not explosion; incorporation was a process of intimately mixing the loosely mixed 'green charge' by crushing and grinding; a mill-cake was the result.

This mill was destroyed in the late 1950s because of contamination.

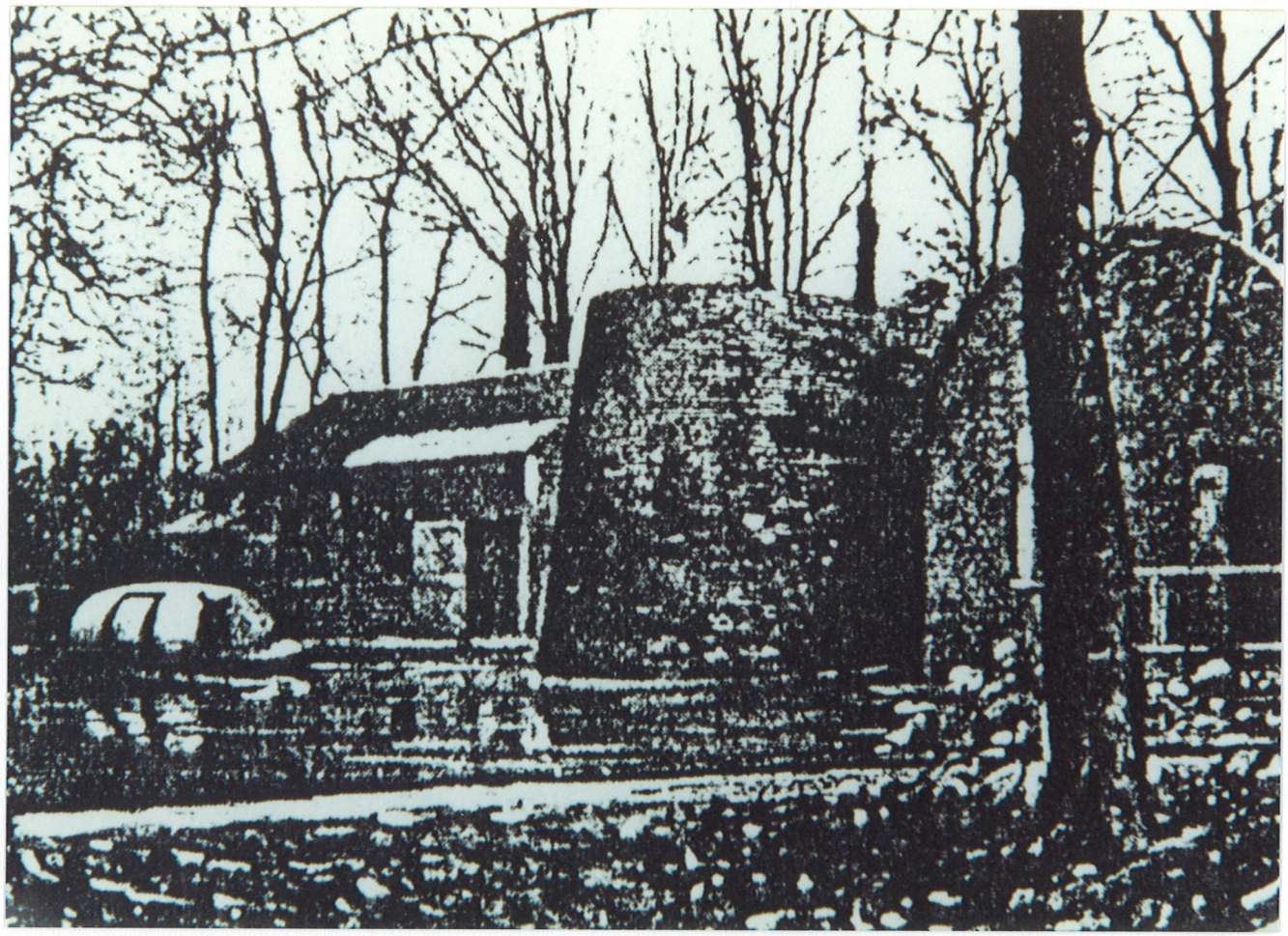
The last functioning mill had been put out of action by a bomb in 1941.



THE ROYAL GUN POWDER FACTORY.

THE PRESS HOUSE,Showing 'Traverse'.

The machine-house is on the left,and the men's retiring-room on the right. Between these two buildings is placed the 'traverse',a mighty mass of masonry,concrete,and earth,which is intended to protect the workmen.



GUNPOWDER.
INCORPORATING MILL.

An Incorporating Mill consisted of two heavy,wide wheels,known as edge-runners,which were placed paralle to each other a few millimetres above a flat circular bed with a raised edge.
The wheels,which were about 2.5-m in diameter and 0.5-m wide,were operated through a system of gears and ran over and around the bed on which was spread a partially mixed gunpowder,moistened with distilled water. The wheels and bed was originally made of stone,as in the old flour-mills,and then of cast-iron,but steel was eventually used,with wheels weighing up to 7-tonnes. The pressure of the runners slowly and remorselessly crushed the mixture and ground it together without subjecting it to any very severe shocks,and the milling process was carried out for up to 8-hours depending on the product required.

The resulting hard mass,called mill-cake or press-cake,could be compacted even further between plates in a hydraulic press and cake of different densities could be made by altering the duration and intensity of the milling.

The three components in the cake were in very intimate contact and bound firmly together.

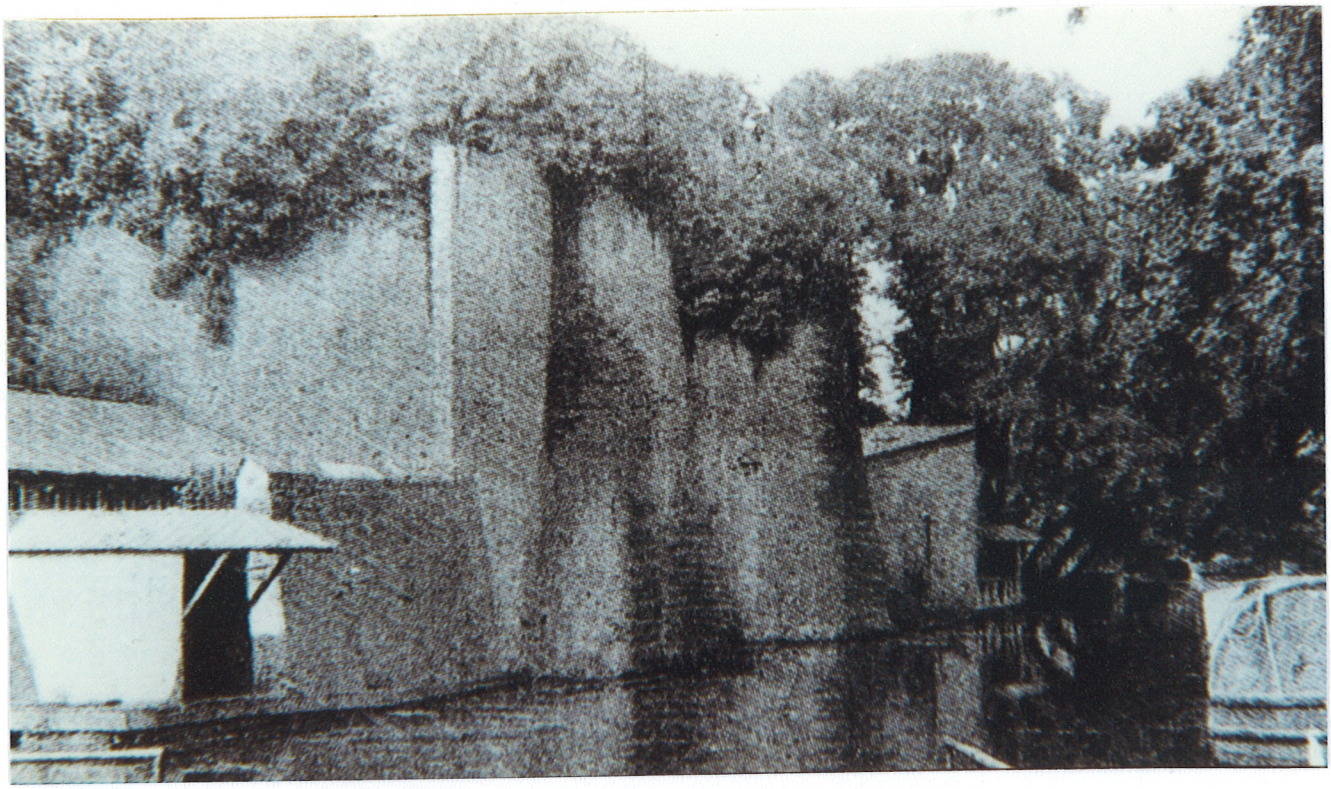
In the corning process,the mill-cake was passed through a series of rollers which broke it down into smaller and smaller grains,the different sizes being separated by sieves with different-sized mesh. Any grains that were too small or too big were reprocessed. The sieved grains were polished by rotating for up to six hours in a drum,and were generally glazed by adding a little graphite during that process.
The corning produced grains which were quite strong,and,particularly when glazed,were free-running and resistance to moisture.

GUNPOWDER.

AN INCORPORATING MILL
WITH THE WHEELS OR RUNNERS OPERATED
BY WATERPOWER.

T POWDER FACTORY.

T lives. The blast wall on the right proved i



THE ROYAL GUN POWDER FACTORY.

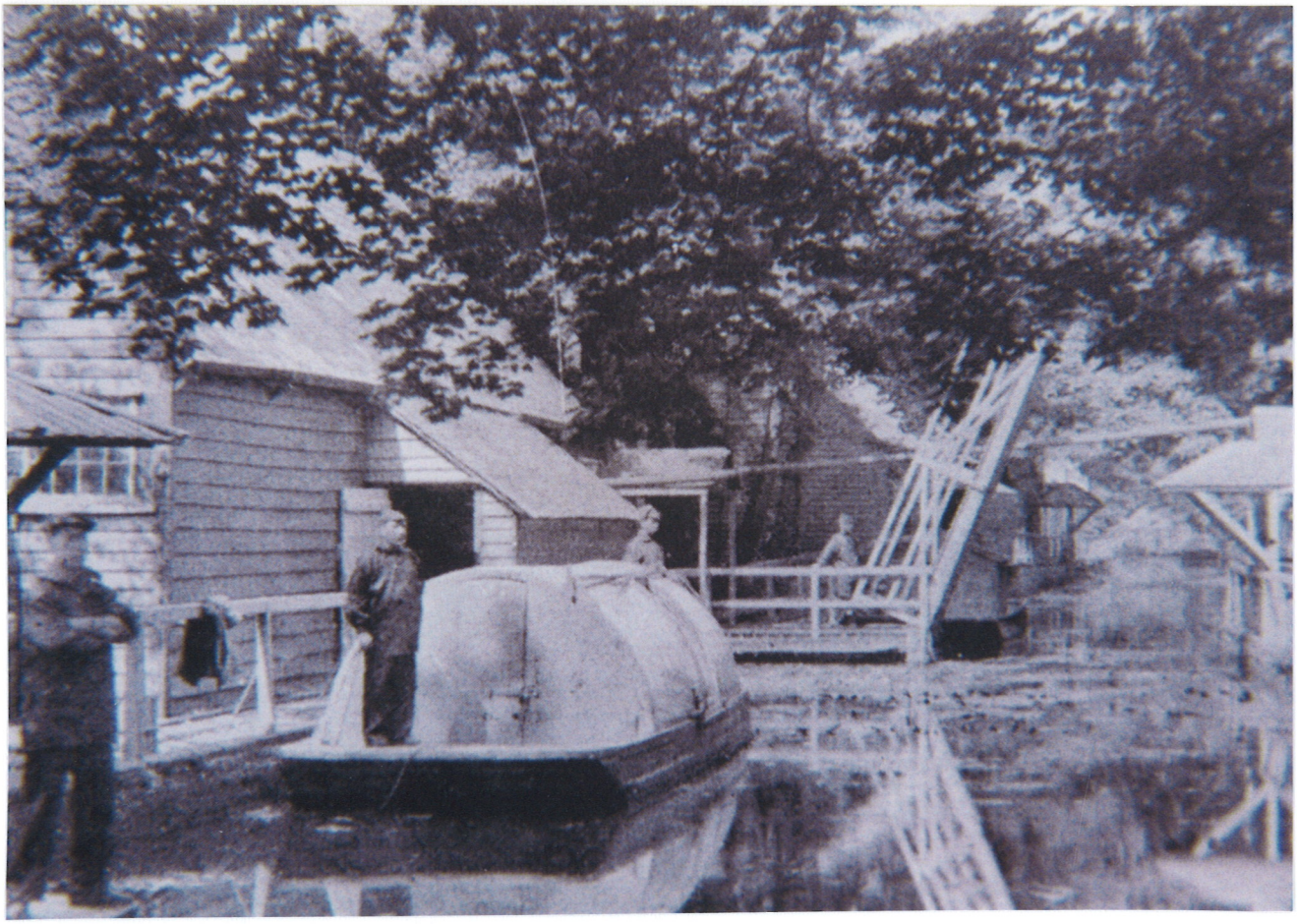
POWDER BARGE.

The finished powder was conveyed to Purfleet and Woowich in barges like this,flying the red flag. In an emergency the boat could be sunk in five minutes.

THE ROYAL GUN POWDER FACTORY.

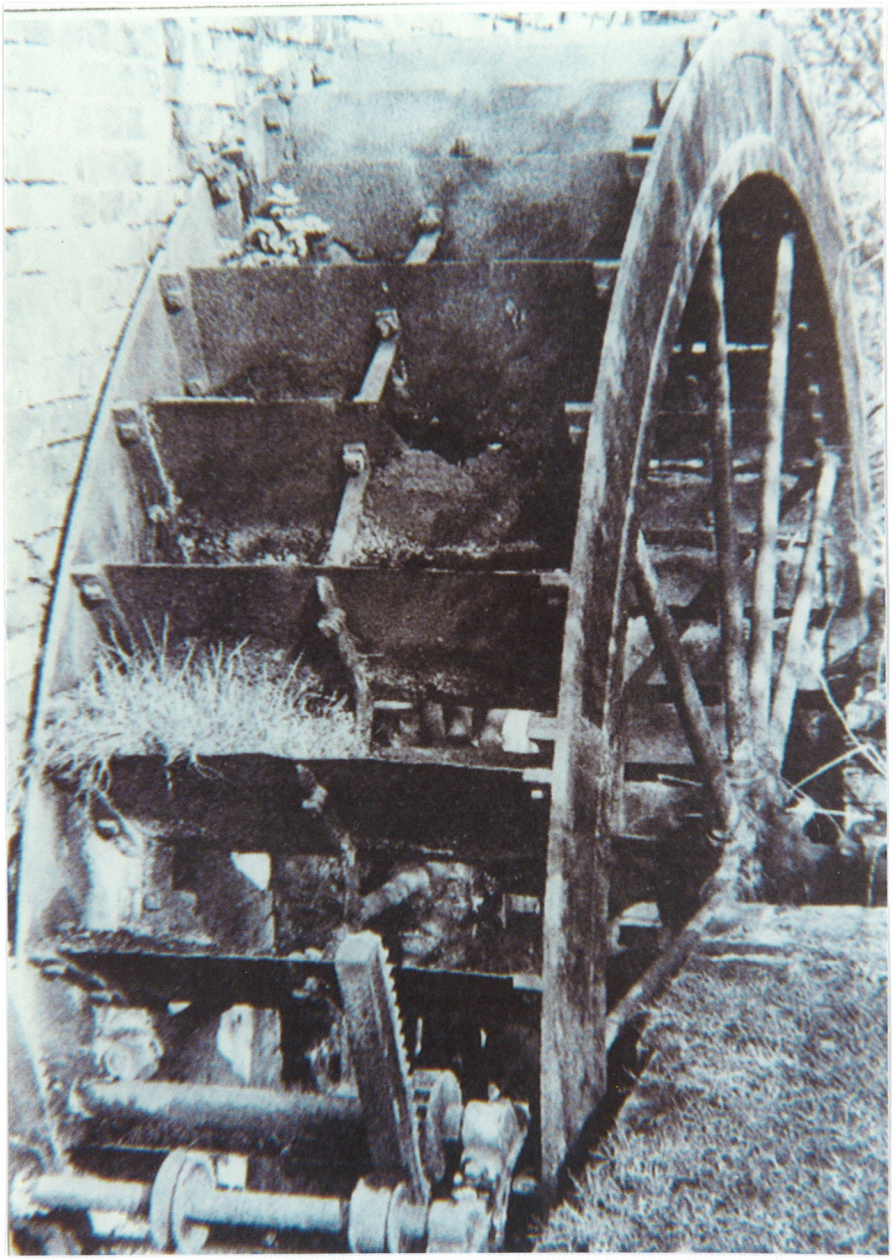
COVERED POWDER BOAT.

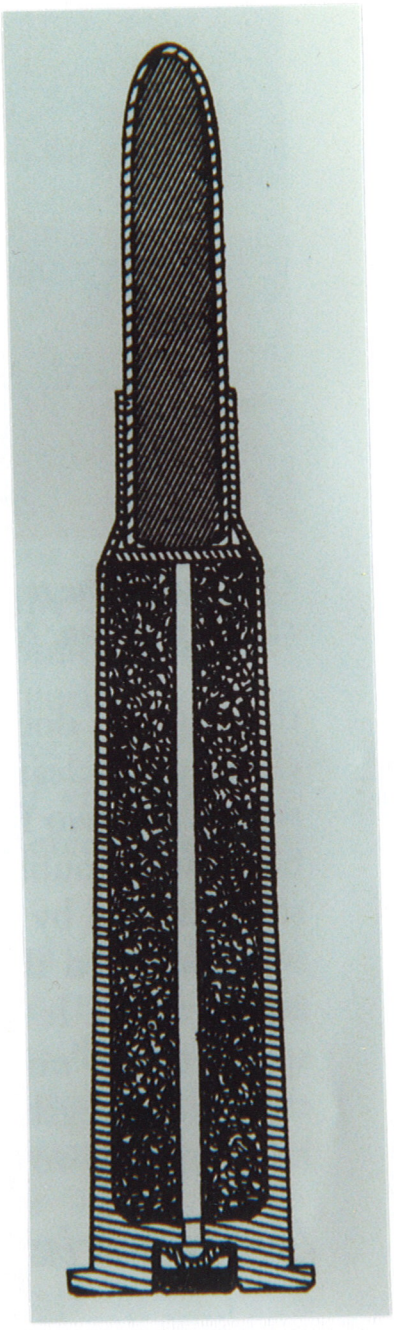
There were 36 of these boats in 1895. No one was allowed to go over the bridge while one of them was passing beneath,lest any dirt or grit should fall on the deck.



THE ROYAL GUN POWDER FACTORY.

This wheel is beside a single-storey brick building which retains its mid-nineteenth-century water-driven hydraulic pump.





THE ROYAL GUN POWDER FACTORY.

"The Royal Gun Powder Factory turns out about 500-tons of cordite and 5,000,000-lb. of black powder every year,though the output varies according to orders received. For our own part,we would far sooner work in the cordite factory than in the powder mills,for once the dough is mixed,cordite is absolutely safe to handle; indeed,you might hold a piece of it to a lighted match without causing any excitement it would simply burn.

When we had concluded our tour of inspection,twilight was falling upon the woods and streams of this strange place. Night-watchmen,armed with wonderful little electric hand lamps,fitted mysteriously here and there,and the electric lights immersed in water outside the windows of the danger buildings began to glow softly. We passed the explosive pond with a shudder of nervous apprehension,and left behind,as speedily as possible,the buried nitrating-house,wherein scarlet-clad men were manipulating the terrible liquid. The tremendous energy that lay dormant in every building oppressed us,even though that energy slept behind massive traverses and walls 10-foot thick;so we came away".

by William G. FitzGerald. 1895.

.303-inch SERVICE CARTRIDGE.

Bases of .303-inch cartridge cases filled with pellets of black powder weighing 71.5-grains,developing a muzzle velocity of 1,850-fps.