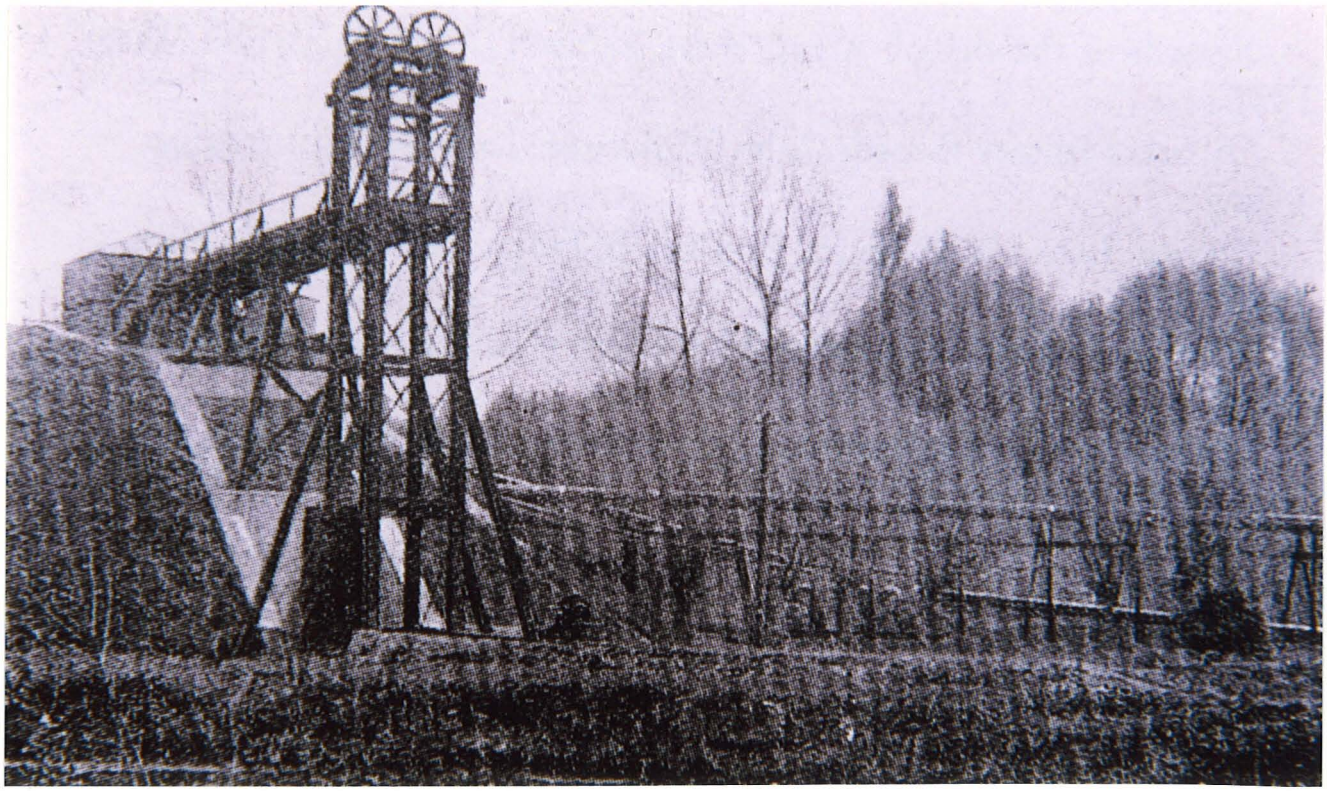
WALTHAM ABBEY POWDER AND CORDITE FACTORY 1899.

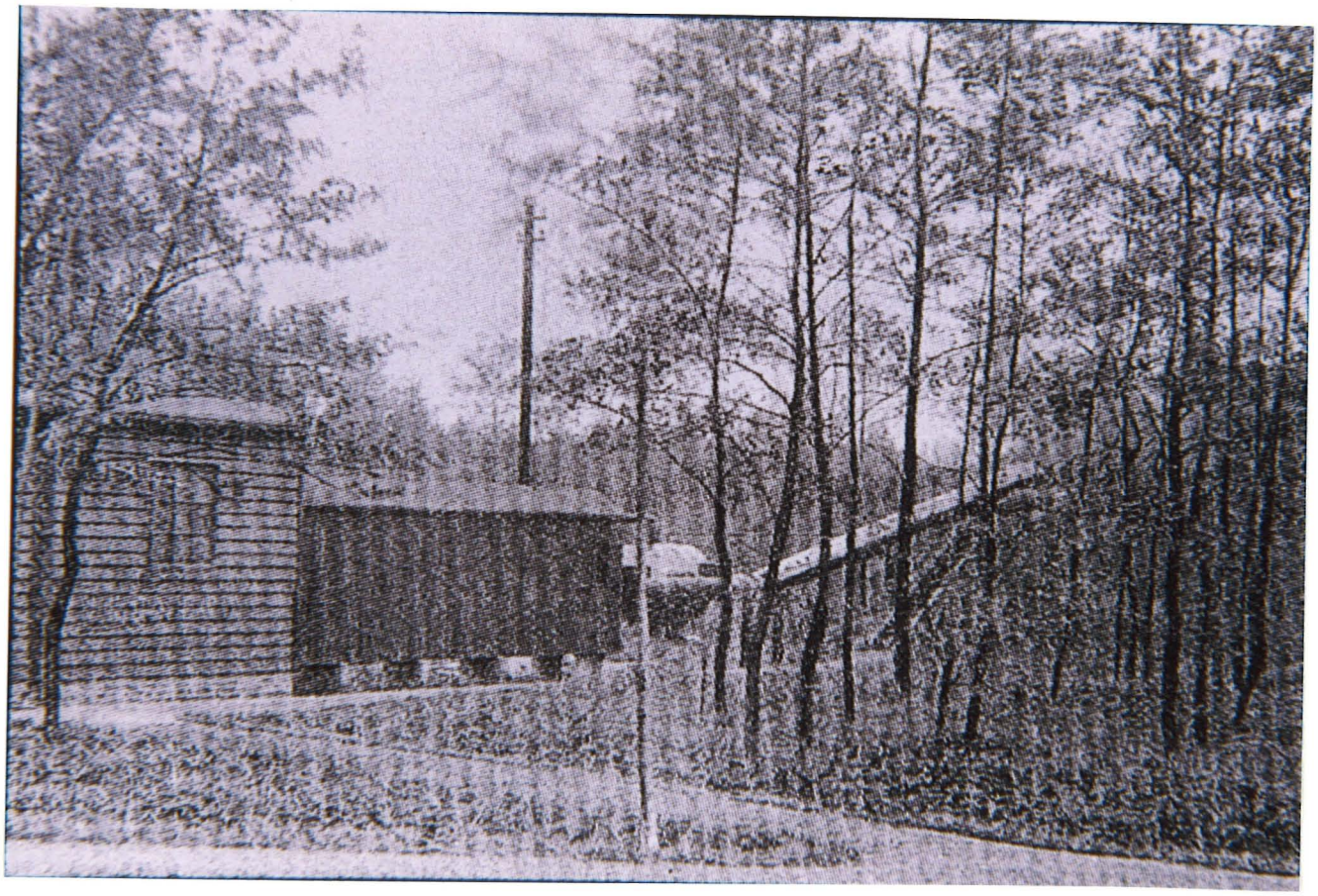
THE MANUFACTURE OF CORDITE.



'A Dangerous Rival to Gunpowder'

On 25th August 1846,Christian Friedrich Schonbein,Professor of Chemistry at Basle,used these words in a letter to Faraday with reference to the guncotton he had just been demonstrating at Woolwich Arsenal.

On May 27th of that year he had announced at a meeting of the Society of Scietific Research in Basle that he had produced a powerful new explosive by the action of a mixture of sulphuric and nitric acids on cotton.



Sir Frederick Abel

His Process For Making Guncotton.

Mixed acid consisting of 3 parts of 96% Sulphuric Acid to 1 part of 91% Nitric Acid was run into cast-iron dipping pans holding about 220-lbs. The pans were supported in an iron tank through which cold water circulated to keep the temperature at 70 degrees F and were provided at the back with gratings on which to press out some of the acid from the charge.

The charge of purified,dried and cooled cotton waste weighing 1-lb.4-ozs was raked into the acid as rapidly as possible and allowed to remain there for 8 minutes. It was then transferred to the grating and as much acid as possible squeezed out by an iron lever with a plate on one end. After a charge had been removed from the dipping pan about 13½lb.,of mixed acid was run into it to replace the acid removed with the charge.

The charge with its adherent acid,now weighs about 15-lbs.,and was transferred to an earthenware pot with a cover and placed in the cooling pit through which a stream of cold water flowed and where it remained 12 hours. The contents of the pots were then transferred to centrifugal machines which extracted the bulk of the acid. the guncotton was then placed in galvanised iron pans with long handles-these pans,when full,were carried quickly across to the immersing tank and the guncotton thrown into a large bulk of water,the workmen standing by the tank and pushing the guncotton at once under the water with a stout wooden paddle,the immersing had to be done as quickly as possible,as if the guncotton was allowed to come gradually in contact with the water it was liable to fume off. The immersing tank was fitted with a perforated copper plate to allow the water to overflow so that fresh water was constantly passing through the tank. When 2cwt had been immersed the inflow of water was stopped and the tank drained down. It was then refilled and drained again six times or until the cotton no longer tasted of acid. Then after further washing with water in a centrifugal the guncotton was fit for boiling and pulping.

Cordite.

To obtain a smokeless propellent which would remain constant in its ballistics,the Explosive Committee,of which Sir Frederick Abel was President,carried out a long series of experiments. The final result of their labours was the introduction of cordite into the British Services in 1888. The propellent consists essentially of nitroglycerine and guncotton gelatinized and blended together by the aid of a solvent (acetone). A small proportion of mineral jelly is incorporated into the mixture; originally introduced to prevent metallic fouling of the rifle,experience has shown mineral jelly to operate beneficially in cooling the propellent and in helping to maintain its uniform stability under varied climatic conditions. The name "Cordite" was chosen for this propellent owing to the cord-like form in which it is manufactured.

This explosive has proved,after years of use,to be satisfactory in its stability both chemically and ballistically. Its main defect is the erosion it produces,particularly in heavy ordnance,owing chiefly to the great heat it develops. To overcome this defect,a cooler propellent was worked out. This propellent,which is known as Cordite M.D. (modified cordite) contains the same three ingredients,but in different proportions.

Experience with Cordite M.D. has shown it to give rise to more erosion than certain other propellents,but it remains still one of the best rifle powders.

During WW1 certain other propellents were introduced into British Service. Acetone,the solvent which is used in the manufacture of cordite,could not be obtained in sufficient quantity,and a modified composition known as cordite R.D.B. was introduced. This could be made with a mixture of ether and alcohol,solvents which were readily available,but the propellent was never used for small arms.

The British factories were also incapable of turning out the enormous quantities of propellent required during the war,and it became necessary ti purchase supplies from America. As the American factories were not equipped for the manufacture of cordite,but for nitrocellulose powders,and as these were found to shoot satisfactory in British guns,enormous quantities of nitrocellulose powders were introduced into the British Service. The American rifle propellent,originally known as Dupont No.16 powder,is now termed N.C.Z. in the British Service.

Cordite.

The mixture,numbered 128 in the original series,became "Cordite,Mark 1"
Its composition was:-

Nitroglycerine	58.
Trinitrocellulose	37.
Vaseline	5.

The name "Cordite" appears to have been first used in the Proceedings of the Committee for the 5th of 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 Superintedent,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.

Start of Cordite Manufacture.

The erection of the first cordite factory at Waltham Abbey and its start up ran parallel to the manufacture of nitroglycerine there. The first nitroglycerine made was immediately incorporated with guncotton and left Waltham by barge on 21st March,1891,to be pressed at Woolwich.

By 11th of May,1891 complaints were received of irregular performance of Waltham Abbey Cordite,anf the Superintendent replied that he was not surprised at irregular results as arrangements were far from satisfactory "It is incorporated here,pressed at Woolwich,mixed here-for you cannot call it blending-and,so far as I am aware,never tested before it is issued.

By 20th May,however,a considerable degree of success had been achieved for we find Thomson (the Manager) asking Skerman (the foreman imported from Woolwich) how many men and boys he would require to press,reel and cut two tons of cordite a week,if he had enough presses,etc. Pressing started at Waltham on 17th June,and on the 7th July the Explosives Committee paid theit last visit of inspection to Waltham. Cordite had been well and truly launched by this band of pioneers.

Manufacture of Cordite 1895.

by William G. FitzGerald.

Let us now turn to the manufacture of cordite,that new and terrible explosive which eminent experts tell us will increase a hundredfold the carnage on the battle-fieldd of the next European war in which we are engaged. The following facts attest the tremendous power of this explosive: The charge of ordinary black powder for the service rifle is 70-grains,and this gives a muzzle velocity of 1,850-fps. A cordite charge of 30-grains gives a velocity of 2,000-fps. Again,the powder charge for the 12-pounder gun is 4-lb.,while the cordite charge for the same weapon is 15 3/4-oz.; and the latter gives far better results. As cordite is primarily founded on gun-cotton,we first visited the picking-room,under the courteous guidance of Captain Nathan,the cordite superintendent. Girls pick over the cotton waste,which comes from the Manchester spinning mills in hundredweight bales,and costs about £30 per ton. It will be seen that the connection between peaceful trade and this formidable explosive is as close as it is curious. The stuff 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 twenty-four hours,the lots,or charges,are ready for dipping. Each dipping pan contains 220!lb. of mixed acid- three parts of sulphuric and one of nitric acid. The operator simply 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 13½-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 he proceeds to remove the saturated cotton from the bath or pan. He has an earthenware pot ready to receive the charge. The earthenware vessels containing the charges are then allowed to stand in shallow water for some little time. From the earthenware vessels the cotton is shot into a centrifugal machine,whirling round at a speed of 1,200-rpm. 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,where 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 2½-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 gun-cotton press-house is furnished with what is called a protective rope mantelet,or wall of rope,such as is used in fortifications.

Picking Cotton For Cordite.

Women picking over cotton waste,in order that fragments of wood,rope,wire,and rag may be removed.

To make cordite,the dry gun-cotton is taken to the nitro-glycerine house,a wholly extraordinary building,literally buried under a mound or hill,and approached by a burrow-like,brick-lined passage in the earth. The two most dangerous nitro-glycerine houses. Beneath the mound on the left is the washing-house; the other building to the right is the nitrating-house. The dry gun-cotton,as we have said,is taken to the nitro-glycerine house in boxes,and it is there saturated with nitro-glycerine,an almost colourless liquid. Should a single drop of this fall on the leaden floor,it is instantly wiped up with a damp cloth.
The saturated gun-cotton is now called "cordite dough",and it is taken direct to the kneading-house. The men wear curious respirators as they bend over the sticky mass,which gives forth nauseous and deadly fumes. When throroughly 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 component parts of cordite,by the way,are as follows: nitro-glycerine 57 parts,gun-cotton 38 parts,and five parts of mineral jelly,this latter being added three and a half hours after the dough or paste has been in the incorporating 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-hous. There 1 1/4-lb. of cordite paste is pressed and moulded; the mould and its contents are then placed in another machine,and,to the amazement of the onlooker,out comes 2,000-ft. of what looks like brown twine,with a diameter of .0375-in. This is finished cordite,and it is wound upon a reel. For 6-inch quick-firers,cordite with a diameter of .3-in. is turned out,and as it emerges from the machine it is cut into 14-inch lengths.
An interesting operation called "ten-stranding" takes place. Ten reels of cordite,just as they come from the machine,are fixed in a rack and are wound simultaneously on to a single reel,the object being to secure uniformity of explosiveness. Furtermore,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 whose hands it has passed through accompany each reek; and the end of the thread is secured with a band of webbing. Ultimately,the cordite is cut into little bits and made into bundles for the cartridge cases,but this work is not done at Waltham.

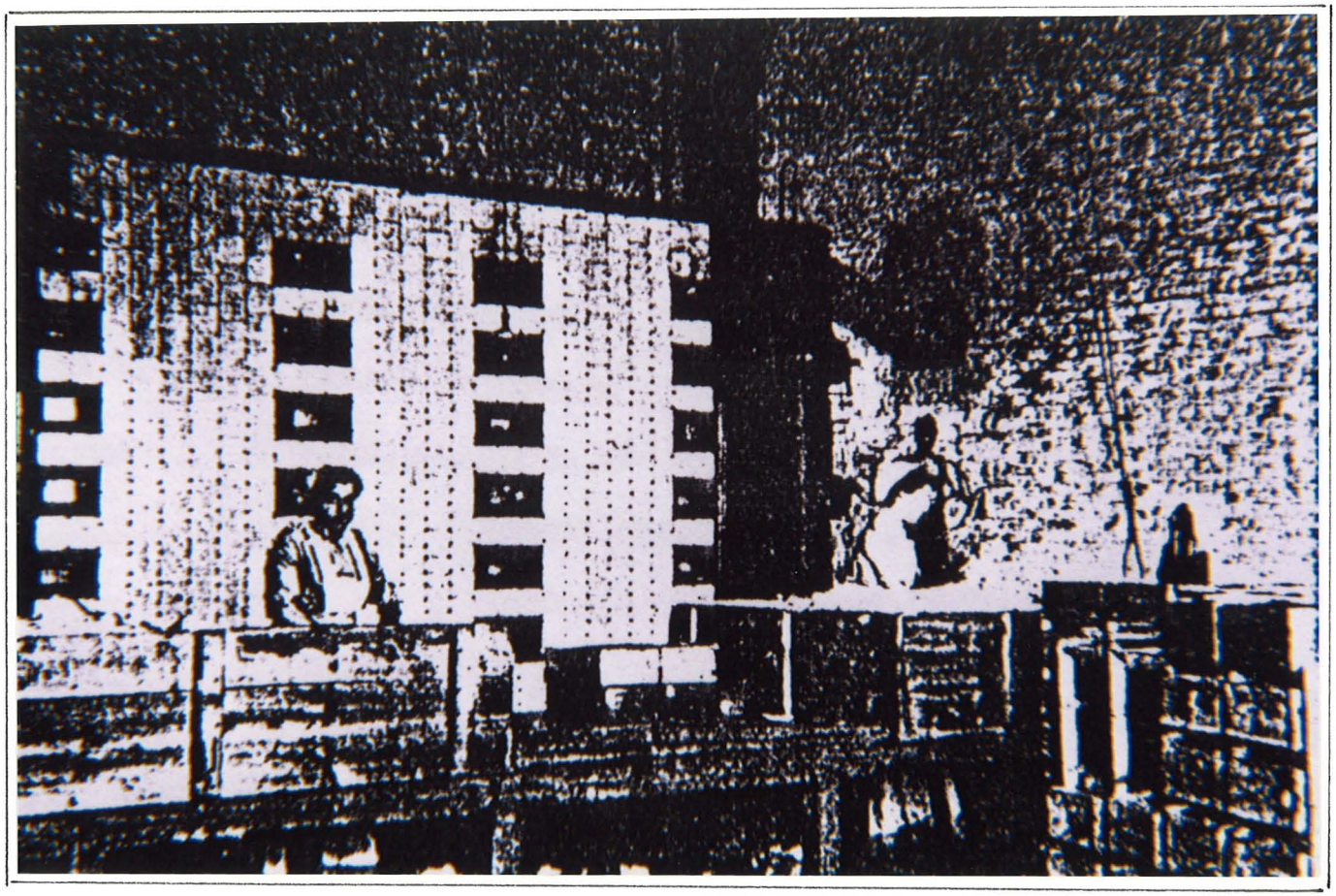
In a pool adjoining the cordite works all water from the various nitro-glycerine houses is most carefully drained,since such water contains a certain quantity of nitro-glycerine. Every Saturday this extraordinary pond is blown up by means of a dynamite cartridge,in order to get rid of the explosive matter it contains. After the terrible explosion in the nitro-glycerine house,on the 7th of May,1894,when four men were blown to pieces,such a large quantity of nitro-glycerine accumulated in the pool that when it came to be blown up,the result was really startling Colonel Ormsby,the general superintendent of the works,has lent us,for reproduction,a photograph taken immediately after this particular blowing-up. A glance will reveal the tremendous force of the explosion,which blew holes 20-feet deep around the pond.

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 hurles its projectile 17-feet 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 Gunpowder 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,flitted 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-feet thick; so we came away.

THE WEIGHING AND DRYING ROOM.

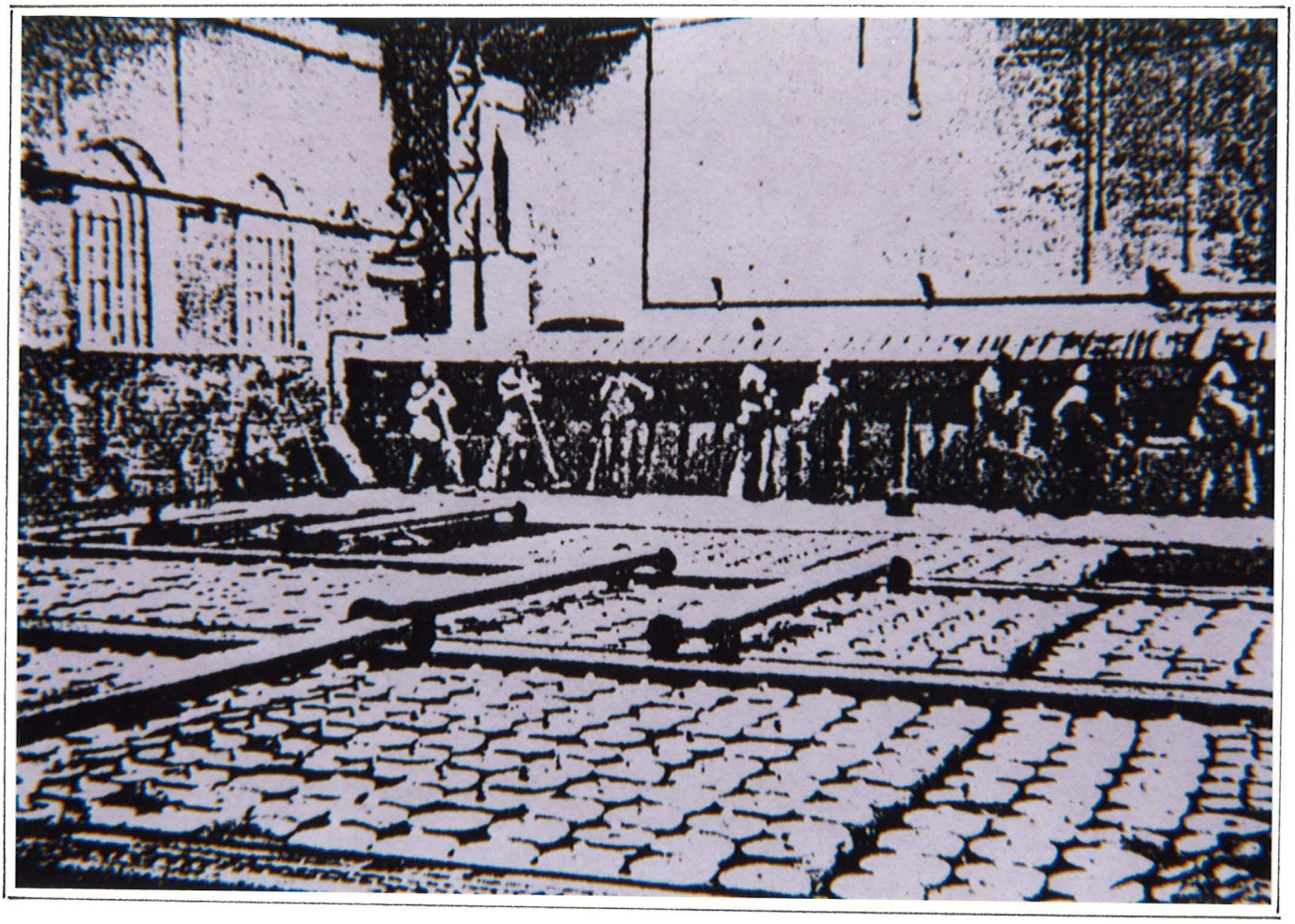


The cotton is picked carefully in order that fragments of wood, rope,wire,and rag may be removed. The cotton waste is then thrown on to a powerful teasing machine,which rends and tears its fibre; after this it is cut up by another machine,and then it passes on an endless band into a drying-room heated to 180 degrees. The cotton is then weighed up into lots of one and a quarter pound,and each lot is placed in a tin cooling box; these operations are shown in the picture.

THE DIPPING TANKS.

The cotton soaked in acid is taken from the dipping tank and placed into an earthenware pot.

THE COOLING TANKS.

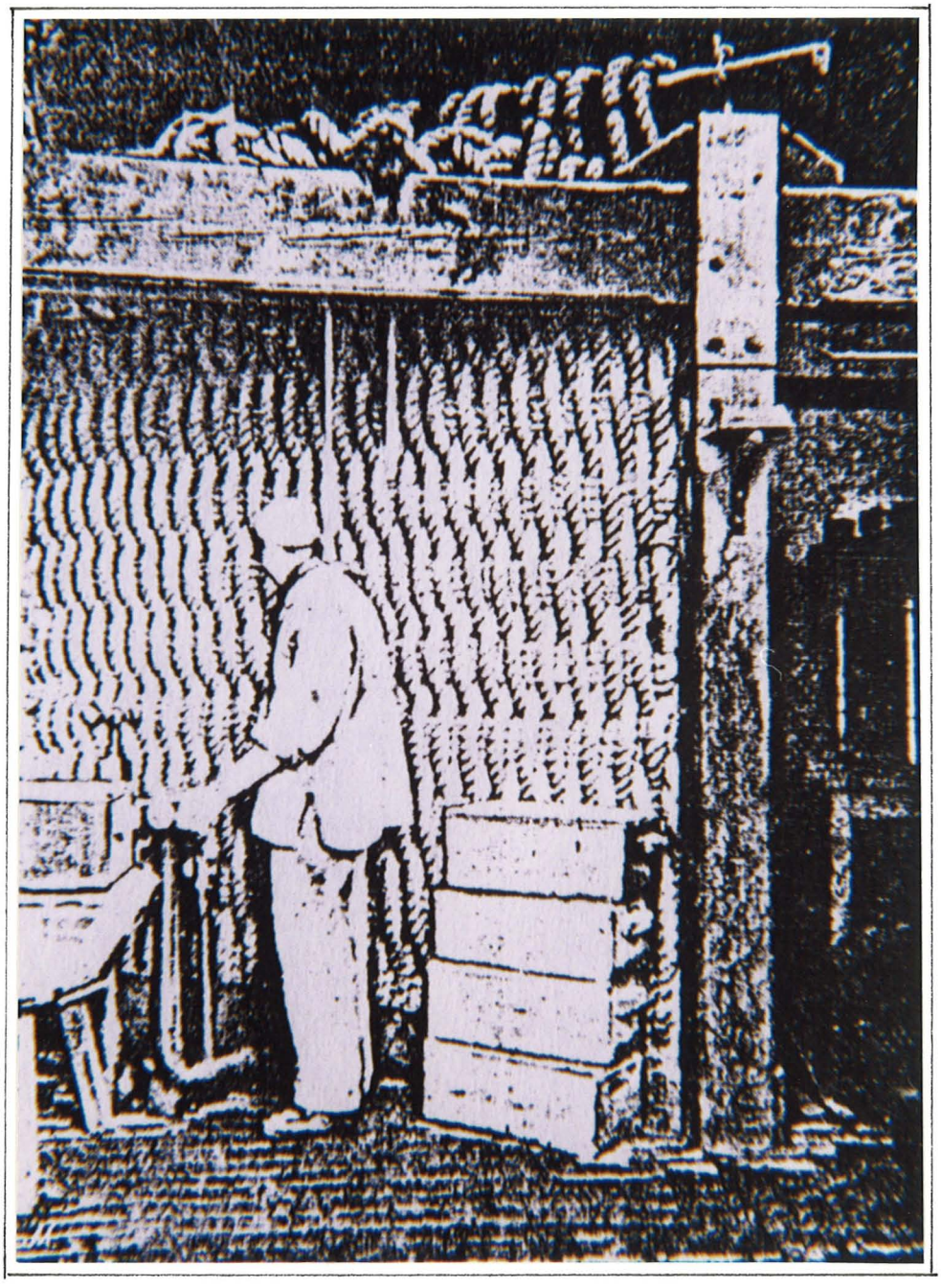


The earthenware pots containig the charges are allowed to stand in shallow water for some little time.
The picture is a general view of the cooling tanks,with the dipping baths in the background.

THE BOILING VATS.

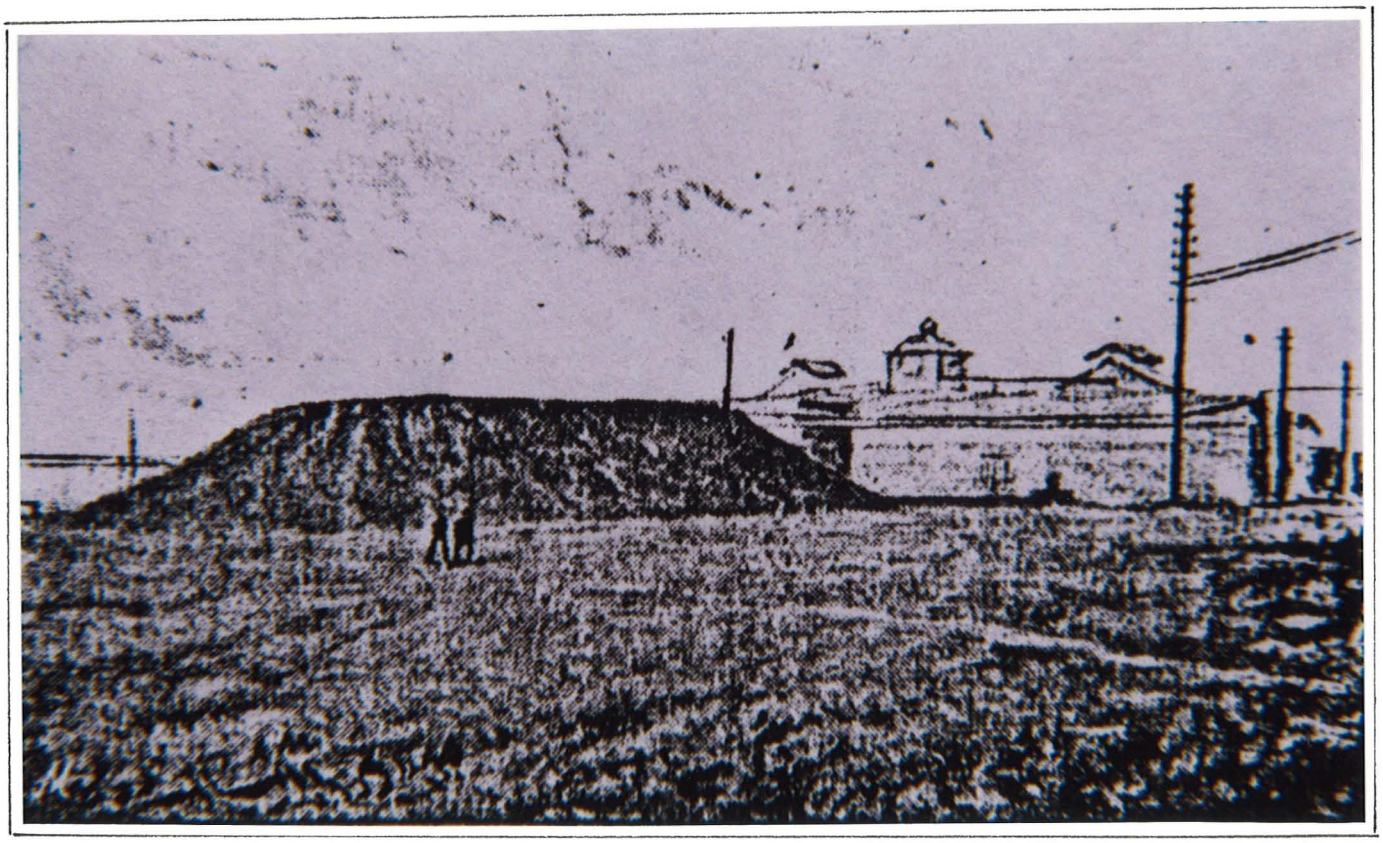
The water is wrung out and the cotton is then removed to the vat-house,where it is then removed to the vat-house,where it is boiled in monstrous vats for four or five days. Each vat holds about 18cwt of cotton.

THE CORDITE PRESS HOUSE.



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

THE NITRO-GLYCERINE WORKS.



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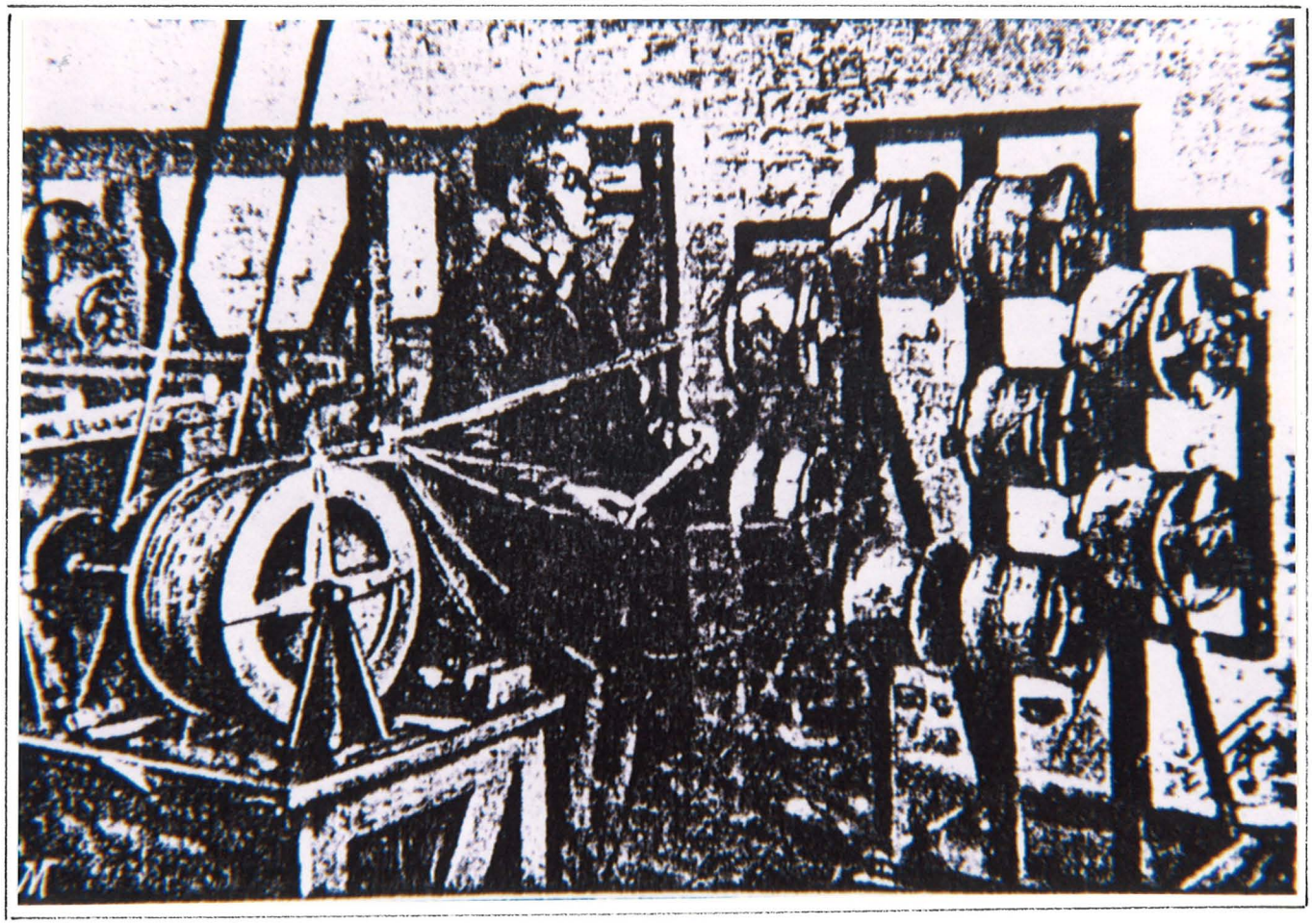
Beneath the mound on the left is the washing-house; the other building to the right is the nitrating-house.

MIXING CORDITE DOUGH.

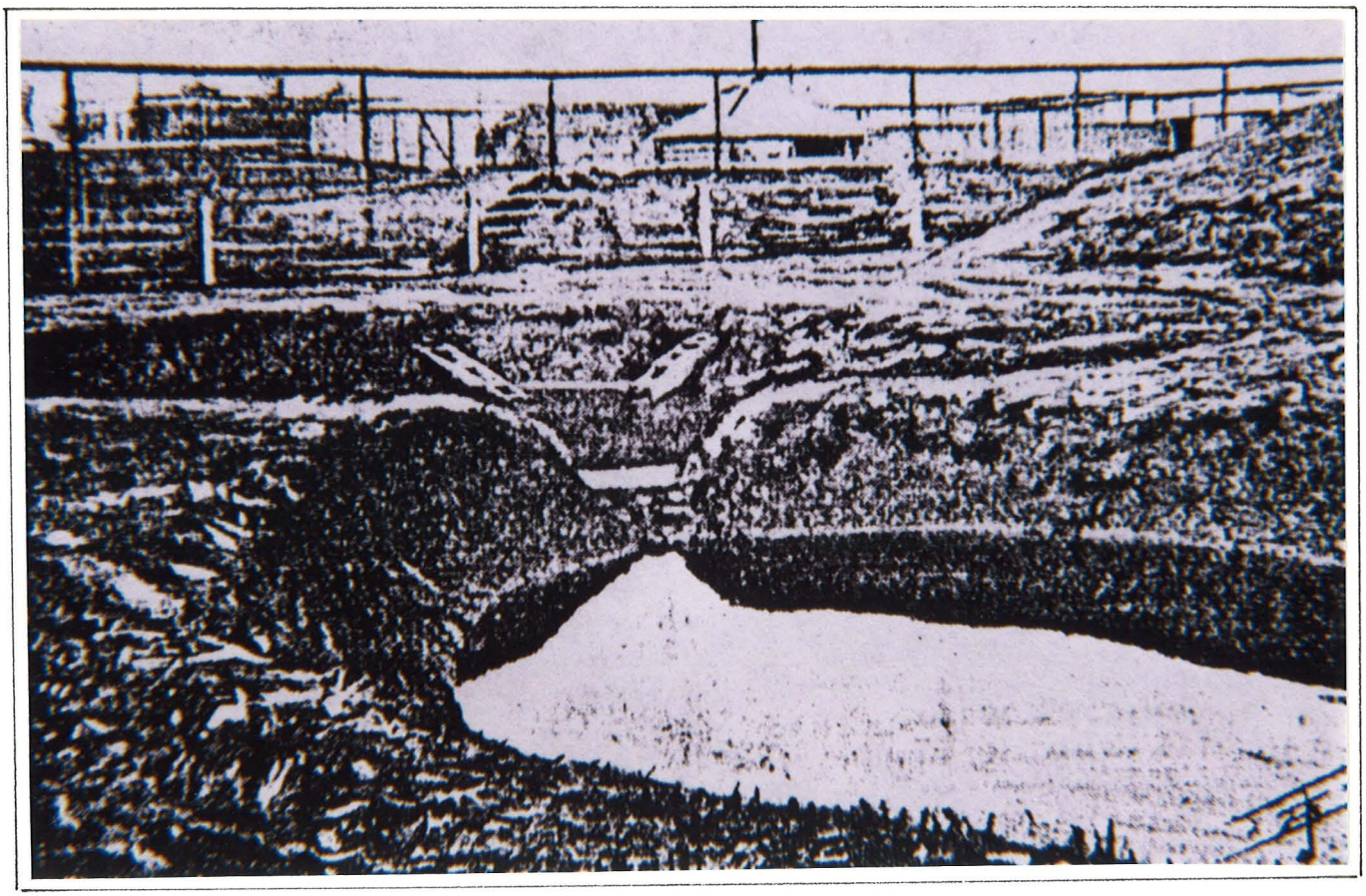
The saturated gun-cotton is now called "cordite-dough",and it is taken direct to the kneading-house. The men as may be seen from the picture,wear curious respirators as they bend over the sticky mass,which gives forth nauseous and deadly fumes.

"TEN-STRANDING".



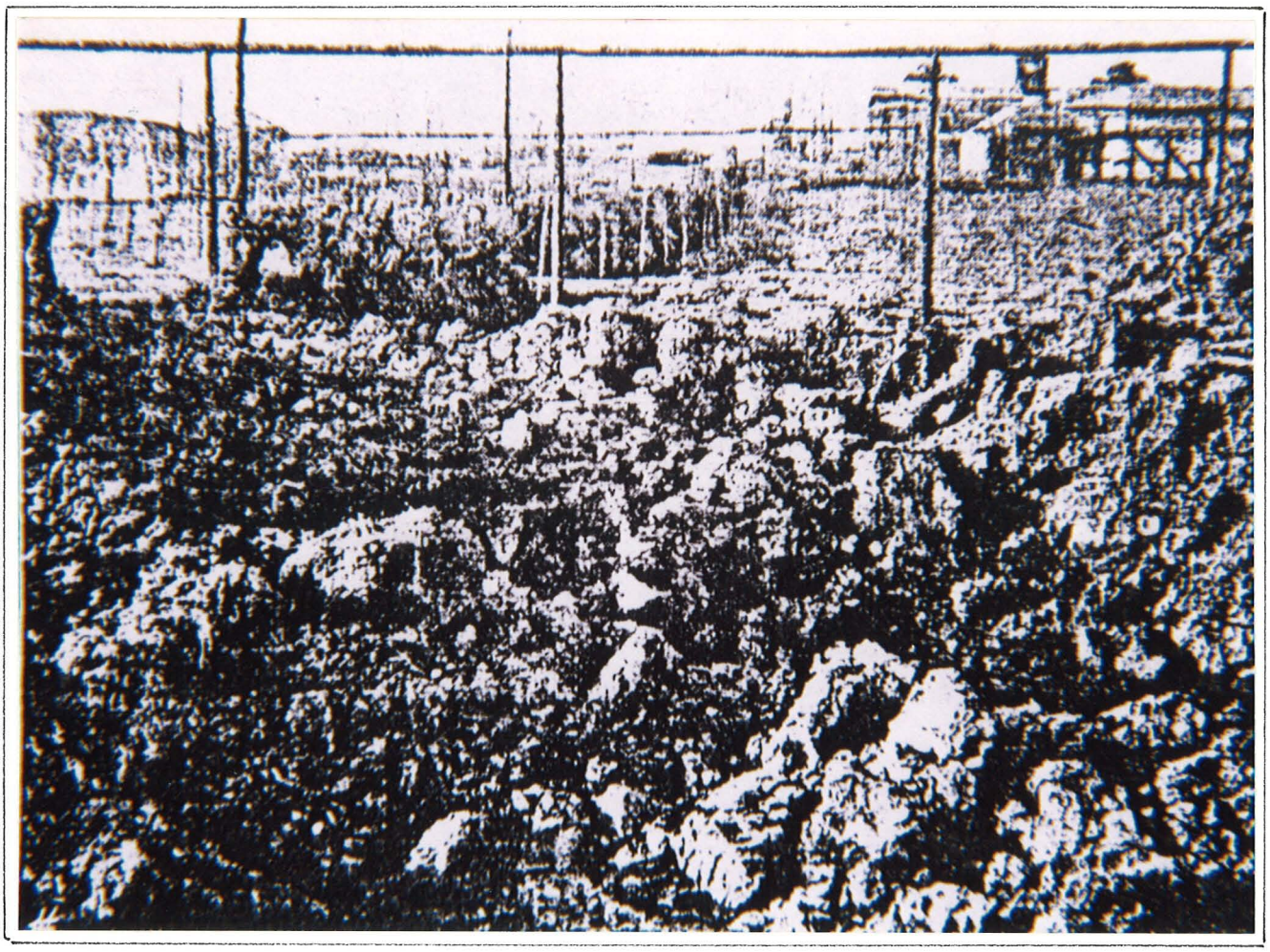
The picture shows the interesting operation of "ten-stranding". Ten reels of cordite,just as they come from the machine,are fixed in a rack (the lad in the illustration is about to fix the tenth reel) and are wound simultaneously on to a single reel the object being to secure uniformity of explosiveness.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

THE SETTLING POND.



A pool adjoining the cordite works is shown. Into this pool all water from the various nitro-glycerine houses is most carefully drained,since such water contains a certain quantity of nitro-glycerine. Every Saturday this extraordinary pond is blown up by means of a dynamite cartridge,in order to get rid of the explosive matter it contains.

THE POND AFTER AN EXPLOSION.



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Cordite.

Explosions.

Despite precautions taken,there was a number of explosions that destroyed buildings and ramparts,with resulting casualties.

Manufacture of Small Arms Propellant.

The manufacture of practically all natures of smokeless small arms propellants is generally conducted on the same broad lines,and the principle operations may be summarized as follows:-

1. Manufacture of stable nitrocellulose.
2. Incorporation of the nitrocellulose with other ingredients together with a solvent to form a plastic colloid.
3. Formation of the plastic colloid into shapes of definate dimensions.
4. Elimination of the solvent.

WALTHAM ABBEY POWDER AND CORDITE FACTORY 1899.

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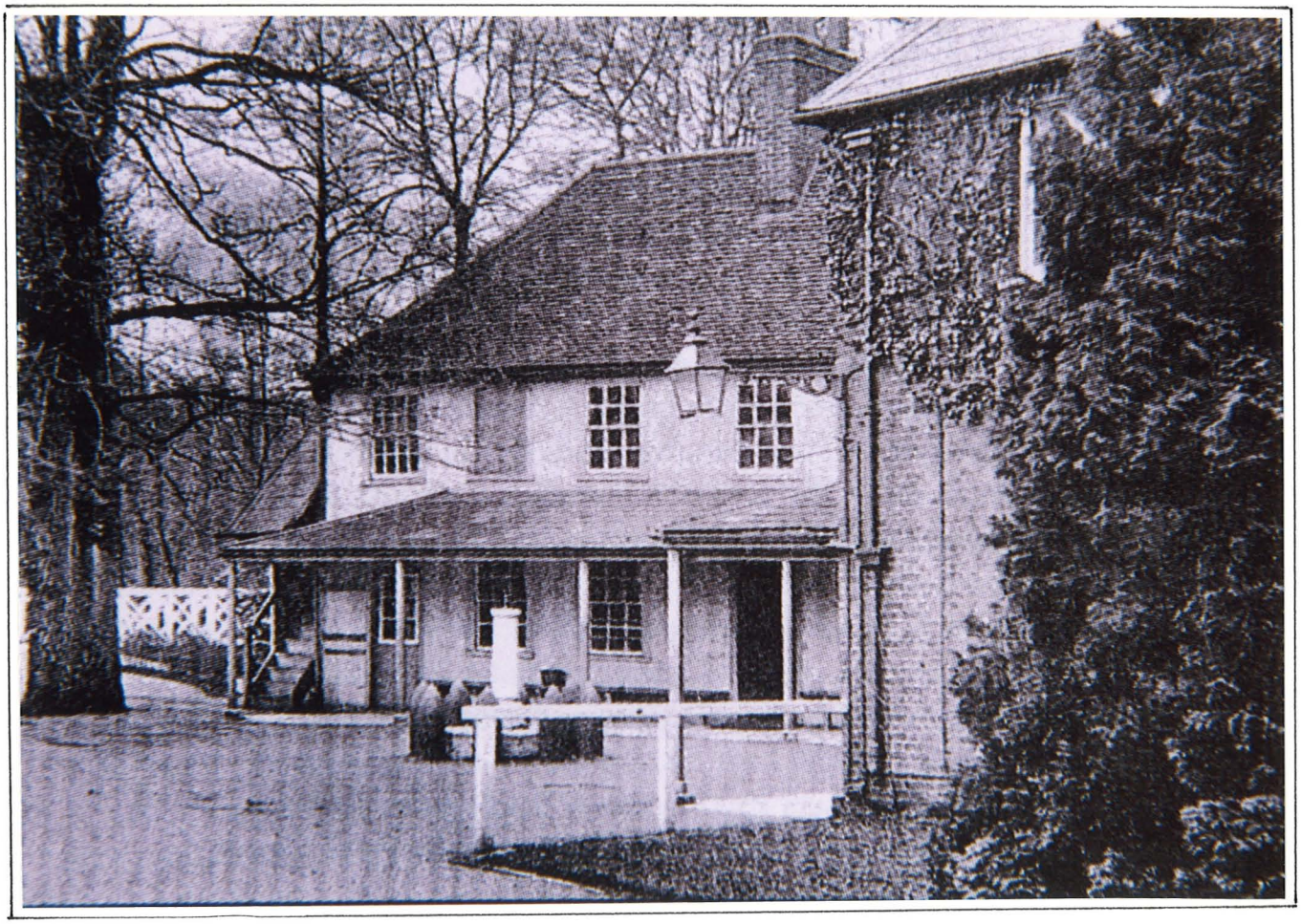
290 separate buildings,comprising iron and wooded huts were situated at considerable distances from one another. Of flimsy construction so as to offer little resistance in the event of an explosion,the huts were positioned between,in some cases,high earth banks with brick ramparts and in most cases,plantations of popular and alder trees. They were positioned alongside four miles of navigable waterways which enabled the explosives to be trasported easily and with a minimum of danger. All the buildings were however,linked by an extensive and tortuous series of steam heating pipes which kept an even temperature in the work places throughout the winter months.
In 1899,command of Waltham Abbey was in the hands of Colonel John Ormsby RA,who had wide experience in matters of ordnance and warlike stores. His past had,until a few years before,been chiefly concerned with production of black powder,but,at the turn of the century,cordite was the propellant then in favour.



Gun Cotton.

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 a lead conduit,the nitric followed by the sulphuric,both flowing into clyindrical 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.

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

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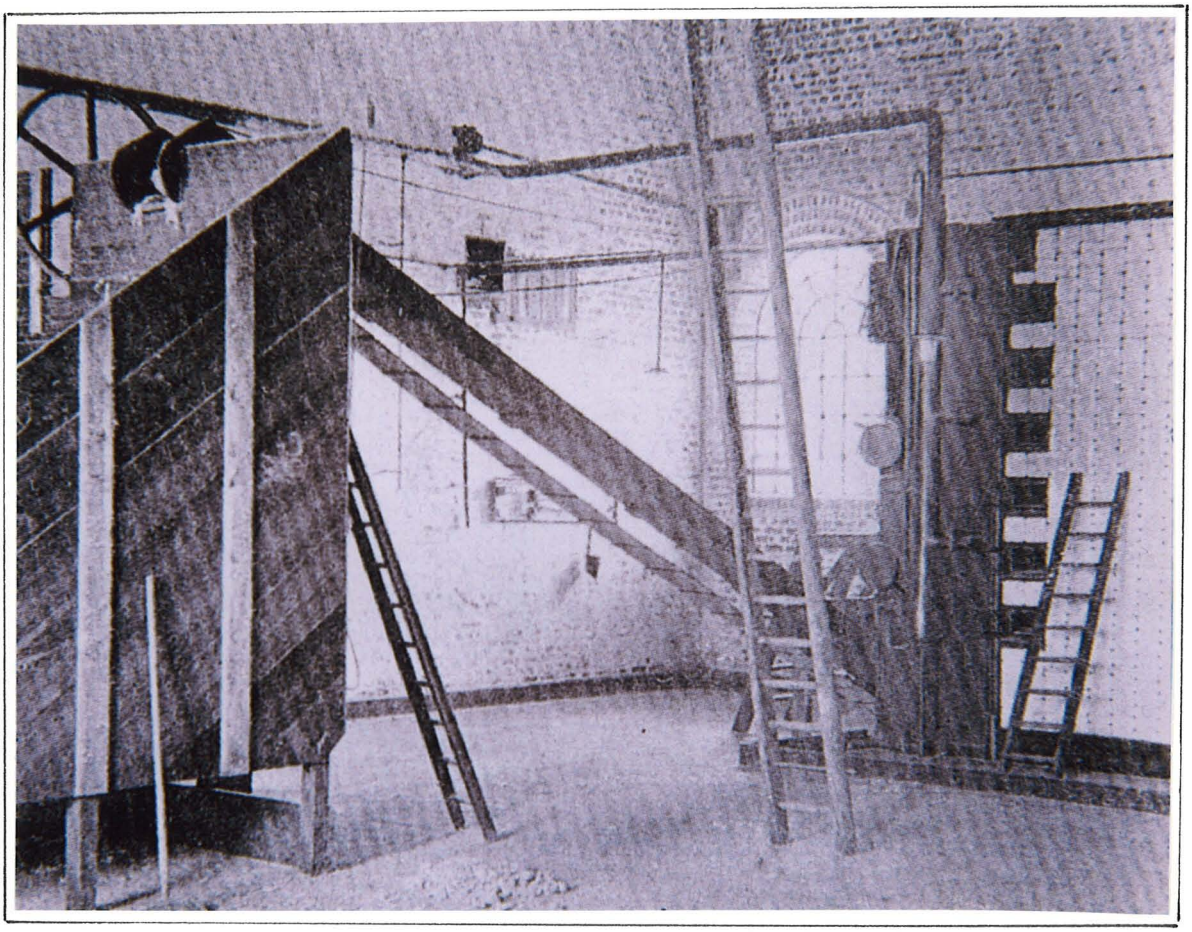

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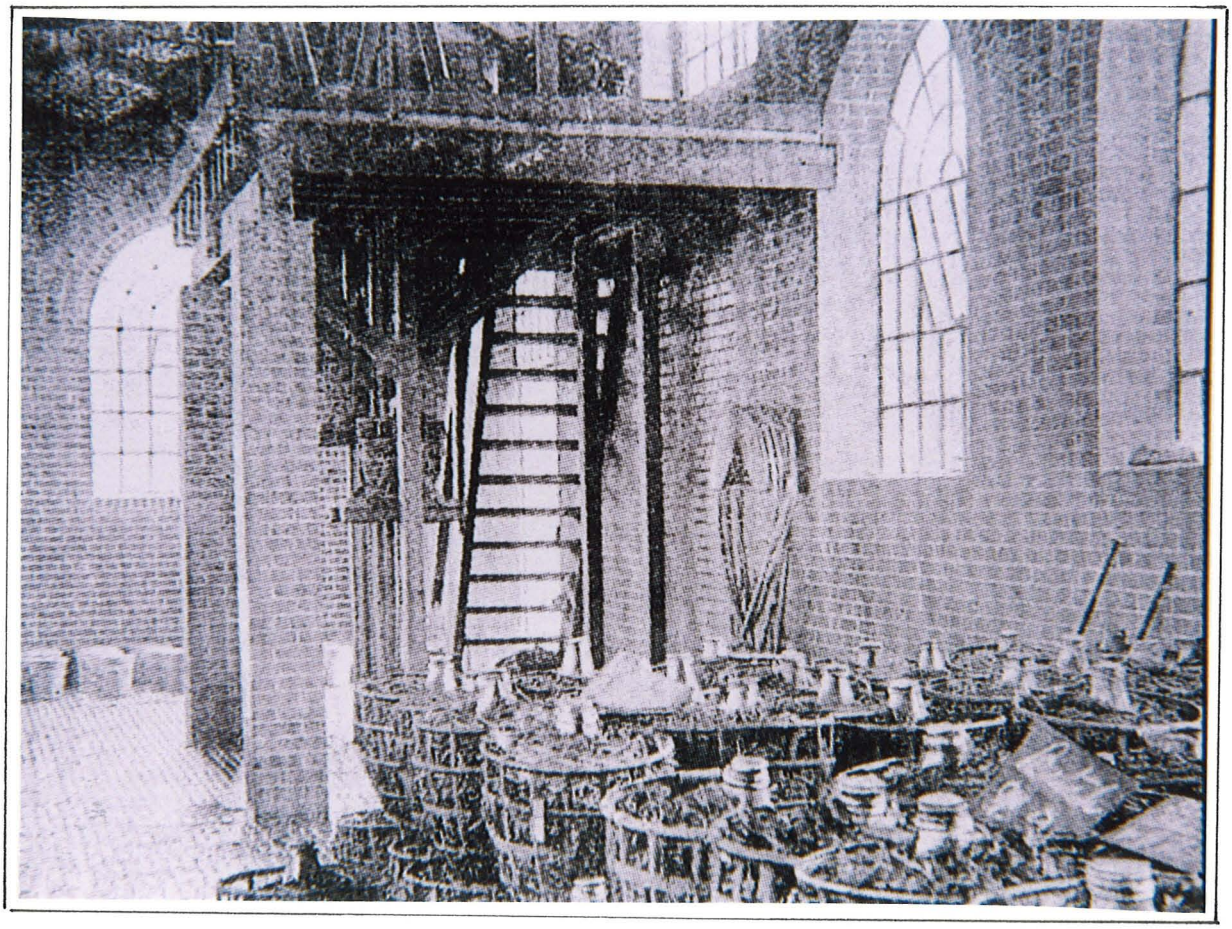
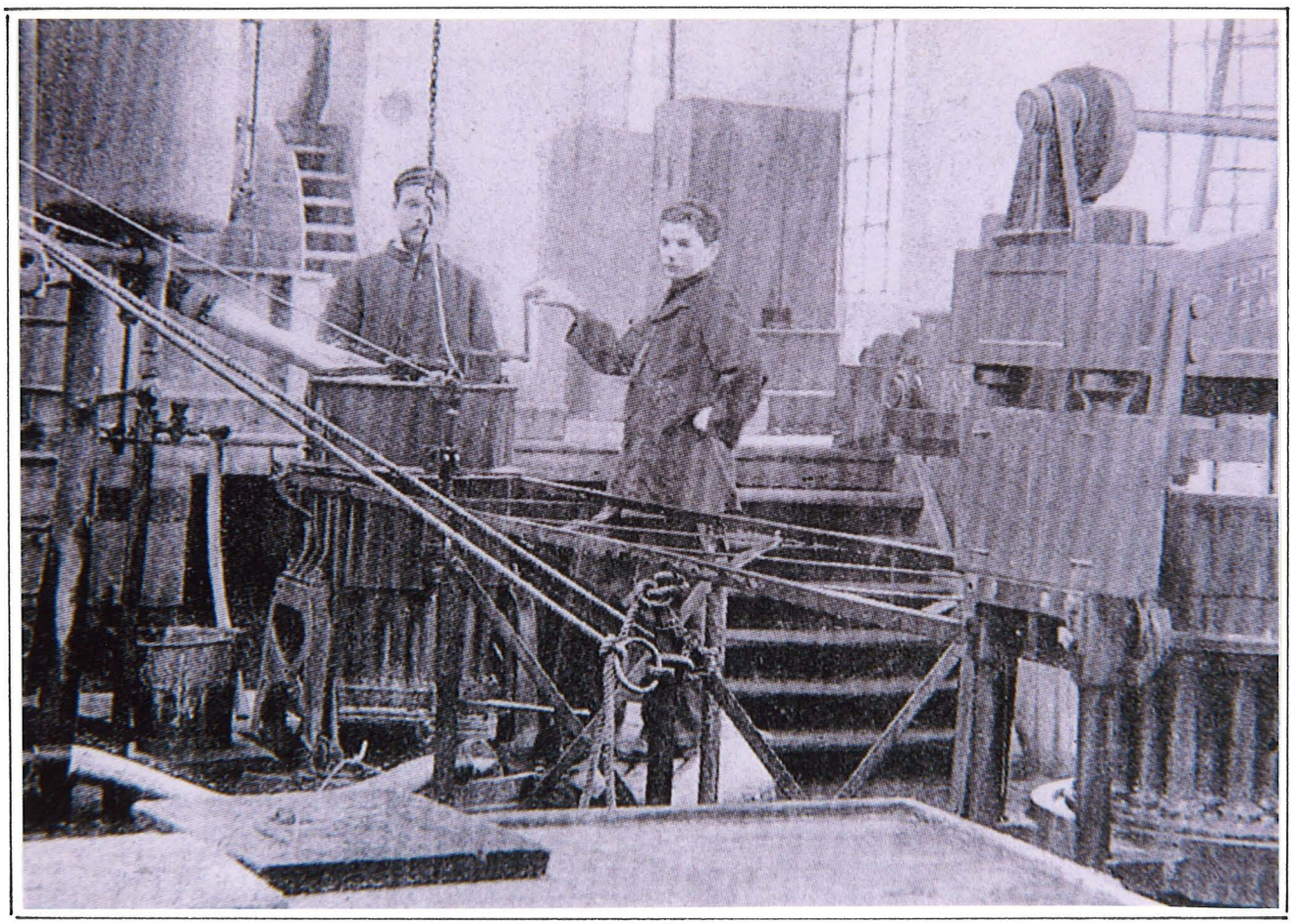


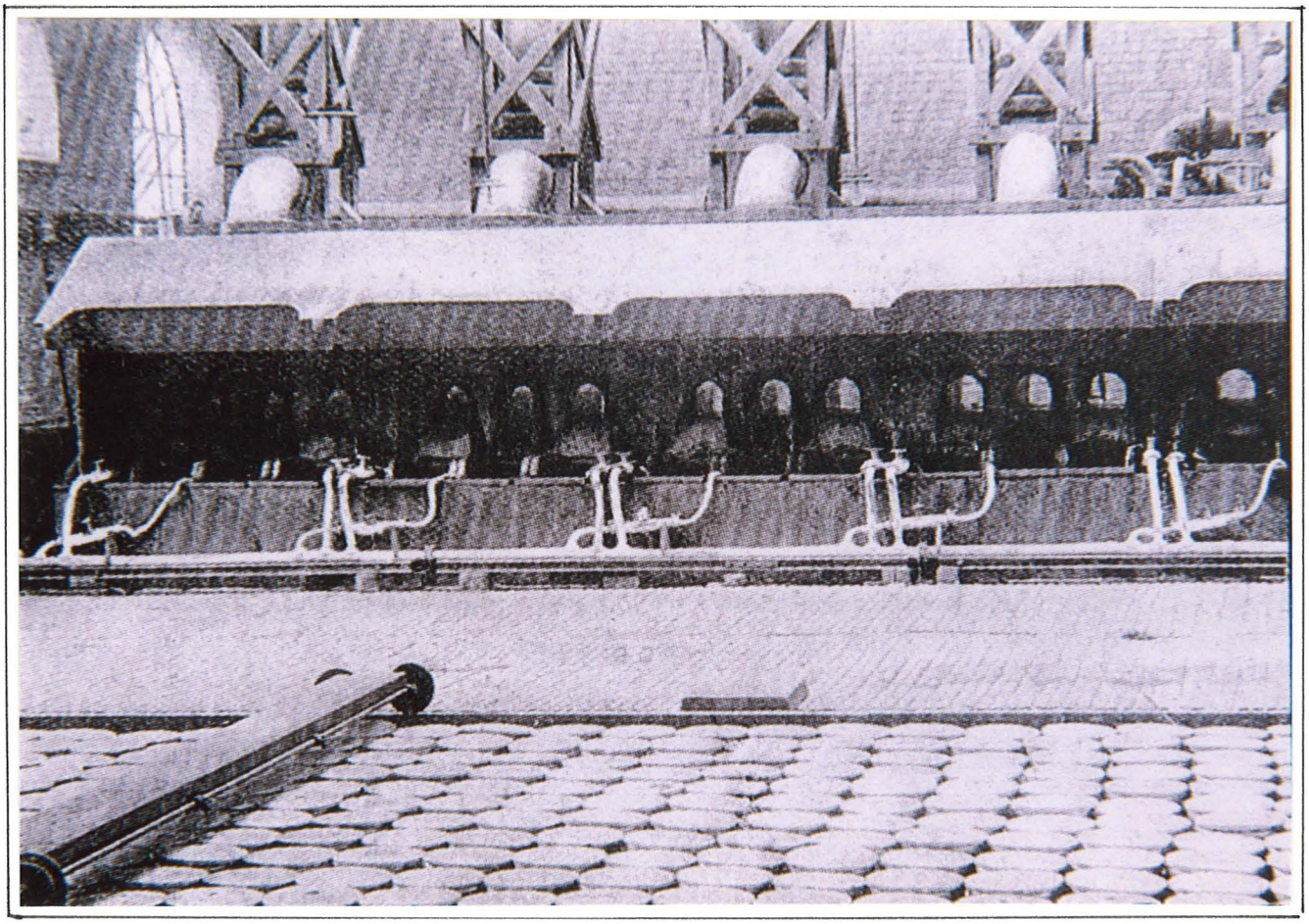
Gun Cotton.

Each pack 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.



Cooling Tank.

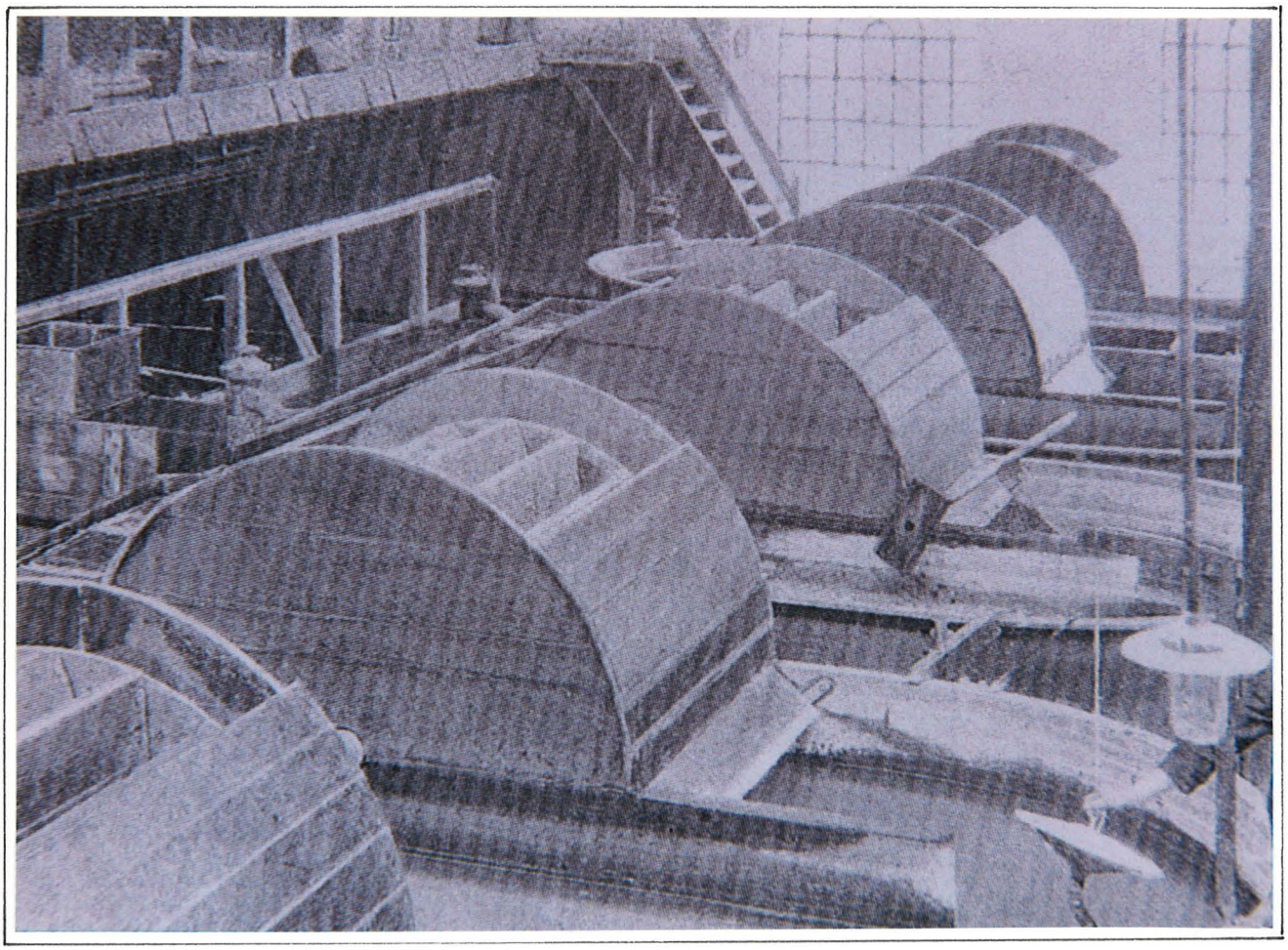
Earthenware vessels containing guncotton soaked in acid, standing in shallow water to cool. Dipping tanks can be seen in the background, these contain acid.



Gun Cotton.

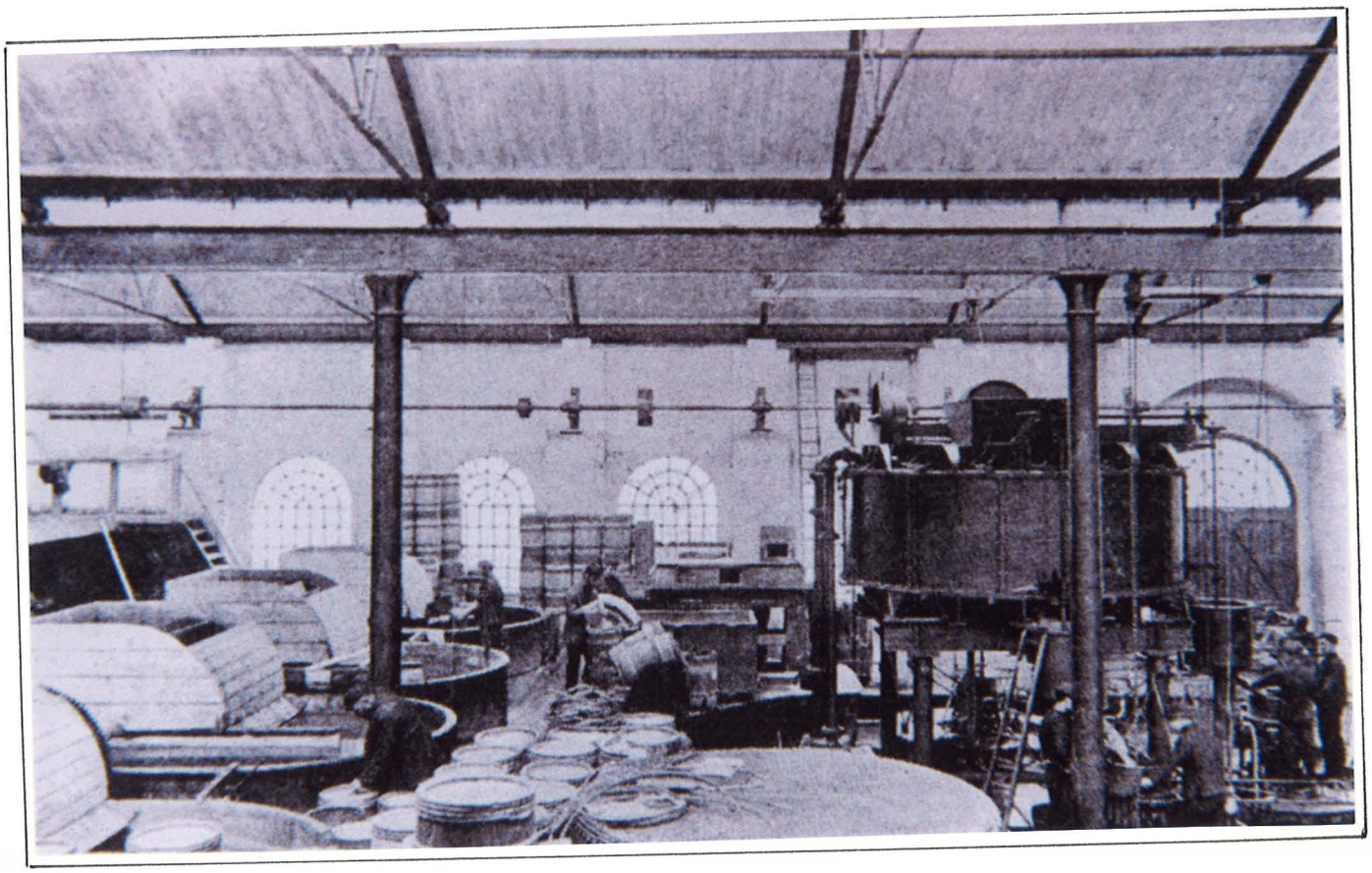
The Pulping Room.

The cotton was minced and again thoroughly washed.



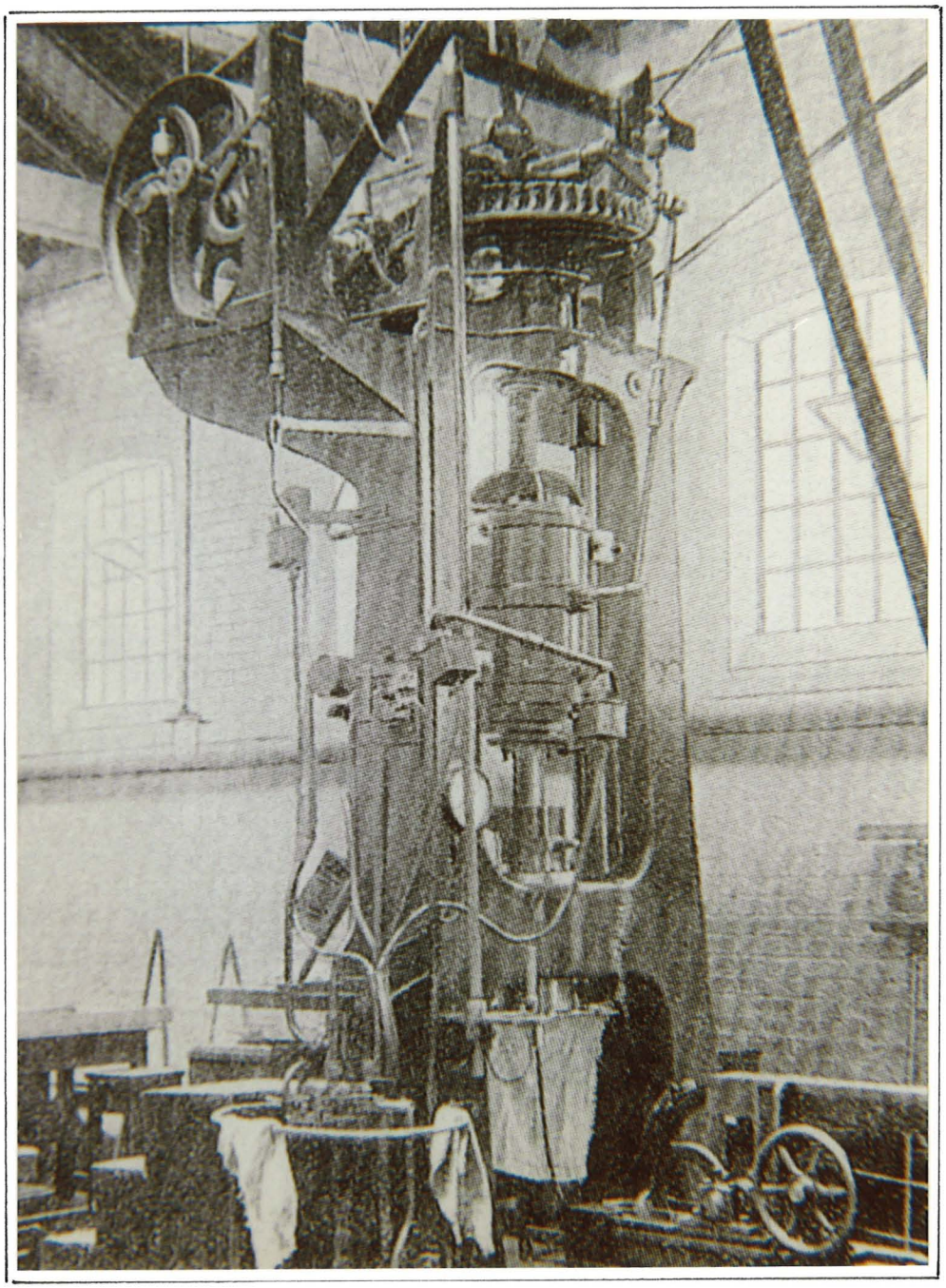
Gun Cotton.

The pressing and moulding room. The press on the right was probably for the hydraulic moulding of gun cotton slabs.



Gun Cotton.

The cotton was washed thoroughly to remove all trace 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 excess water drawn off,the remaining cotton was transferred to a press and formed into discs. Having still 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 the water content to 14%.



Massive press for extruding cordite into cords

Cordite.

The nitro-glycerine part of Cordite was obtained by the action of nitric and sulphuric acid on glycerine,resulting in a heavy,oily fluid,straw-like 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.

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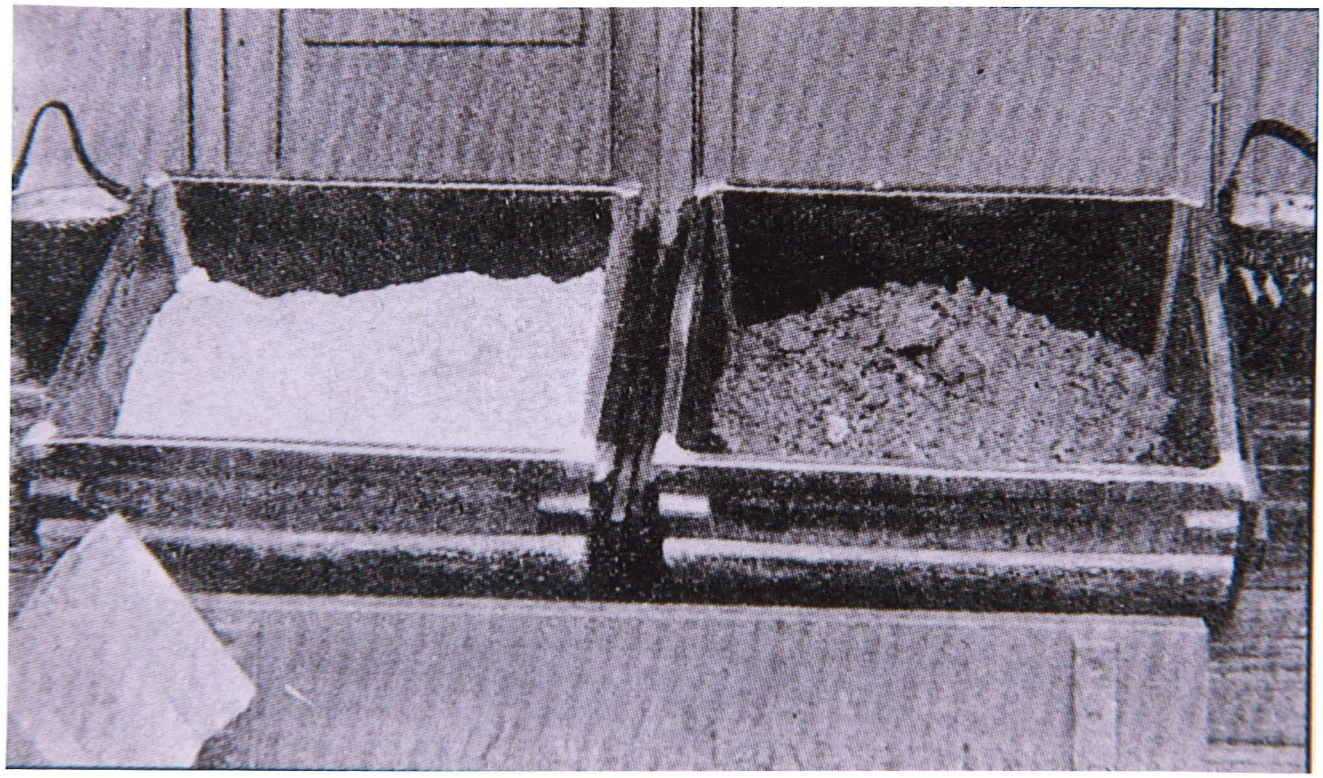
The nitro-glycerine part of Cordite was obtained by the action of nitric and sulphuric acid on glycerine,resulting in a heavy,oily fluid,straw-like in colour.
Nitro-glycerine is exceedingly sensitive to concussion. For ease of handling and to limit possible damage by explosion,relatively small quantities 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.

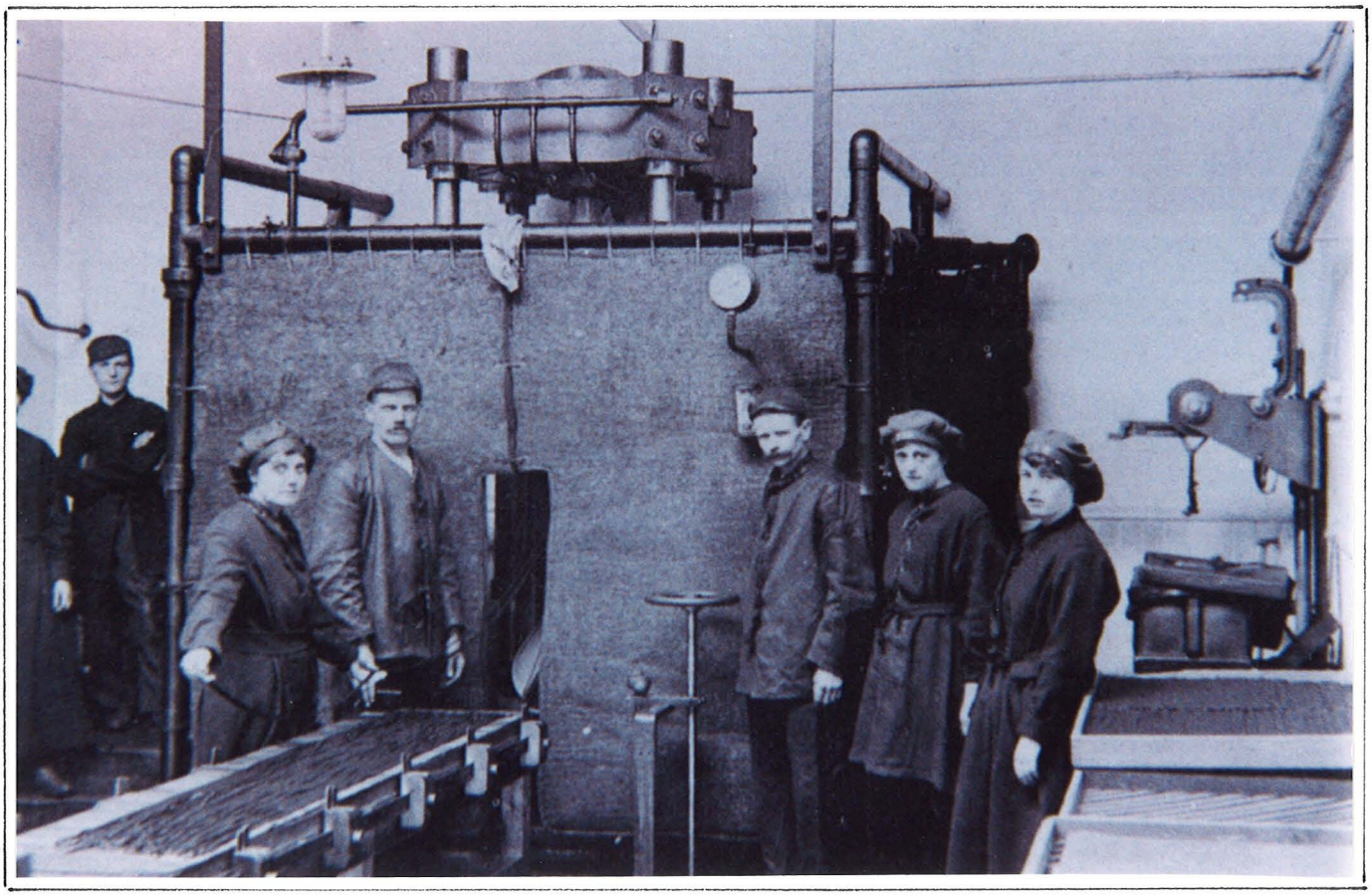


Cordite.

Acetone.

Drums being transported by barge,c.1895. These are thought to contain acetone which was first used in the manufacture of cordite in 1889.
Acetone,a derivation of acetate of lime,dissolved and amalgamated the gun-cotton and nitroglycerine for the purposes of moulding both into shape. The excess solvent was removed by drying under gentle heat.

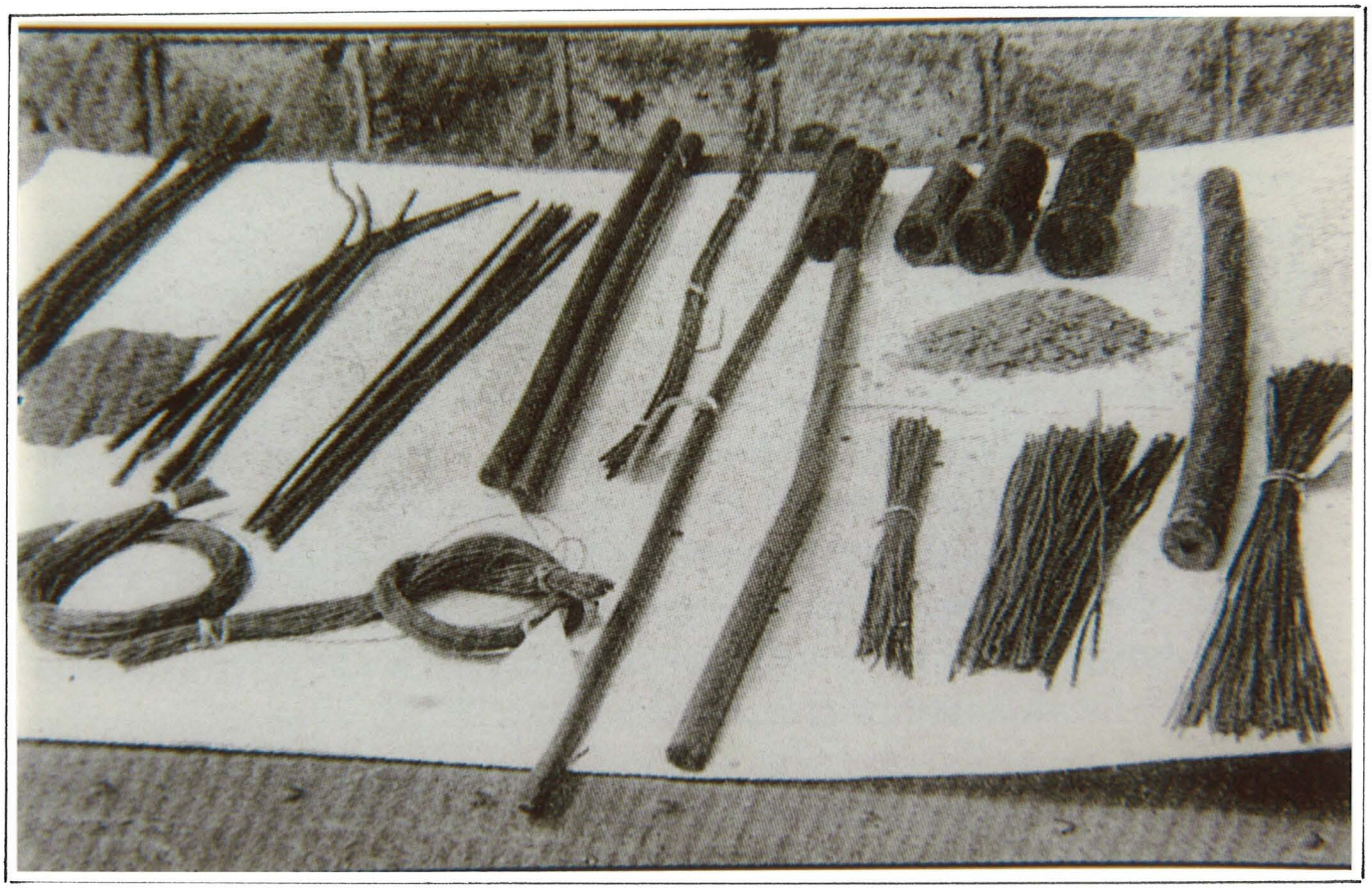
The extrusion of cordite by means of a Tange press,c 1899. In case of explosion the workers were protected by a thick curtain or a rope mat.



Extruding Cordite Strands

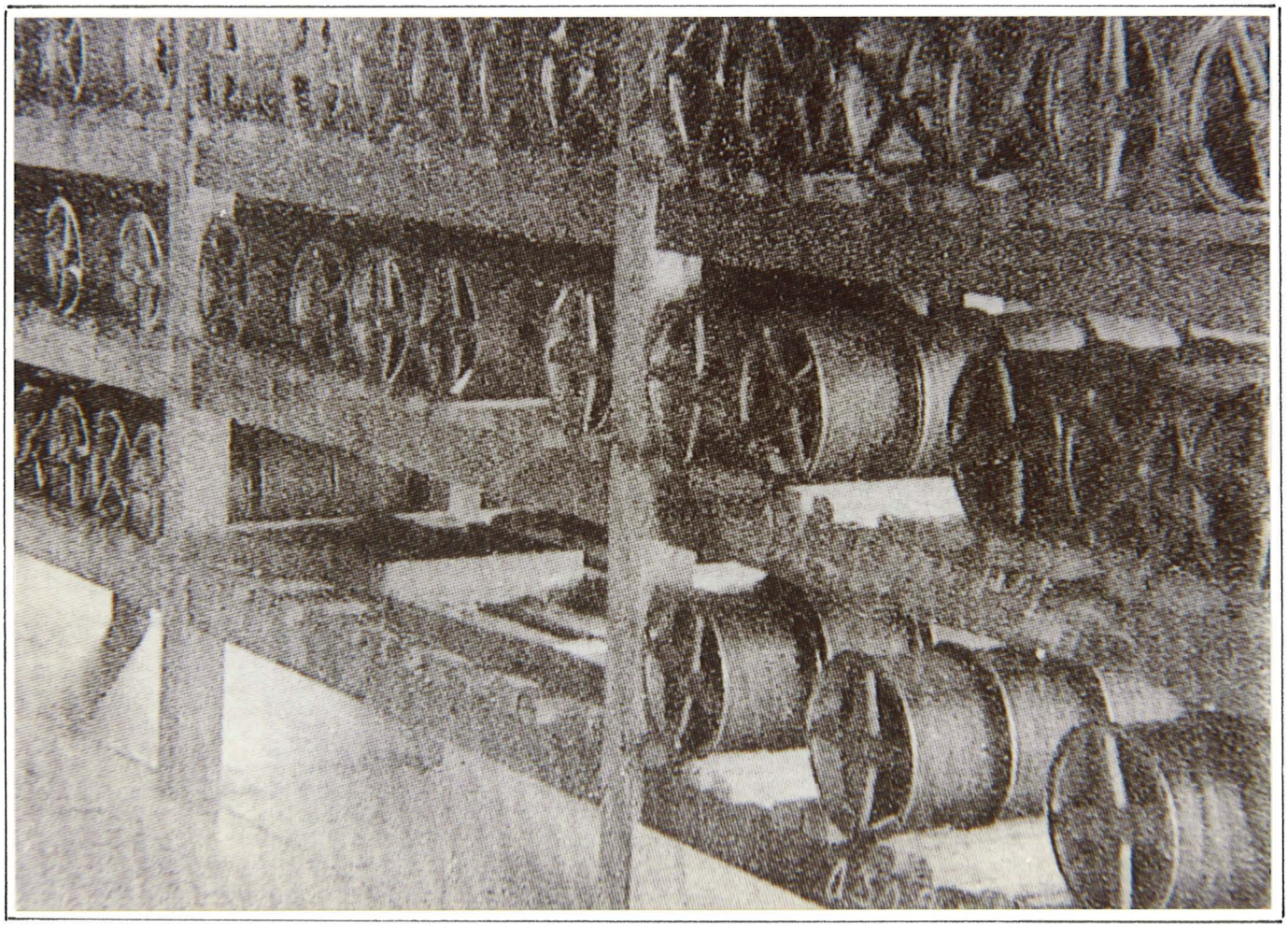
Cordite.

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 illustration,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 the 12-inch BL Naval Gun. All the components for the production of the cordite,with the exception of acetone,were manufactured within the factory.



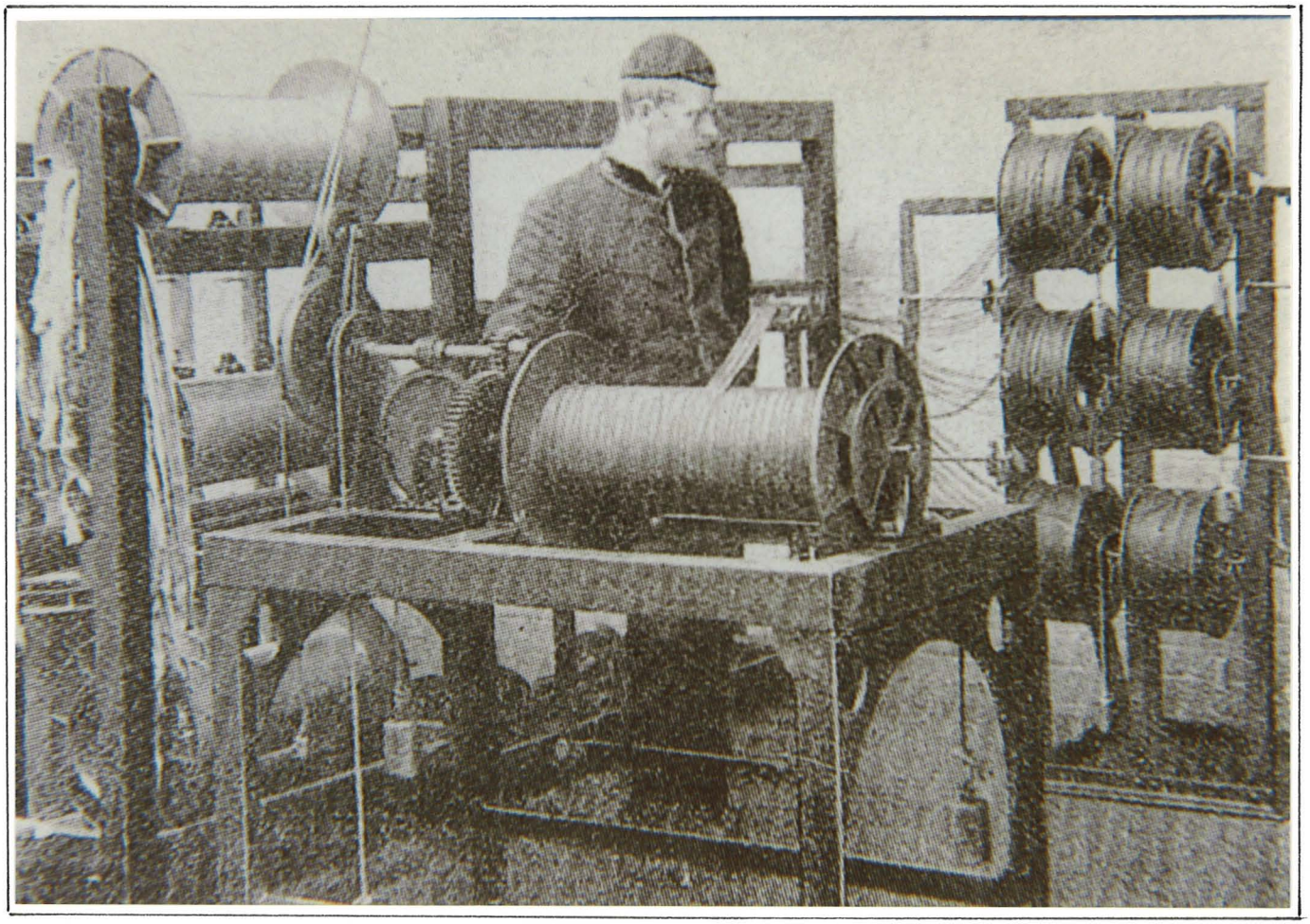
Cordite.

Incorporation complete,the cordite was taken in lots of 20-lbs weight to the pressing room. Here it was loaded into a cylinder and subjected to hydraulic pressure of 600-lbs per square inch. Escape hole sizes being previously chosen from between .01 to .5 of an inch,the finished cordite was extruded into a grooved block and cut into lengths or wound direct onto drums. In order to remove excess acetone,the cordite was removed to a drying room and exposed to a heat of up to 100-degrees.
Half-inch cordite required drying for 15 days,pistol and rifle cordite for 2 days.



Cordite Stranding.

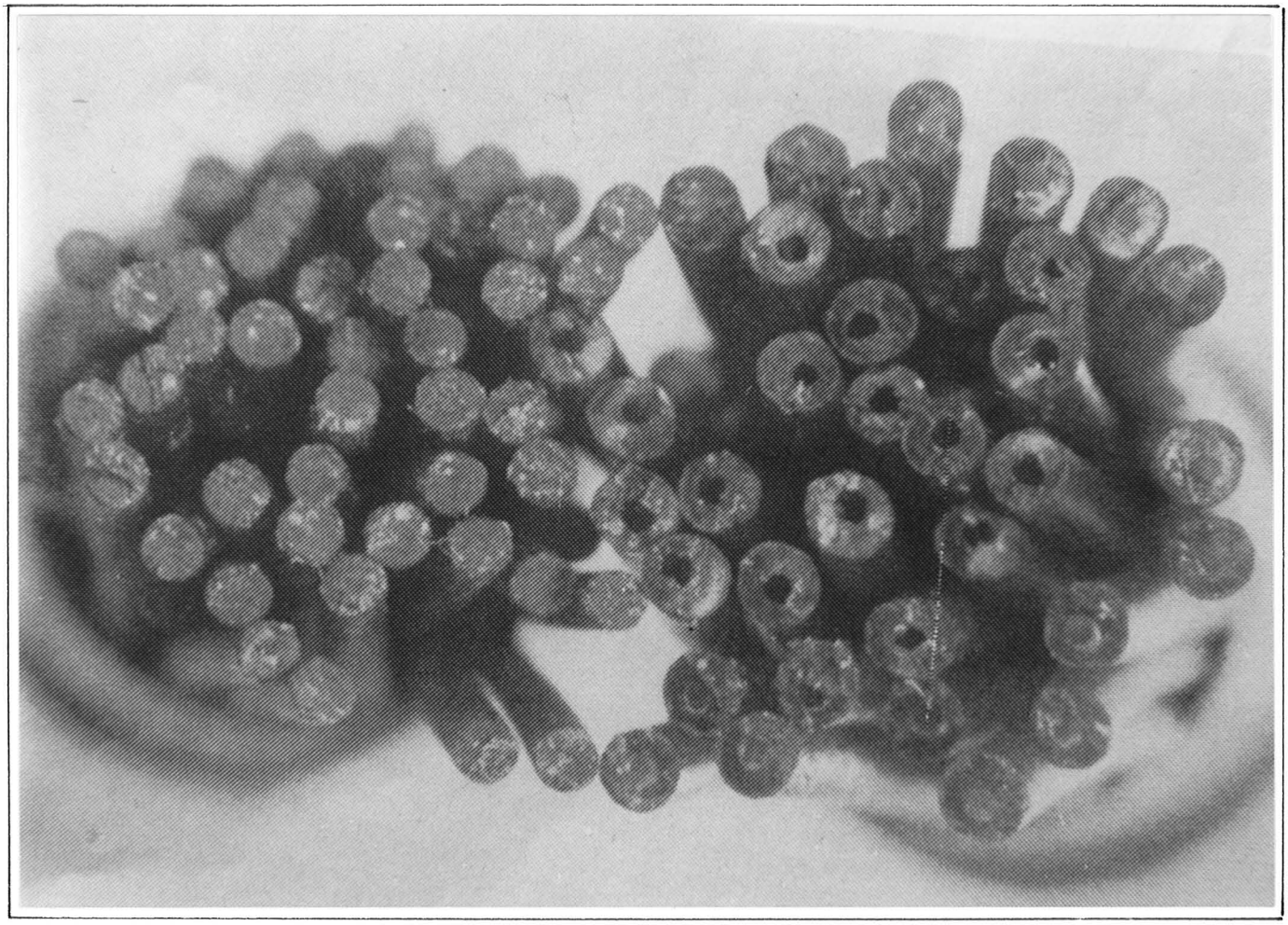
Ten stranding.-Ten reels of cordite,just as they come from the machine,are fixed in a rack and are wound simultaneously on to a single reel,the object being to secure uniformity of explosiveness.
Six "ten-stranded" reels are afterwards wound upon one,and the "sixty-stranded" reel is then ready to be sent away. Details of manufacture accompany each reel and the end of the thread is secured by webbing.



Cordite.

.303-inch Cartridge.

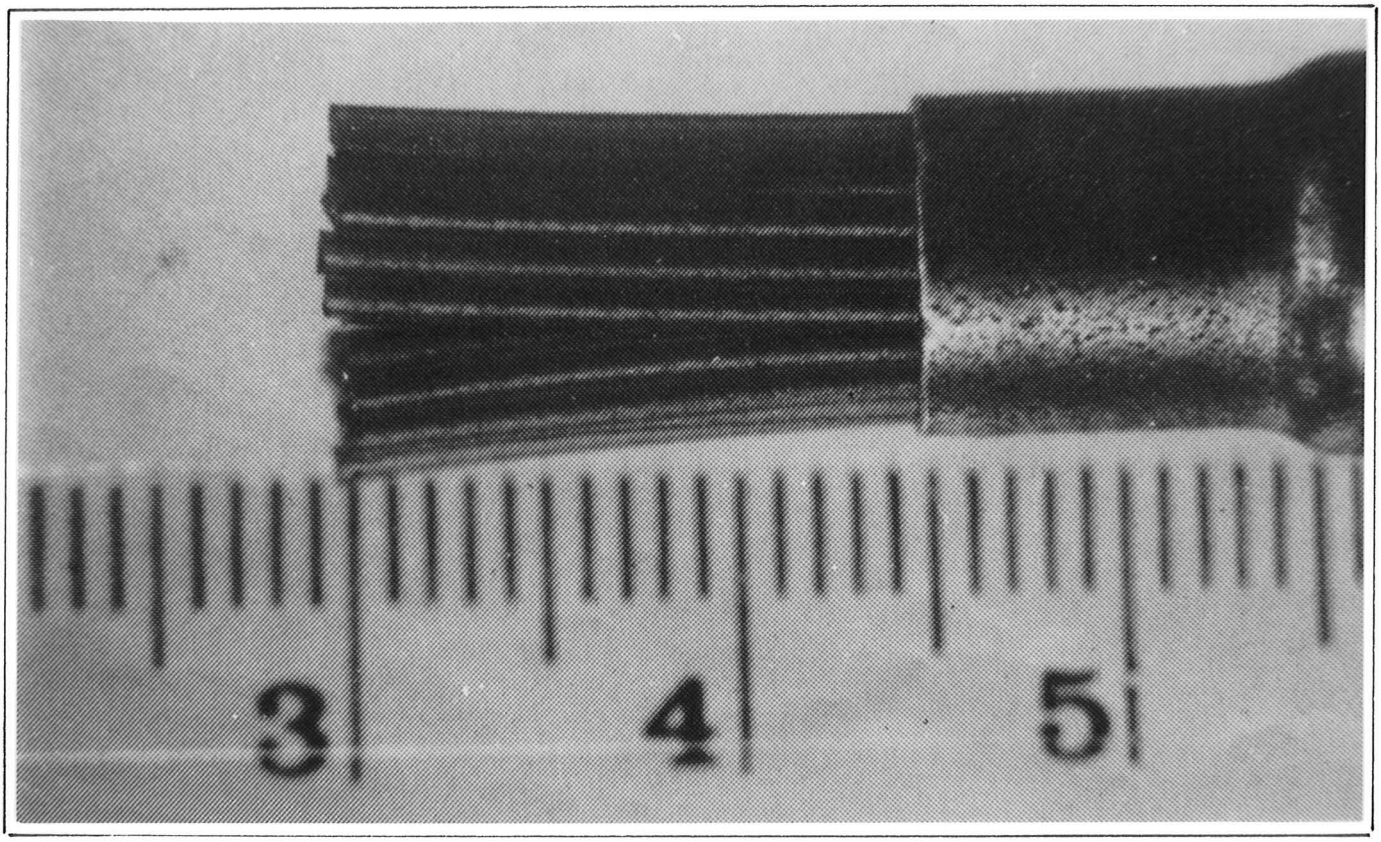
Two main types of Cordite for the .303-inch cartridge.
The original Cordite Mk1 solid rods of 0.375-inch diameter (left)
The later type,Cordite MDT5-2 (right),single perforate rods of outside diameter 0.050-inch and inside diameter 0.020-inch.



Cordite.

.303-inch Cartridge.

A bundle of Cordite Mk1 size 3/3quarter,31-grains in weight and consisting of 60-sticks,which make up the full charge for a .303-inch Mk2 cartridge.



Royal Gunpowder Factory.

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 temperature 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 of 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 proved very successful,saving about 50% of the acetone used and was in operation until 1918.

Cordite.

Workers.

All workers at the explosive factory were subject to the most strigent conditions which required daily physical searches for metal items or matches which might have caused a spark to ignite the contents of a workplace.
Similarly,special clothing without buttons and pull-on boots without nails had to be worn.

Cordite.

The Workers.

The boiler-hous gang,the two men wearing bowler hats are the charge hand and the foreman.

Male worker wearing danger clothing. Notice the footwear which shows a flat combined sole and heel,to negate the risk of sparking from nail-heads c.1899.

THE ROYAL GUNPOWDER FACTORY
WW 1.

1914-1918 War.

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 increased 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.

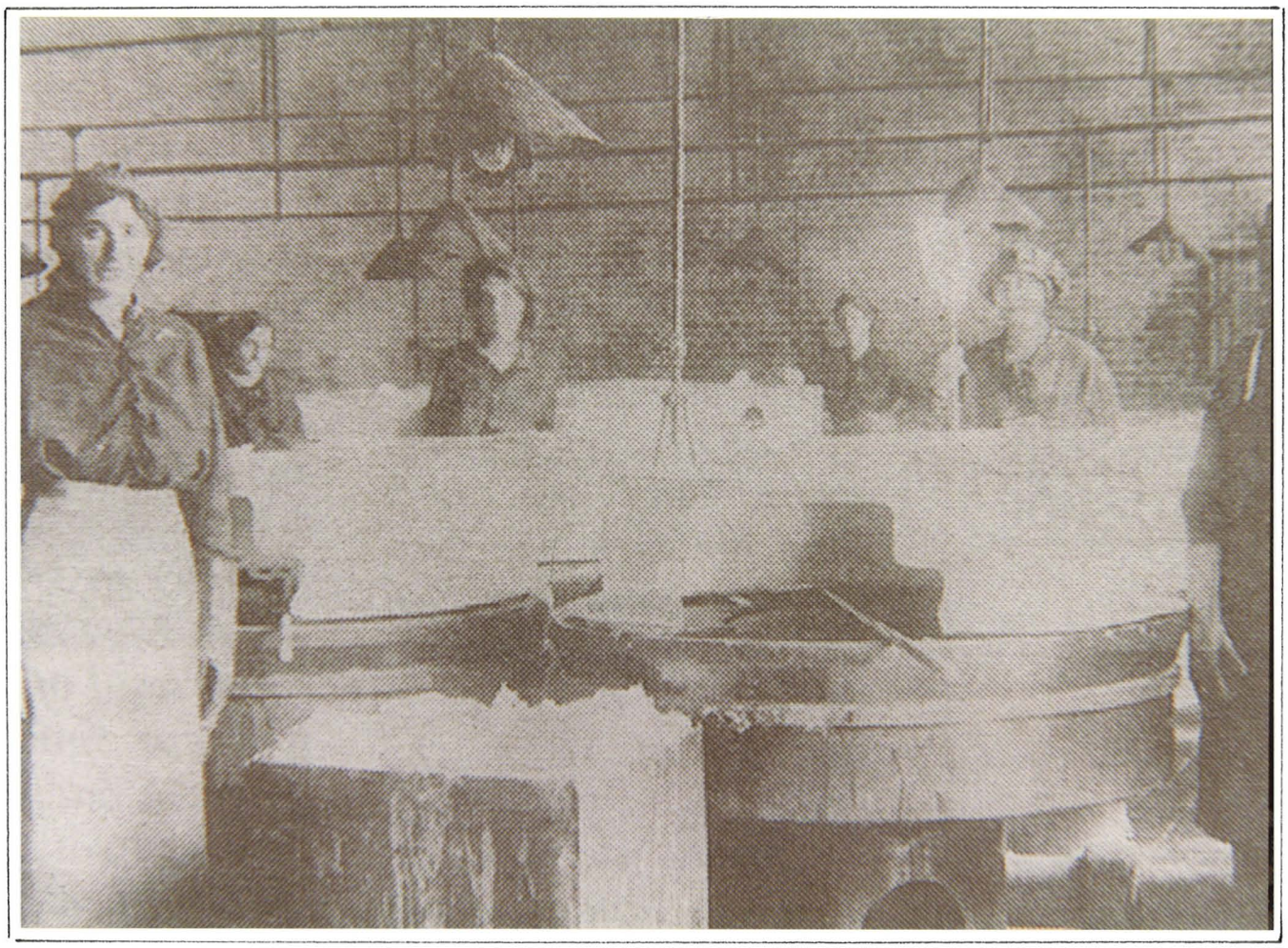
Woman Munition Worker 1917.

Women Munition Workers 1917.

Possibly another part of the guncotton production.

Guncotton Nitration Plant.

1917.



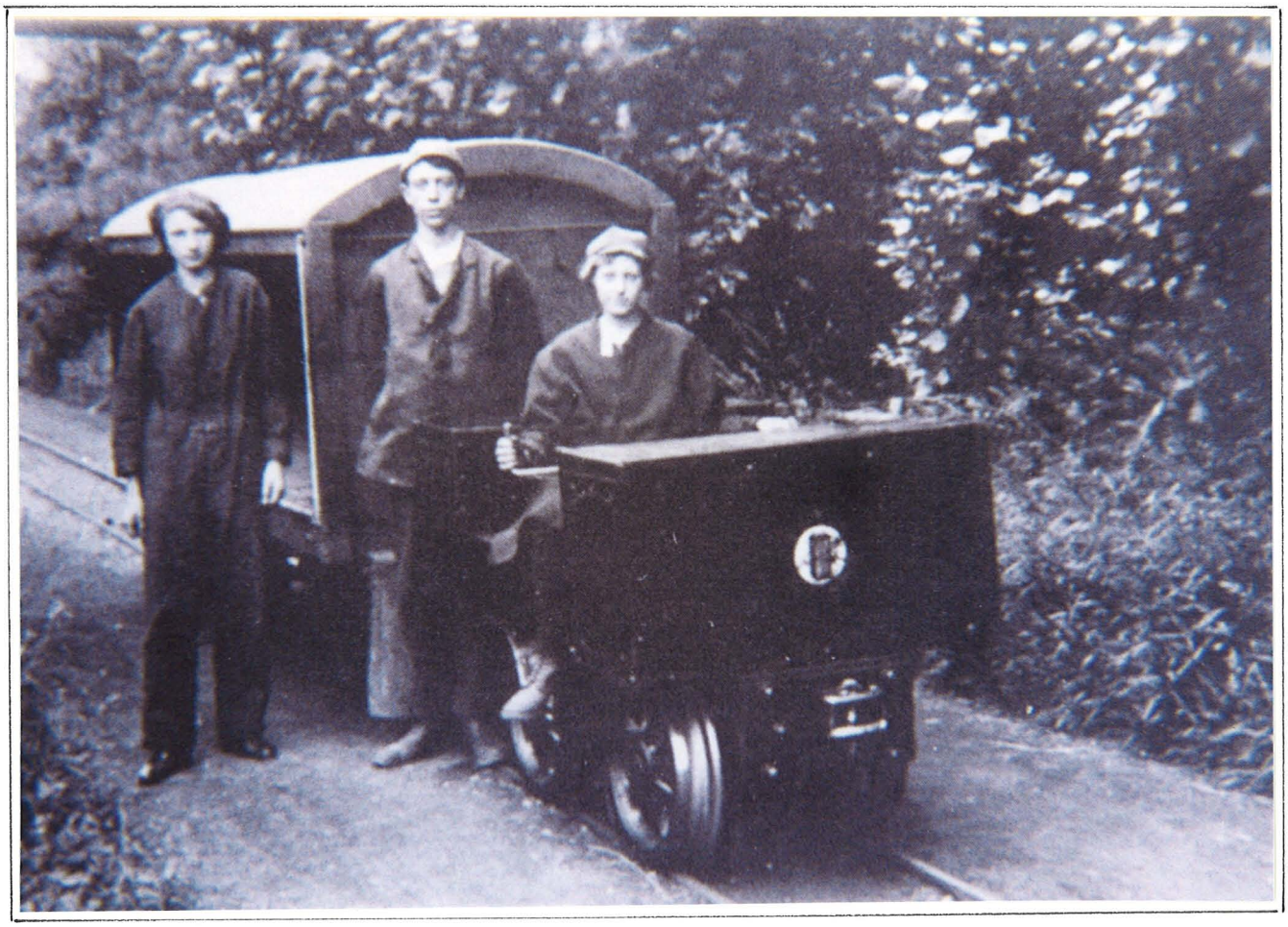
Guncotton Nitration by Displacement Process

Gun Cotton.

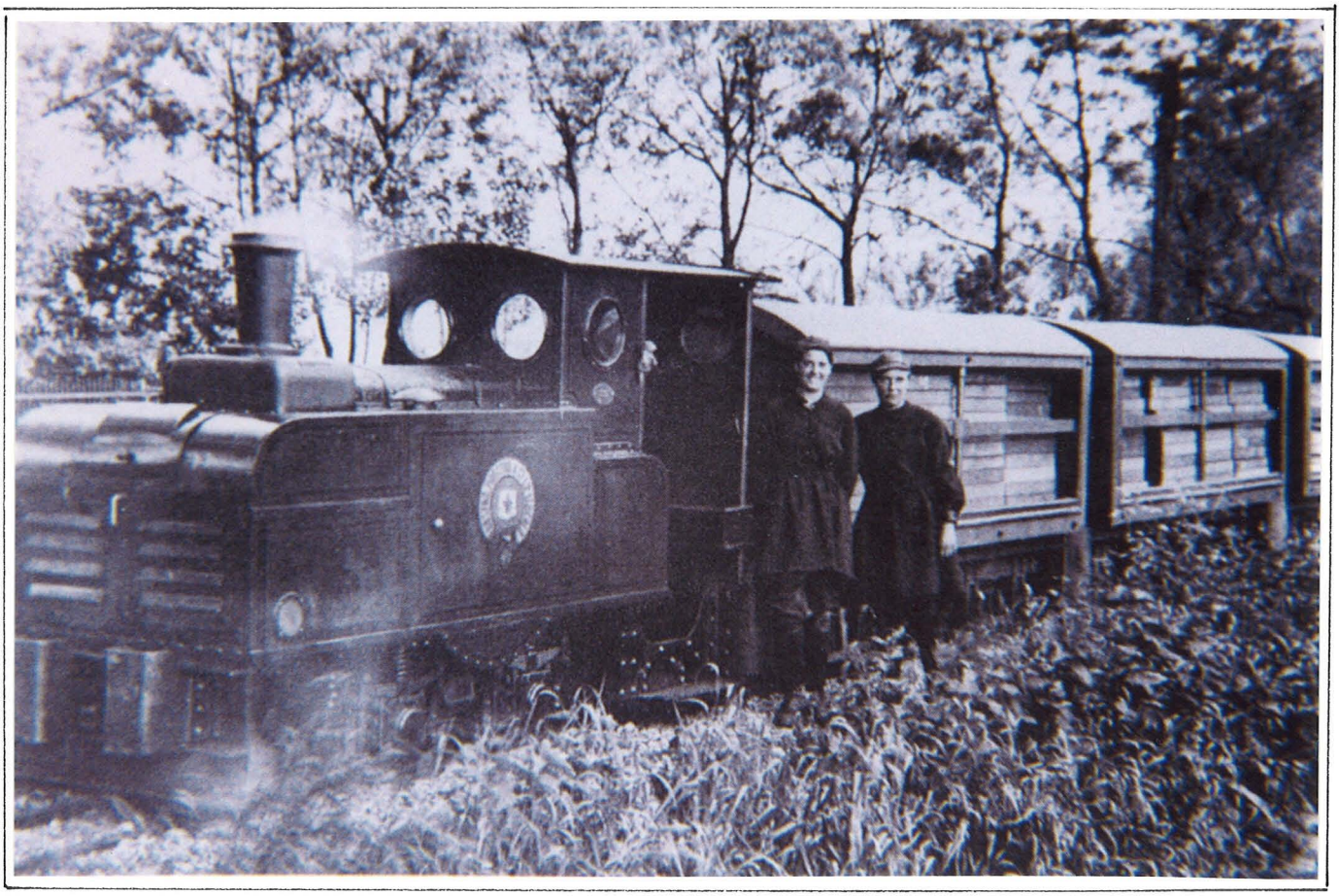
After nitration the guncotton was unstable,so excess acid was removed by throrough washing.
The date on the machinery is 1899; the photograph was taken c. 1917.

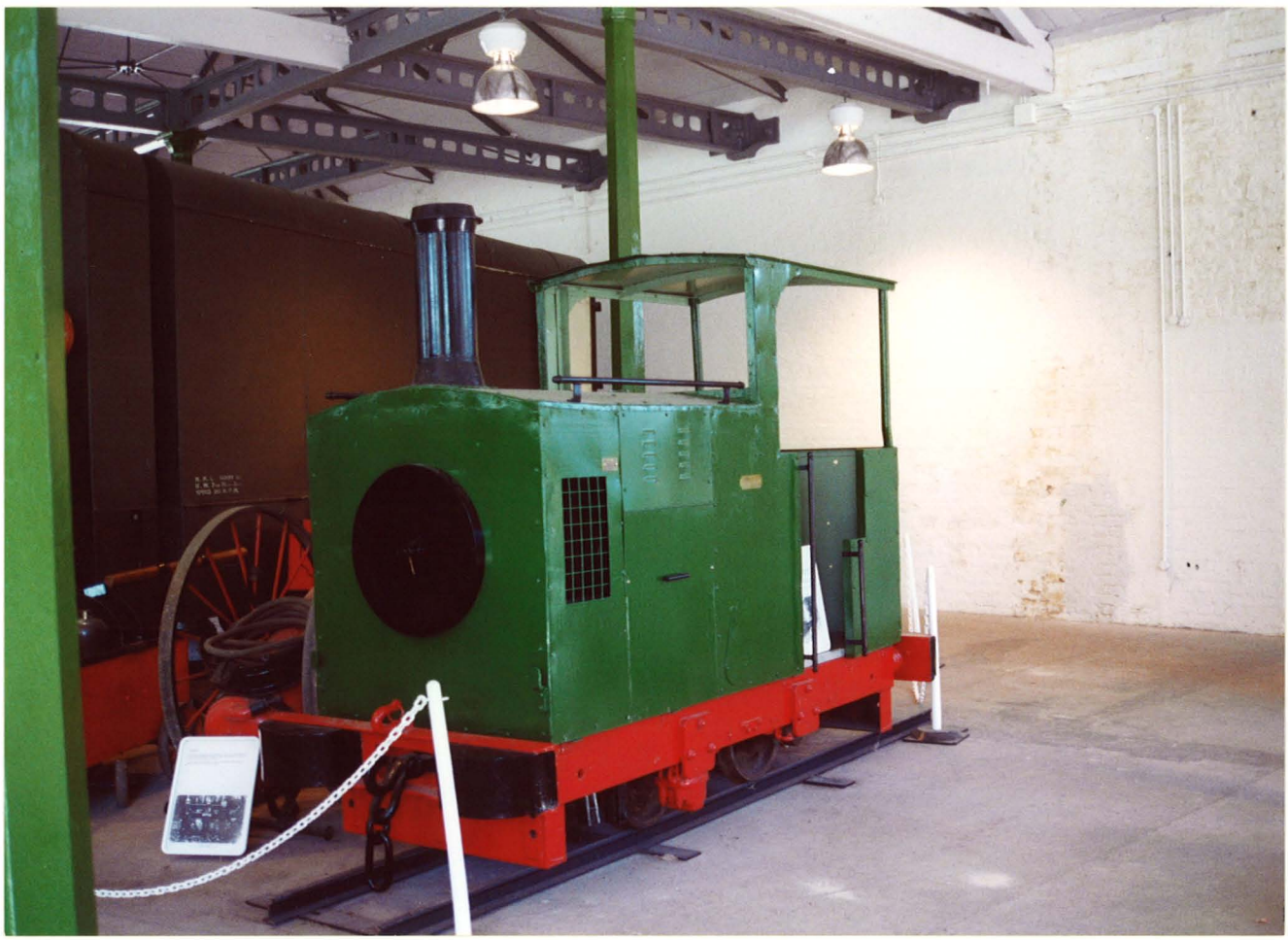
Guncotton Pulping

Explosives were transferred by rail in the 1850s,but mechanical haulage started in 1916. This truck was powered by Edison storage batteries; note the battery box. One such truck still survives.



This engine,one of four bought in 1917,had a 10 hp single cylinder water-called engine; it was started on petrol and then ran on the less dangerous paraffin.





THE ROYAL GUNPOWDER FACTORY.

At the cessation of WW1 the production effort was run down,but experimentation continued and a number of important explosives were developed. The scaling down of the factory effort was reversed in the early 1930s with the rearmament programme,and on the outbreak of war,Waltham was producing TNT and was the only site producing the major explosive of this new war,RDX,this explosive was used by the 'Dam Busters' in 1943.

There were major problems caused by the inter-war shut down. Ever since the factory had opened,virtually all transportation had been by canal barge. Small dumb barges moved the materials around inside the site and delivered the finished product to larger sea-going sailing barges which were pulled down the Lee Navigation to the River Thames and Woolwich. However,following the end of WW1,the canals had silted up,and instead reliance was placed upon the tramway and a small internal electric railway system. Although the railway connected with the main line from London to cambridge,it was some months before the silt problem was overcome by a massive programme of dredging which left the railway at full stretch. In the meantime,much of the explosive went through the streets of Essex and London by road. Fortunately there were no accidents.

A greater threat was the lack of skilled manpower to operate the processes in the factory. Although there was a core of trained process workers in the surrounding population,with the passage of some 20 years since the last war there were insufficient of the right age group to fill the large shortage that the war had created.

This resulted in a massive training programme to integrate whatever workers could be found into a highly dangerous environment. Nevertheless,no matter how much training was given; no matter how long the worker was involved in producing the final product,there would always be accidents involving human error, The materials gave little leeway and any accidents invariably involved severe injury and death.

Precautions involved a police force dedicated to finding out all items of smoking items. In peacetime,workers found with a few flakes of tobacco,a paper,match or pipe on their person,would face a criminal prosecution followed by instant dismissal. In time of war they might get away with just a fine of £5 fine,a weeks wages in those days.

The Years Between The Wars.

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.Knapman 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.

Years Between The Wars.

In the year 1934 an entirely new era in the history of the Royal Gunpowder Factory opened,for in that year Dr.R.C. Bowden was appointed Superintendent,the first civilian to hold such a post. There then commenced the work of rehabilitation of the factory for rearmament after many years of idleness and neglect caused by short sighted economy.

It was quickly realized that nothing could be done to turn Waltham into a large scale and economical producing unit. Efforts were concentrated on getting the available facilities working quickly and at the same time planning the removal of the main production to less vulnerable sites,and the training of staff to operate new factories.

The first step in this direction was the opening in 1939 of the Royal Ordnance Factory at Irvine to operate the new continuous T.N.T. process. The major problem was,however,the siting of the new propellant factory. The authorities were very properly pressing for a site in one of the depressed areas to be chosen. Dr.Bowden,assisted by the Building Works Surveyor at Waltham and the Land Agent for Scotland and surveyed some 4,000 square miles and finally recommed a 2,500 acre site at Bishopton in Renfrewshire. No alternative being offered,the recommendation was approved and planning staff engaged and located ,under Superintendent,R.G.P.F.,at Waltham. The construction of the Factory was undertaken by His Majesty's Office of Works and it was brought into operation in 1939 when Dr.Bowden was transferred there.

Several other factories followed,both for propellants and high explosives,and they all relied very largely on Waltham for experienced staff.