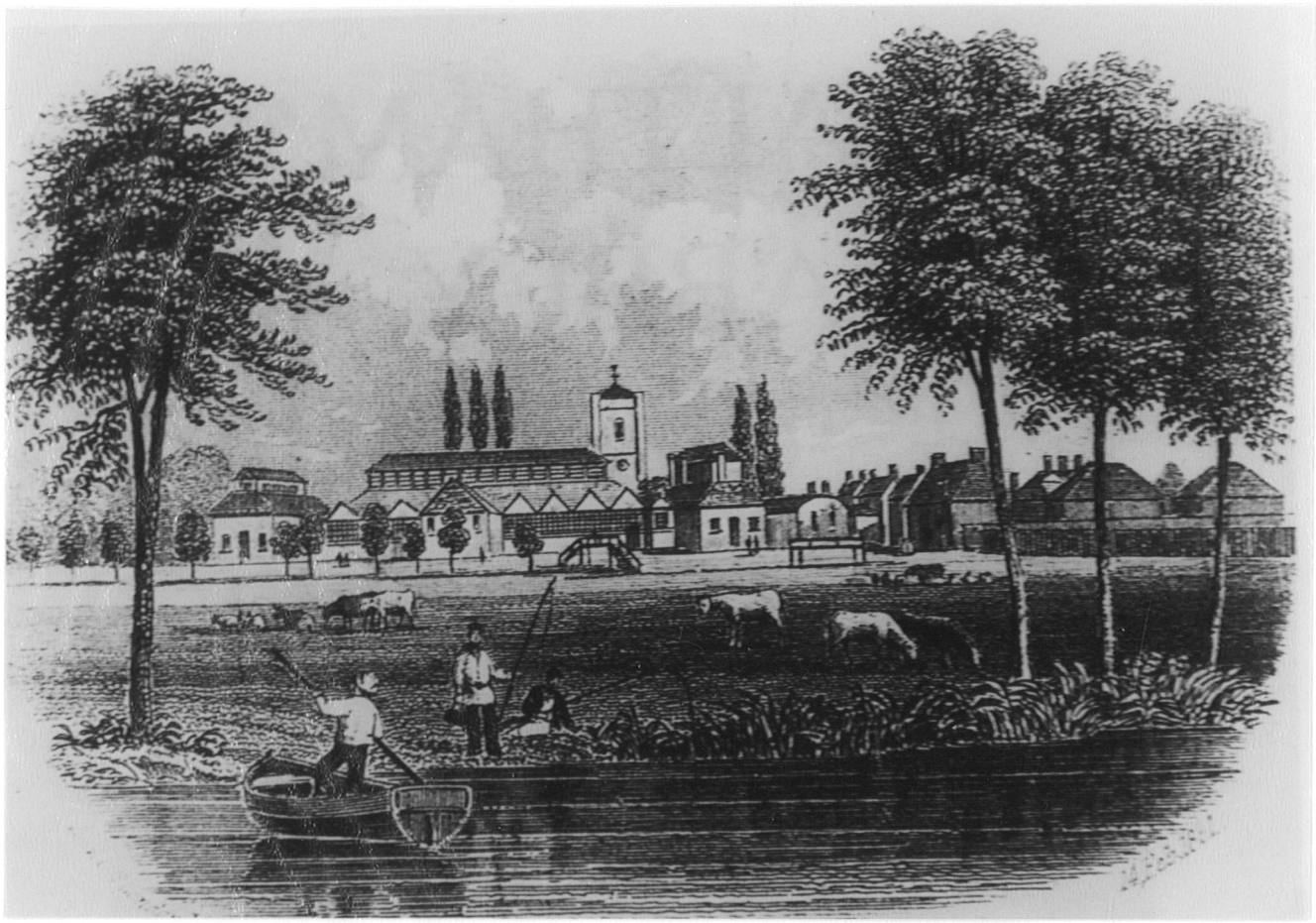
THE ROYAL GUNPOWDER FACTORY WALTHAM ABBEY.



THE ROYAL GUNPOWDER FACTORY.

Gunpowder manufacture at Waltham can be traced back to the 1660s,when a former oil mill was converted to a powder mill. The constituents of gunpowder are saltpetre,sulphur and charcoal,and a large number of powder mills are recorded down the Lea,but all except Waltham,the furthest upstream,ceased working by 1700. The fact that Waltham controlled its own water supply may have been the reason for its survival. A print of 1735 shows horse mills,dumb mills,stamping mills and a corning and glazing engine,the latter two clearly shown water wheels. In 1787 the government considered it desirable to by the works. Major Congreve,deputy controller of the Royal Laboratory at Woolwich,agreed and the purchase was effected. The mills were thus ready to meet the needs of the Napoleonic wars with France.

In 1872 a guncotton factory was built; guncotton is formed by treating cellulose such as cotton with acids. In 1891 the first cordite,a mixture of nitrocellulose and nitroglycerine,was made here. Cordite became the standard explosive of the British Army. The factory closed in 1945. The site then became the Government Explosive,Research and Development Establisshment (ERDE).

THE ROYAL GUNPOWDER FACTORY

The Royal Gunpowder Factory has been involved in the research and manufacture of explosives for over 300 years. Initially producing gunpowder,the site then developed to manufacture chemical-based explosives and propellants and finally experimental development of explosive materials after the Second World War.

The first dicumented references to gunpowder production on the site come from two sources. One is a contract between Ralph Hudson,a sub-tenant of the Waltham Mills,and the government,for the supply of gunpowder. The other is the first recorded death in the parish caused by an explosion within a mill. Both references date to 1665.

The early factory,based around a former fulling mill,probably situated to the south of the Island Site,quickly expanded to form the well established works depicted on the engraving by Farmer in 1735. The site continued to develop and became one of the principle suppliers of gunpowder to the Board of Ordnance.
In the second half of the eighteenth century the board became concerned about the quality,quantity and reliability of the black powder produced by these private firms. So much so that in 1759 the Government purchased the Home Works at Faverhsam,the first royal Gunpowder Factory.

Later in1787 they purchased the Waltham Abbey works. Almost immediately after,the demand for powder rose as a repercussion of the French Revolution and later the Napoleonic wars. There was major expansion and investment including the development of the Lower Island Site,a narrow strip of land to the south of the original site.

In sharp contrast,the first half of the nineteenth century,between 1802 and 1840,saw little new development. This period of relative inactivity did not last,and by the second half of the century the demand for cannon powders for larger guns and for moulded powders in greater quantities resulted in rapid changes and innovations. It was also in the latter half of the nineteenth century that tentative production of the new chemical explosive guncotton took place. Manufacture of the new liquid explosive nitroglycerine soon followed and by the last decade of the nineteenth century,cordite,a mixture of guncotton (cellulose nitrate) and nitroglycerine was in production.

Cordite was such a successful explosive,it quickly became the main service propellant and by 1900 the majority of the old gunpowder buildings on site were converted to produce cordite. Initially the South Site consisted of a guncotton factory bt nitroglycerine and cordite production areas followed shortly afterwards. Back on the North Site an acid factory and nitroglycerine facility were built in the 1890s. The wet guncotton was produced on the South Site and barged up to the Grand Magazine where it was stored. Then it was moved down the site North to South from drying to mixing and pressing,finally resting at Building H12 the cordite reel magazine.

The First and Second World wars naturally produced peaks in production and investment into the site. During the First World War the labour force rose to 5,000 its greatest number,over half were women,working shifts to ensure continuous production. A number of high explosive products were made at the Royal Gunpowder Factory even though the site was never a high explosive plant.

Picric acid was produced in the 1870s and 1890s and later around 1910 tetryl (C.E. or Composition Exploding) was produced.
Between the Wars important research was carried out on the safe and efficient production of TNT and RDX.

The site's proximity to urban areas and the continent forced its closure as a production site in 1943 in favour of the new purpose-built Ordnance sites in Scotland and the northwest of England.
The site reopened in 1945 after the war as a Government research establishment,initially set up to research into liquid fuels for rockets and other applications. A plant was also constructed to develop plastic propellants for use in rocket motors. Over the next 30 years research into propellants,plastic and rubber propellants,properties of high explosives and many other aspects of energetic and inert materials took place on North Site. By the 1960s Waltham Abbey was the sole Government Laboratory carrying out research on non-nuclear explosives of every kind.

Many of the old cordite and gunpowder laboratory buildings were used as laboratories; also some of the test beds were converted from nineteenth-century process buildings. A number of purpose-built test beds were also constructed. The site finally closed in June 1991 after 204 years of Government service.

Between 1992 and 1996 a programme of decontamination and remediation was carried out with the aim of putting the site to beneficial reuse in the public sector. The decontamination process removed the collected silts from disused canals which resulted in the discovery of many explosives related artefacts such as millstones and barges.

THE ROYAL GUNPOWDER FACTORY

"A mill for making of gunpowder's 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-pounds of saltpetre,

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

The Gunpowder 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.

Gunpowder.

Gunpowder is an explosive which has a relatively low detonation velocity. Its action is propellant rather than shattering. The general term "propellant" is applied to any explosive which can suitably be used for the propelling of projectiles fired from guns or of rockets. These explosives conist either of intimate mixtures of substances which react with one another and release a considerable amount of energy while doing this,or of chemical compounds which release energy on decomposition. In both cases,however,the reaction does not take place at ordinary temperatures: ignition of the explosive is necessary,i.e.,the reaction has to be initiated by supplying energy at one point. Once the reaction has thus been started,the energy that is released initiates the reaction at adjacent points. This "chain reaction" can spread throughout the whole quantity of explosive in a small fraction of a second.

The significant requirement for a suitable propellant is that a considerable increase in volume shall occur during the course of the reaction. The reaction products are for the most part gases which occupy a much larger volume than the solid explosive. If the reaction takes place in a confined space (as,for example,in a cartridge fired in a rifle),a very high pressure therefore develops,which drives the projectile out of the barrel.

The oldest known propellant is,of course,ordinary black powder (gunpowder).

When this explodes,the reaction forms about 45% gases (nitrogen,carbon monoxide,carbon dioxide) and 55% vaporised salts. A pound of gunpowder will thus produce about 5 cubic feet of gas and about 300 kilocalories (1200 B.T.U.) of heat.

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THE ROYAL GUNPOWDER FACTORY.

Congreve Rocket.

It was from this site that a form of artillery rocket was developed for use by British armies from the early 19th century. Known as the 'Congreve Rocket',among the targets bombarded by these weapons was Fort McHenry in 1814.

In Napoleonic times the factory was producing some 1,100 tons of powder per year.

THE ROYAL GUNPOWDER FACTORY.

THE MANUFACTURE OF GUNPOWDER 1895.

The Process of Making Black Powder.

The Process of Making Black Powder.

HOW EXPLOSIVES are MADE.

By William G. FitzGerald.

1895.

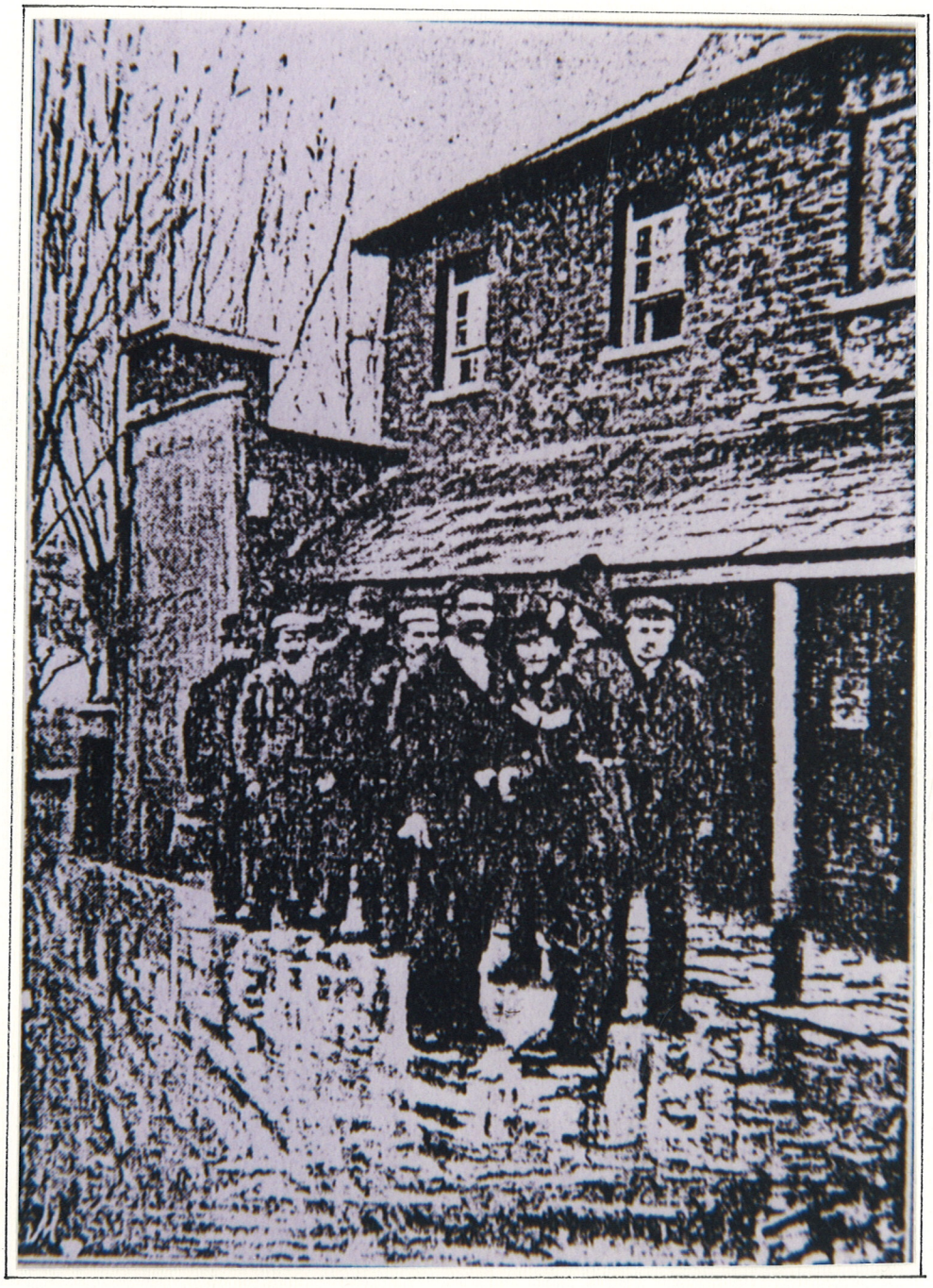
In writing to a Government Department for assistance in literary matters,there is a delightful uncertainty. You may be refused-let down gently,it is true-but still refused. The refusal,on the other hand,may be chilling,or even severely aggressive. If the reply is none of these,it surely contains official assent-formal,gracious,comprehensive. Such was the letter sent by Dr.W.Anderson,Her Majesty's Director General of Ordnance Factories,in answer to our application for official permission to visit the famous Royal Gunpowder Factory,whose main gate is almost under the shadow of the ugly Norman tower of Waltham Abbey.

Here,indeed,is the most extraordinary factory in the world. Factory is quite a misnomer applied to this lovely and picturesque domain. The establishment consists of about four hundred acres of wooded land,intersected by four miles of crystal streams,which would fill the angler's heart with delight.

As a matter of fact,the place was bought by the Government,in 1787,from John Walton,a direct descendant of the immortal Izaak: and the name of the former may yet be seen inscribed on a sundial in the quadrangle near the office of the superintendent,Colonel Ormsby. This sun dial,by the way,is robbed of much of its quaint and picturesque nature by eight big shells,which are symmetrically arranged about the base,and which,we need hardly say,are not described in any work on conchology.

It goes without saying that Waltham has its stirring and exciting moments. Quite apart from the fact that the vast powder factory is to put it mildly,a continual menace to the local public peace,there are a surprising number of streams about the place,which overflow in winter,and occasionally compel the inhabitants to go a-punting down High Bridge Street. Nevertheless,Waltham is a pretty town; and,as one turns off from the main street into the lane leading to the principle 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 populars,at the end of which the Union Jack floated proudly from a flag-staff. This gave rise to a train of thought from which we were rudely aroused by a aharp 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 reminded us of certain anecdotes in our school-books.

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 gallant colonel assured us that the way was long,and therefore it would be better for us to set off on our personally conducted tour at once. He was right. The buildings seemed to be scattered far and wide,as though it were the primary intention of the authorities to occupy every available square foot of land. We walked miles; we plunged into thickets,crossed innumerable streams,and occasionally glided from one building to another in a swift electric launch,the panting of whose screw scared the birds and rabbits that abound in this extraordinary place.

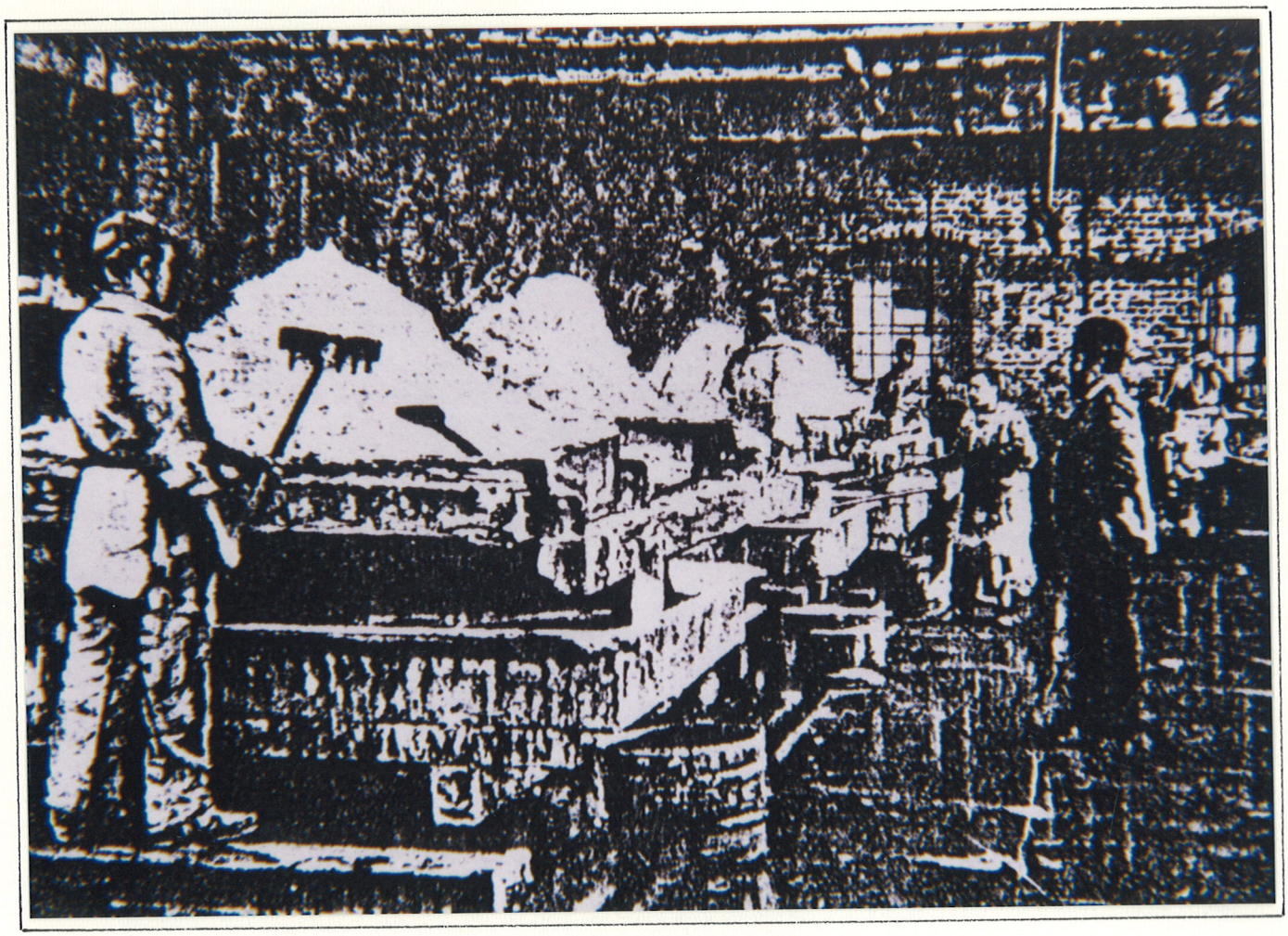
But we must commence ab initio. The first place we visited-and we were calm and appreciative then,not knowing the extent of the appalling task that lay before us-was the saltpetre refinery.

The saltpetre comes from Scinde 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 these coolers,and is then raked from the bottom in the form of wet snow,which is poled 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 8s to 12s. per ton. 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 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 there about 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. It is ladled into casting tubs,in which it is left for about eighteen 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.

There remains one other constituent of powder to be investigated- namely,charcoal. Why,we asked,are there such extensive groves and forests of willow,dog-wood,and alder within the boundaries of this stranngest of factories? One reason is that the wood is converted into charcoal; and another,that a dense growth of trees serves to locate the effects of a possible explosion.

Now let us see what these workmen are going to do with the seasoned branches they are loading on to the trolley. 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. After from three to eight hours of very great heat,during which time the very gases from the burning wood are utilized as fuel in the furnace below,the drums are withdrawn and their contents shot into air-tight iron vessels to cool for four hours. The charcoal is subsequently removed to smaller coolers,where it remains another twelve 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 responsibility of this last-mentioned work may be judged when we state that,if the smallest particle of gritty matter of any sort is inadvertently passed over,it infallible means an awful explosion and certain loss of life.

THE SALTPETRE REFINERY.



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

The sulphur is ground so as to pass through a sieve having 36 openings to the square inch; the charcoal is passed through a mesh 32 to the inch. Now we are ready for the mixing-room. Of this strange 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 sacks of 60-lb and sent to the incorporating mill-the first of the "danger buildings."

The incorporating mills,are built in groups of six,and are worked by independant machinery. Except for the division walls,these mills are constructed of the flimiest material possible,the roof being of wood,and the fronts of canvas,buttoned on to a slight iron framework; this is in order that no resistance may be offered to a possible explosion. It will be noticed that the arms of the danger signals are raised,in order to show that the mills are working; when these signals are up,no barrow or truck-load of powder,in any stage whatsoever,is allowed to pass by the mills. Yet the interior of any one of the incorporating mills is not calculated to strike awe or terror into the heart of the visitor. There is nothing in the place but a big,circular iron bed,round 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 therein lies the raison d'etre of the "flash-board",which is seen 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 violently thrown upwards on hinges,and in its descent backwards would automatically overturn tanks of water,not merely on to its own bed,but also on the beds of its working neighbours,who might otherwise be tempted to join in the riot.

Indeed,the risk is so great,that in order to start the incorporating mill,the operator prudently draws down the flaps of his cloth helmet,puts on his gaunlets,and retires outside. The man clothed in a suit of "lasting"-that curious leathery material affected by the London apprentices in the days of Queen Elizabeth. There are no pockets in this suit,and the buttons are of bone; no powder adheres to this material. The men are even forbidden to cultivate long beards,lest perhaps these hirsute appendages should contain particles of grit,harless enough in themselves,but more deadly than cholera bacilli when introduced into a powder mill.

After being three and a half hours beneath the incorporating rollers,the mixture becomes "mill-cake," and is removed in covered trucks to the breaking-down house. This building,in common with most of the other danger buildings,is lighted at night by electric lamps, immersed in water,and placed outside the windows. In the breaking-down house the mill-cake is placed in a hopper,drawn up on an endless band,and crushed into meal powder by two pairs of gun-metal rollers. Only twelve charges of 120-lb. each are allowed in this house at one time.

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 next department is the press-house. The machine-house is situated 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; these latter are compelled to remain in the lobbies while the machinery is in motion. In the press-house one of the most dangerous operations takes 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 from 63 to 500-tons pressure is then brought to bear upon the plates for half an hour,during which time the men are congreated in the shoe-room on the other side of the traverse. It is no exaggeration to say that there is an awful uncertainty about this operation.

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. The regulations caution the men against "undue haste" in removing the cake,and the authorities have thoughfully provided deep wells outside each danger building,into which men who have been badly burnt may plunge. No more than 900-lb. of powder may be kept in the press-house at one time.

The press-house is the parting of the ways,so to speak,one of the various kinds of powder,which are made from press-cake treated in different ways. For pebble-powder the press-cake-which,by the way,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.

All sorts of fearsome notices and cautions abound in the retiring-room of the press-house. A rigorous line of demaracation 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. This precaution is taken in order that no gritty particles may be introduced on to the soft leather floor of the danger buildings. Having put on these boots,you shuffle shame-facedly round the traverse to the machine-room. We say shamefacedly advisedly,for we defy any man to walk a dozen yards in these safety-boots and yet maintain a semblance of dignity.

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 tray to the right of the press,and then pushed under the hydraulic press,which has corresponding plungers. The hexagonal prisms emerge in batches of 64,or 13,000 per day. A skilled workman weighs 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.

In the drying-rooms,ordinary grain powder is left for from one to three hours; pebble powder,however,takes from 24 to 40-hours to dry,and S.B.C. ("slow burning cocoa"),for 110-ton guns,about 60-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-ft. to 2,050-feet per second.

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 Woowich in special barges,which fly a red flag and can be sunk in five minutes.

THE WOOD STACKS.

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

INCORPORATING MILL.

In this building there is a big,circular iron bed,round which revolve two enormous wheels,each weighing 4-tons.

Consists of a lon-continued trituration beneath heavy runners,by which means the mass of ingredients becomes transformed from a mere mixture of three different substances into gunpowder. This is the most important process in the manufacture,and no subsequent care can possibly improve the quality of the powder.

The incorporating is effected by grinding the mixed ingredients for several hours beneath heavy runners. The bed of the mill is of iron,or of stone with iron tyres.

The runners weigh from 3 to 4 tons each,and vary in size from 3 and a half to 7-feet in diameter.

the incorporating is one of the most dangerous processes; unavoidable accidents,arising from unknown causes,frequently destroy the sheds and machinery. A cistern containing 40 gallons of water is poised upon a support immediately over the runners;the cisterns in the various mills are connectected to each other,so that upon an explosion in one mill all the cisterns empty themselves automatically thus the powder under the various runners is at once rendered non-explosive

The charge requires to be under the runners for 3 and a half hours for cannon powder and 5 and a half for small-ars powder. The maximum charge allowed is 60-lbs.

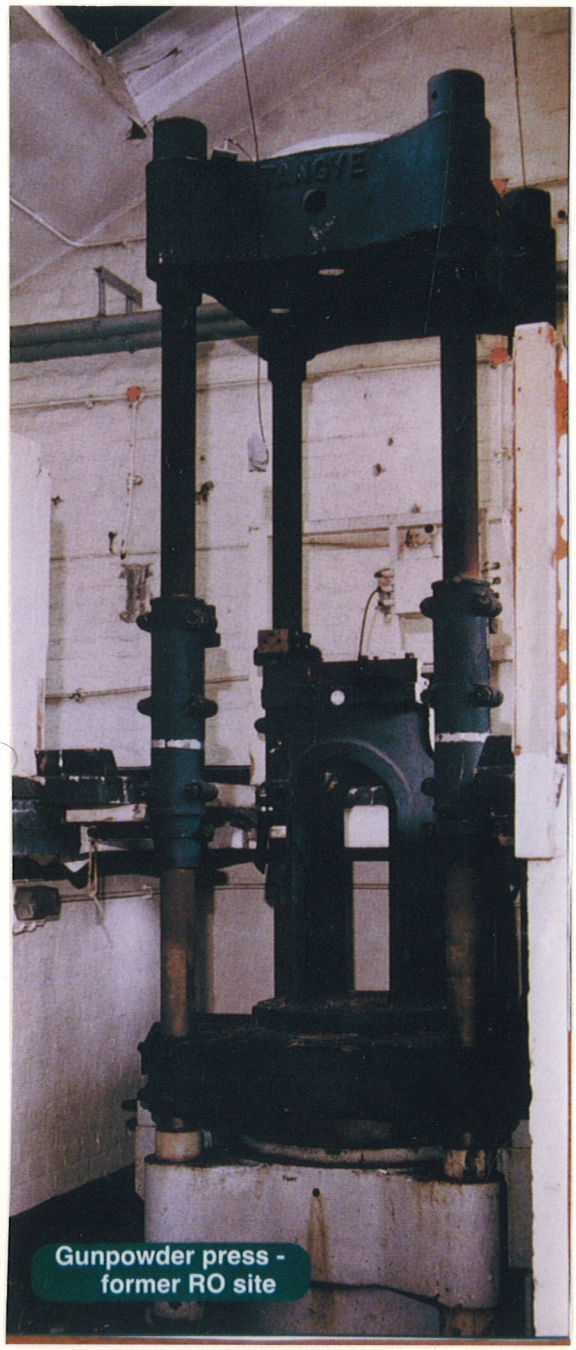
Incorporating Mill.

Consists of a long-continued trituration beneath heavy runners,by which means the mass of ingredients becomes transformed from a mere mixture of three different substances into gunpowder. This is the most important process in the manufacture,and no subsequent care can possibly improve the quality of the powder.

The incorporating is effected by grinding the mixed ingredients for several hours beneath heavy runners. The bed of the mill is of iron,or of stone with iron tyres.
The runners weigh from three to four tons each,and vary in size from 3½ to 7-feet in diameter,the smaller ones,creating less friction upon the bed whilst revoling round the vertical spindles,are considered the safest. Iron runners and beds were first used in Scotland in 1804.
The incorporating is one of the most dangerous processes: unavoidable accidents,arising from unknown causes,frequently destroy the sheds and machinery. A cistern containing 40 gallons of water is poised upon a support immediately over the runners; the cisterns in the various mills are connected to each other,so that upon an explosion in one mill all the cisterns empty themselves automatically thus the powder under the various runners is at once rendered non-explosive. The sheds themselves are made with strong wood frames covered with light boarding or felt,so that in the case of an explosion the damage caused is comparatively trifling. The charges are placed in the mill moist,and require watering from time to time; this is done either automatically by machinery or by hand.
The charge requires to be under the runners 10 to 12 hours for best sporting powder. In the Government mills,3½ hours is considered sufficient for cannon powder and 5½ for small-arm powder; with heavier runners,making eight revolutions a minute,it is not even left so long.

The greatest danger is at the moment of starting; by Act of Parliament,60 lbs is the maximum charge allowed to be incorporated in one mill. The object is to prevent accidents if possible; but it is doubtful if a 100 lb. charge would not be more safe,as it would possibly prevent the two runners from coming into contact with the surface of the bed,which causes considerable friction,and is the cause to which most of the accidents are assigned.

Gunpowder Press.

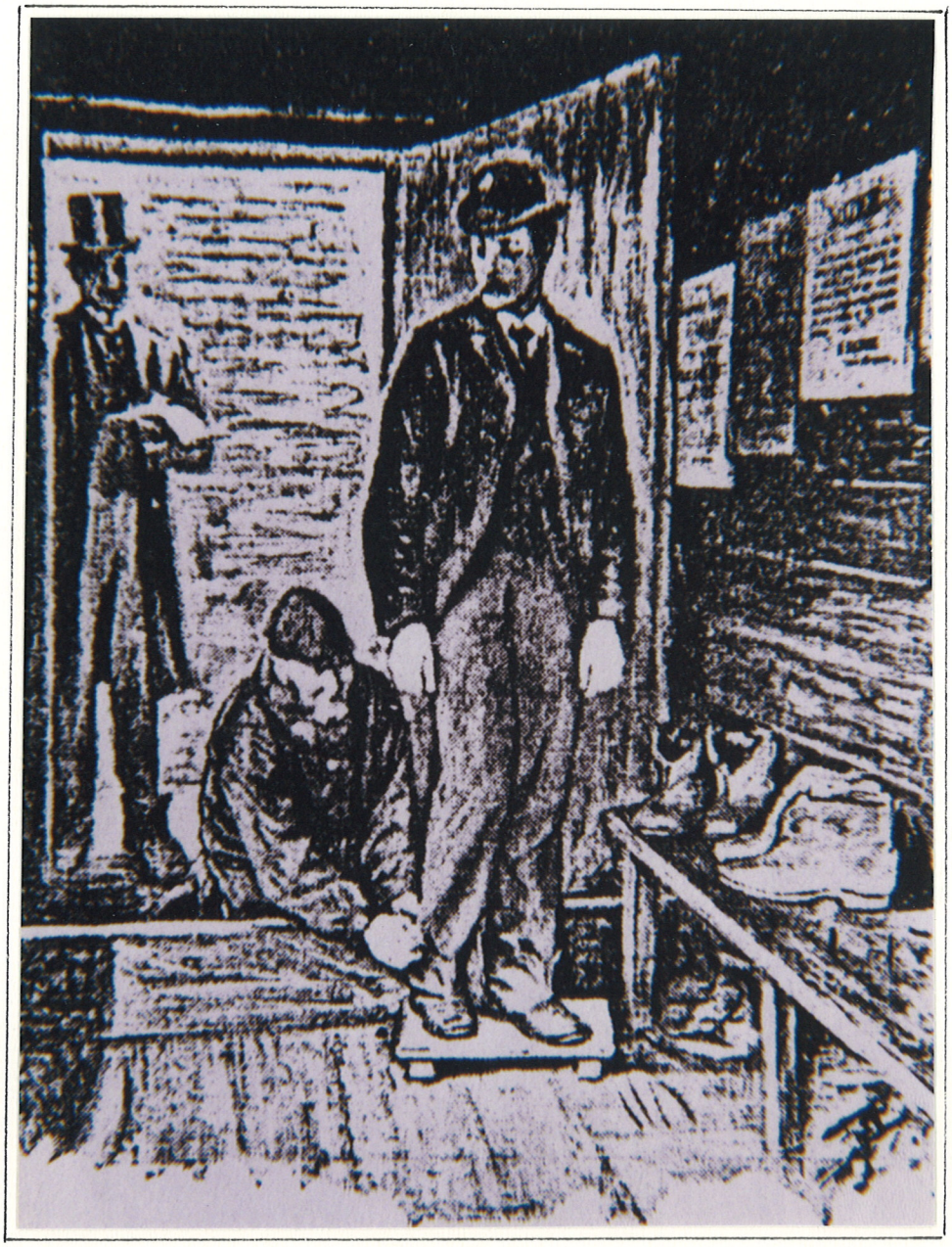


Gunpowder press - former RO site

THE PRESS HOUSE,SHOWING 'TRAVERSE'

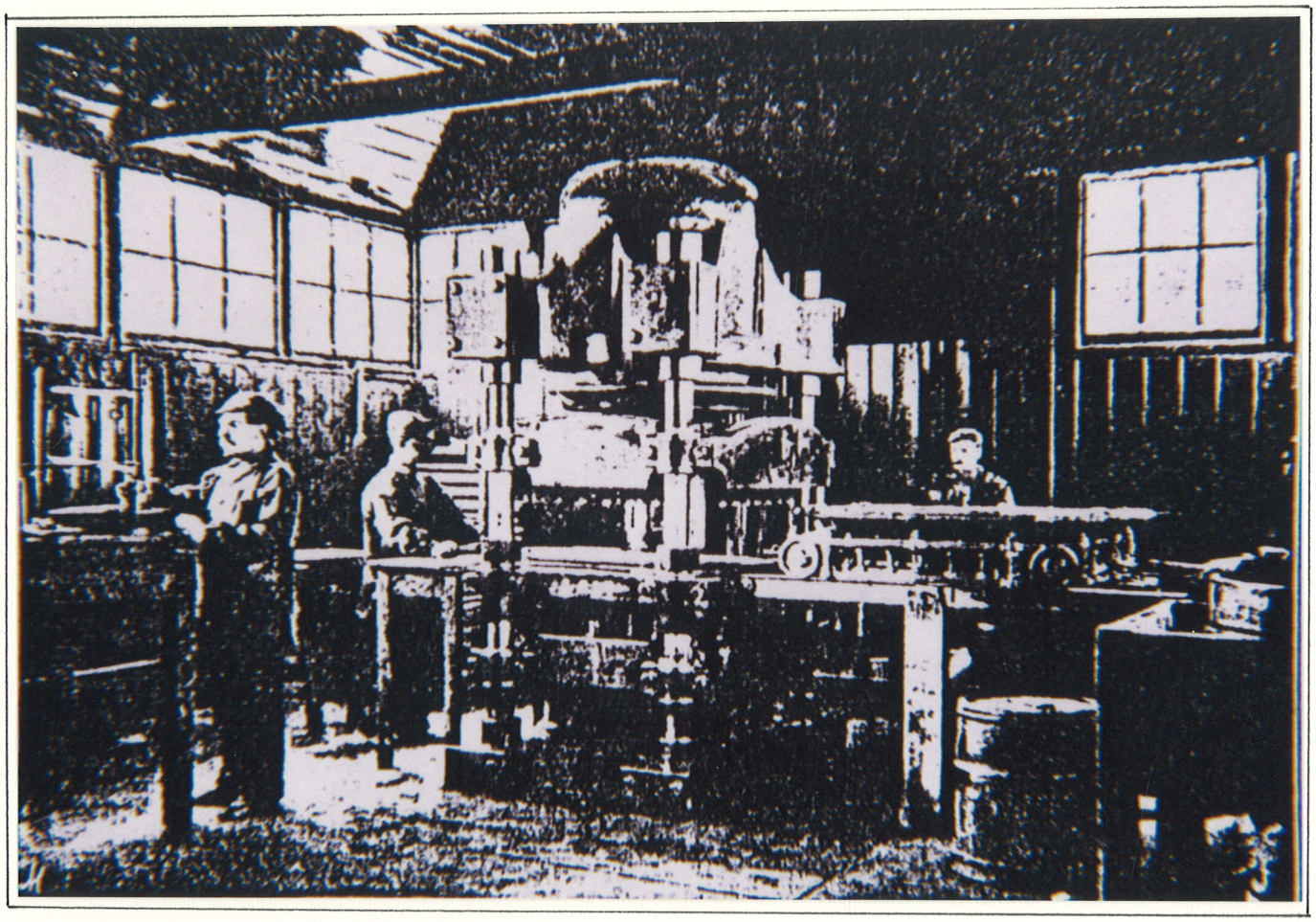
The machine-house is on the left,and the men's retiring-room on the right. Between these two buildings is placed the "traverse," a mighty mass of masonry,concrete,and earth,which is intended to protect the workmen.

ENTERING A DANGER BUILDING.



Everybody entering the press house is compelled to put on a pair of enormous boots over his own. This precaution is taken to stop any gritty particles entering the building.

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."

A POWDER BARGE.

The finished powder is conveyed to Purfleet and Woolwich in special barges,which fly a red flag,and can be sunk in five minutes.

INSIDE THE HOSPITAL.

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

THE ROYAL GUNPOWDER FACTORY.

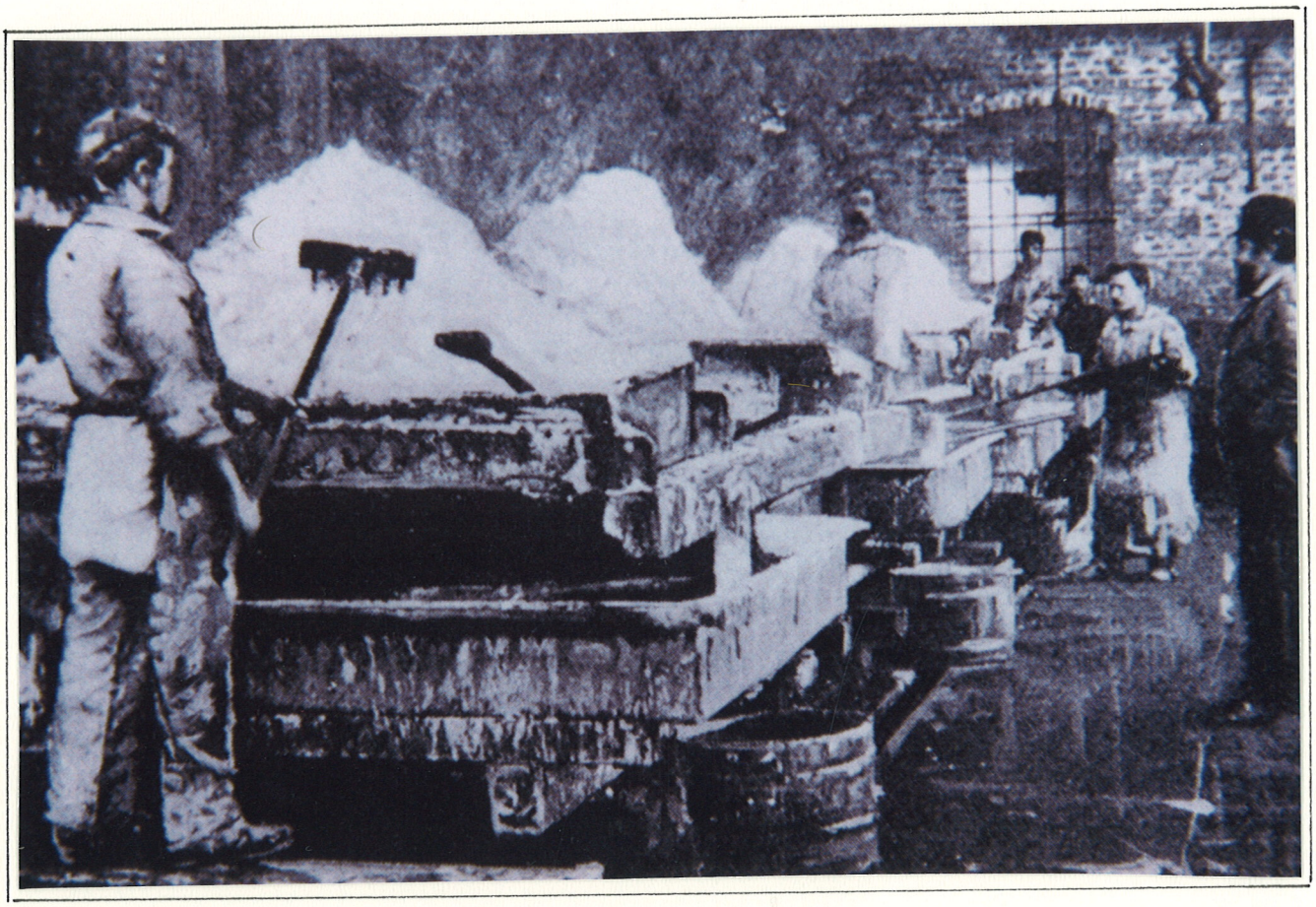
How Explosives Are Made.

Gunpowder.

1895.

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 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 8s to 12s per ton.



THE ROYAL GUNPOWDER FACTORY.

How Explosives Are Made.

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 opening to the square inch.

THE ROYAL GUNPOWDER FACTORY.

How Explosives Are Made.

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 utilized 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.

An important part of 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 byproduct was collected in casks and the gas allowed to escape to assist the firing.

THE ROYAL GUNPOWDER FACTORY.

How Explosives Are Made.

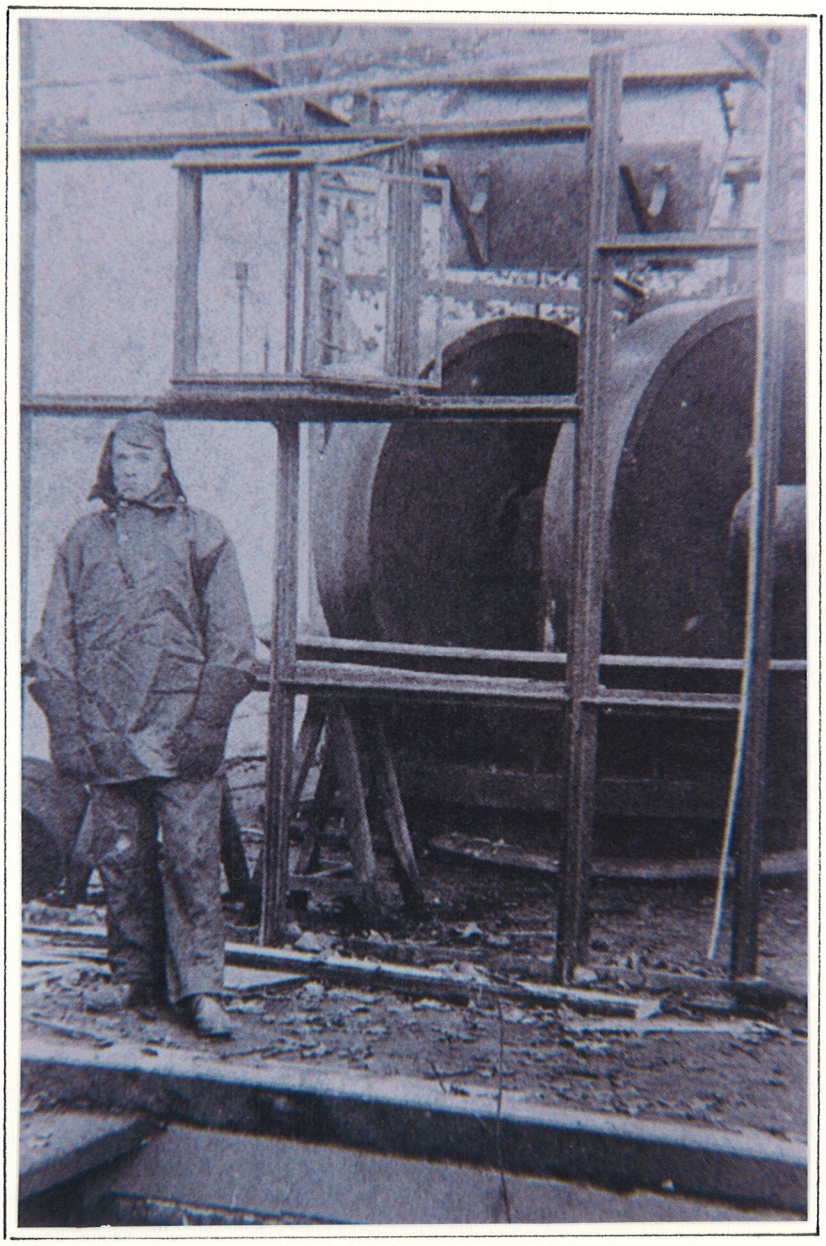
The Mixing Room.

"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 sacks of 60-lb and sent to the incorporating mill-the first of the 'danger mills'."

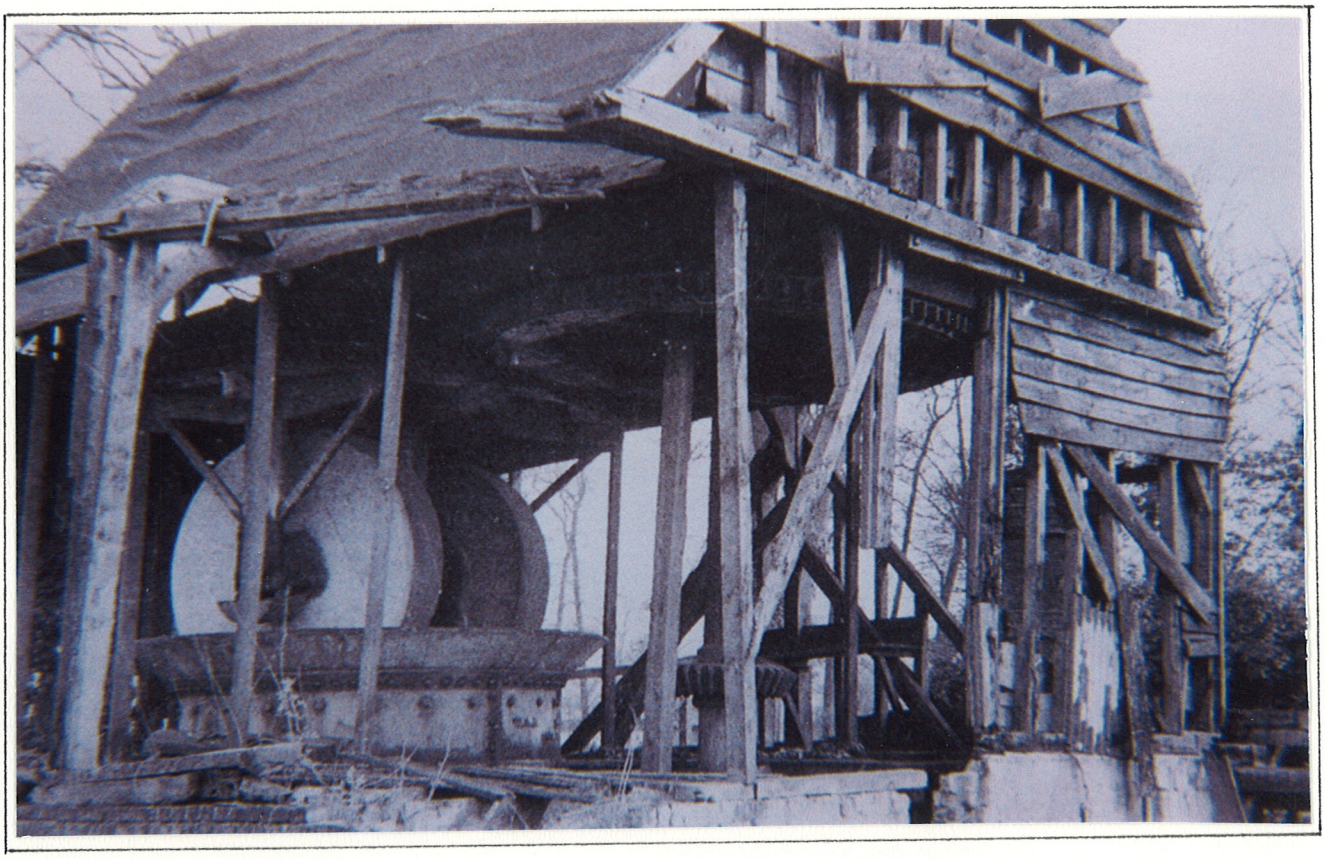
Incorporating Mill.

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 fronts 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,round 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 contains particules of grit.

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.



The last of the gunpowder 'incorporating mills',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.



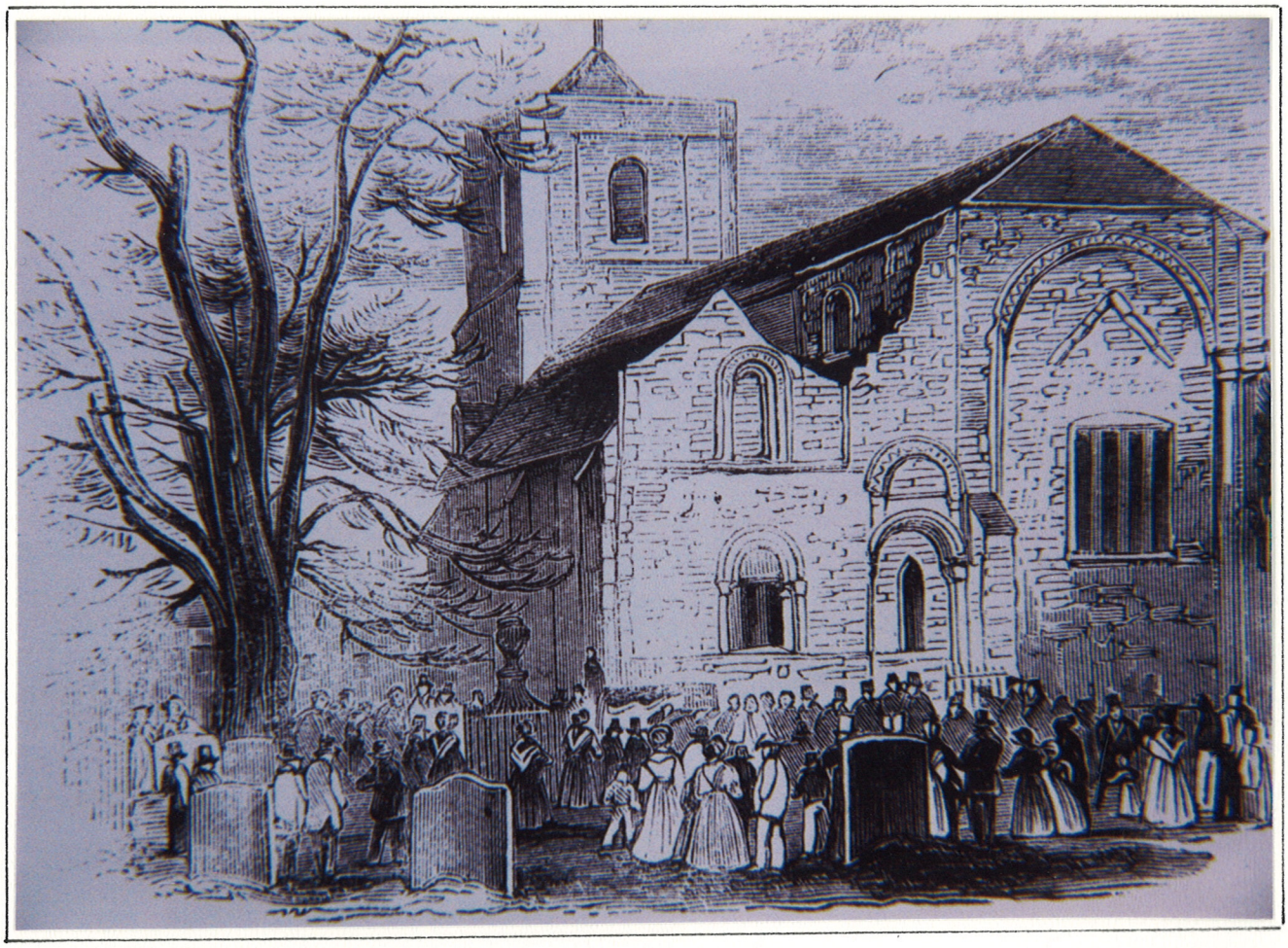
Engraving of the 'Powder Mills' E.Watford 1898.

Incorporating Mill Stone Wheel.

One of the old stone wheels used to mix the ingredients of black powder,which could weigh up to 4 tons..
Iron runners or rollers superseded these stone wheels as they could be smaller and safer.

This explosion of 1843 claimed seven lives. The blast wall on the right proved inadequate. Michael Faraday was brought into the resultant enquiry as a consultant.

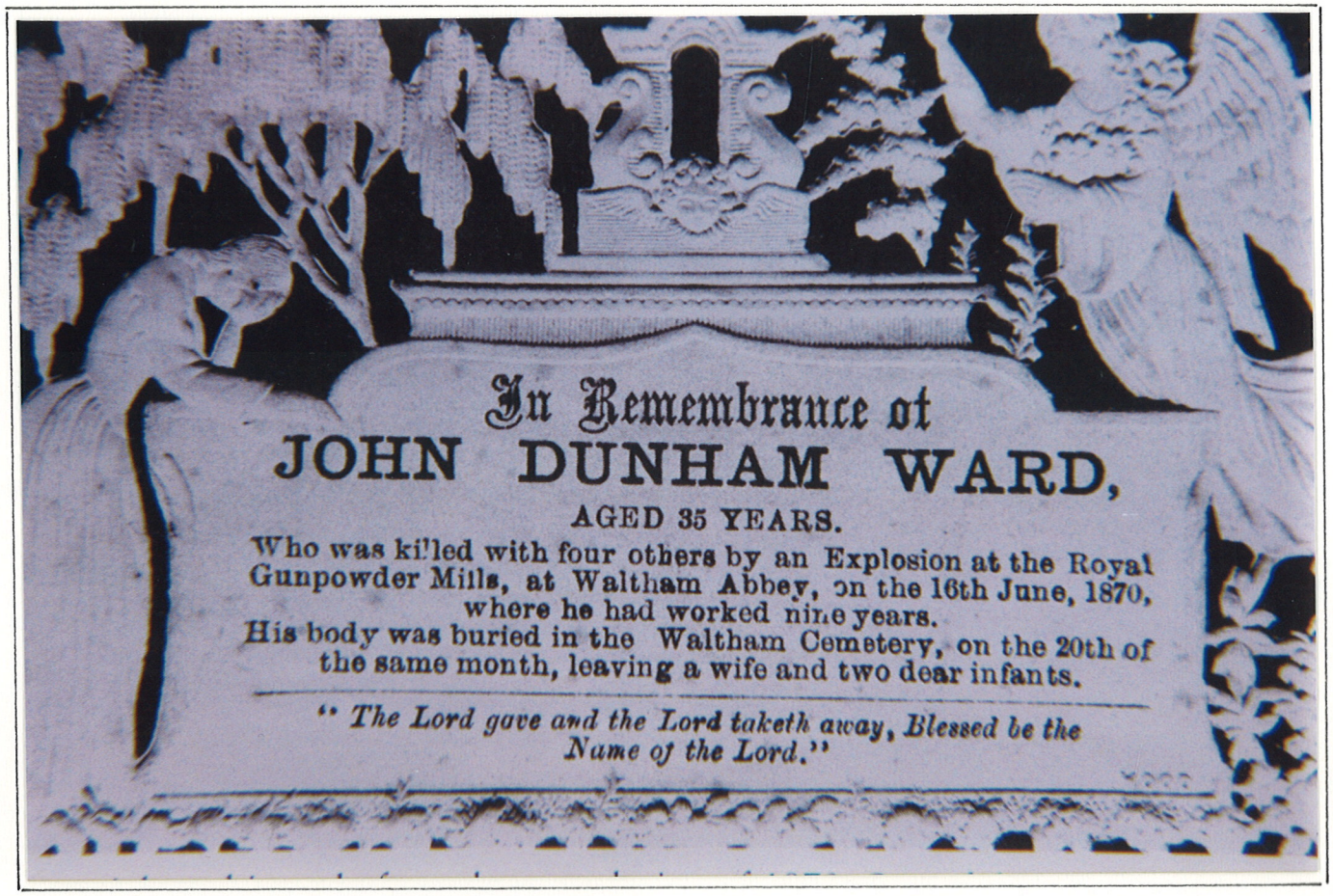
The funeral at the Abbey Church of the men killed in the 1843 explosion. In some cases weighted coffins were used to conceal the absence of a body.



A sketch of the funeral procession turning from Powdermill Lane,en route to the Abbey Church,after an explosion,in April,1843,in which 7 men lost their lives.

This wooden building,was the R.G.P.F. superintendent's,old quarters,south of Highbridge Street facing Powdermill Lane,with the old River Lea running underneath.
Picture,1885.

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



THE ROYAL GUNPOWDER FACTORY.

How Explosives Are Made.

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 sacks of 60-lb and sent to the incorporating mill-the first of the 'danger mills'."

Incorporating Mill.

After being 3½-hours beneath the incorporating rollers,the mixture becomes 'mill cake',and is removed in covered trucks to the breaking down house. This building,in common with most of the other danger buildings,is lit at night by electric lamps,immersed in water,and placed outside the windows.
In the breaking down house the mill-cake is placed in a hopper,drawn up on an endless band,and crushed into meal powder by two pairs of gun6metal rollers. Only twelve charges of 120-lb. each are allowed in this house at one time.

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.

THE ROYAL GUNPOWDER FACTORY.

How Explosives Are Made.

The Press House.

The press house is the parting of the ways,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 glazed and graduated 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 build-up charges used in big guns.
Coarse-grained powder is fed into the compartments of a wheeled tray,and it is then pushed under the hydraulic press,which has corresponding plungers. The hexagonal prisms emerge in batches of 64,or 13,000 per day.
Specimens are weighed from each batch in air and mercury,and if not up to standard the whole batch is rejected.

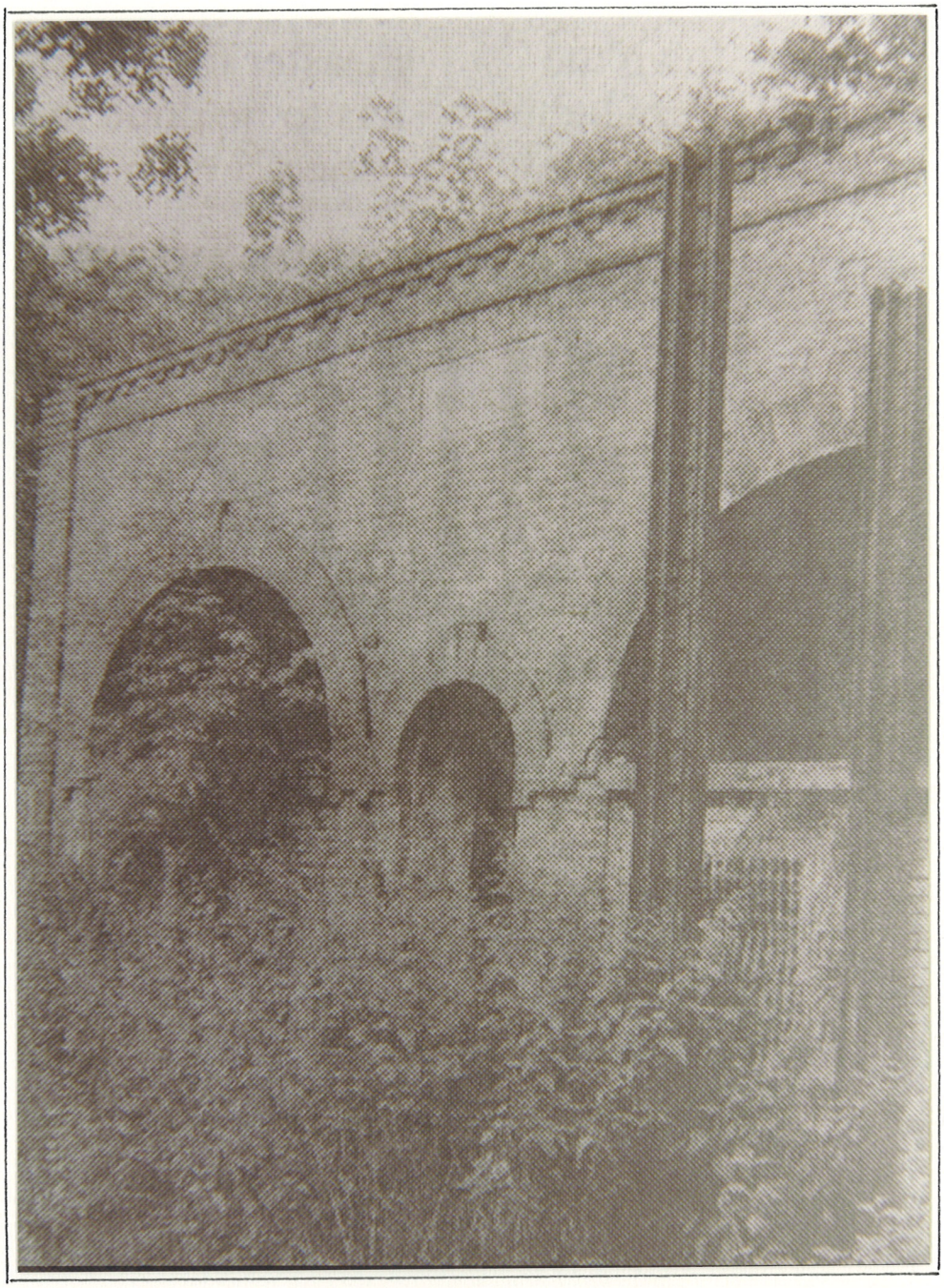
In the drying-rooms,ordinary grain powder is left for from one to three hours; pebble powder,however,takes from 24 to 44-hours to dry,and S.B.C. (slow burning cocoa"),for 110-ton guns,about 60-hours. The last-mentioned powder is proved in 11-inch guns with a charge of 360-lb,and gives a muzzle velocity of from 2,010 to 2,050-fps. Finished powder of all sorts is sent to a laboratory to undergo various tests; it is then proved in the guns at the butts attached to the establishment.

THE ROYAL GUNPOWDER FACTORY.

Old Gunpowder Press.

Press House.

Used to make gunpowder pellets,was built in 1894.



THE ROYAL GUNPOWDER FACTORY.

The testing armoury and proof range are at Quinton Hill,but are within the boundaries of the factory. Here stands an array of field artillery and naval quick-firers,all clean and bright.

"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 17ft. 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."

1895.

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

THE ROYAL GUNPOWDER FACTORY.

Gunpowder Barge.

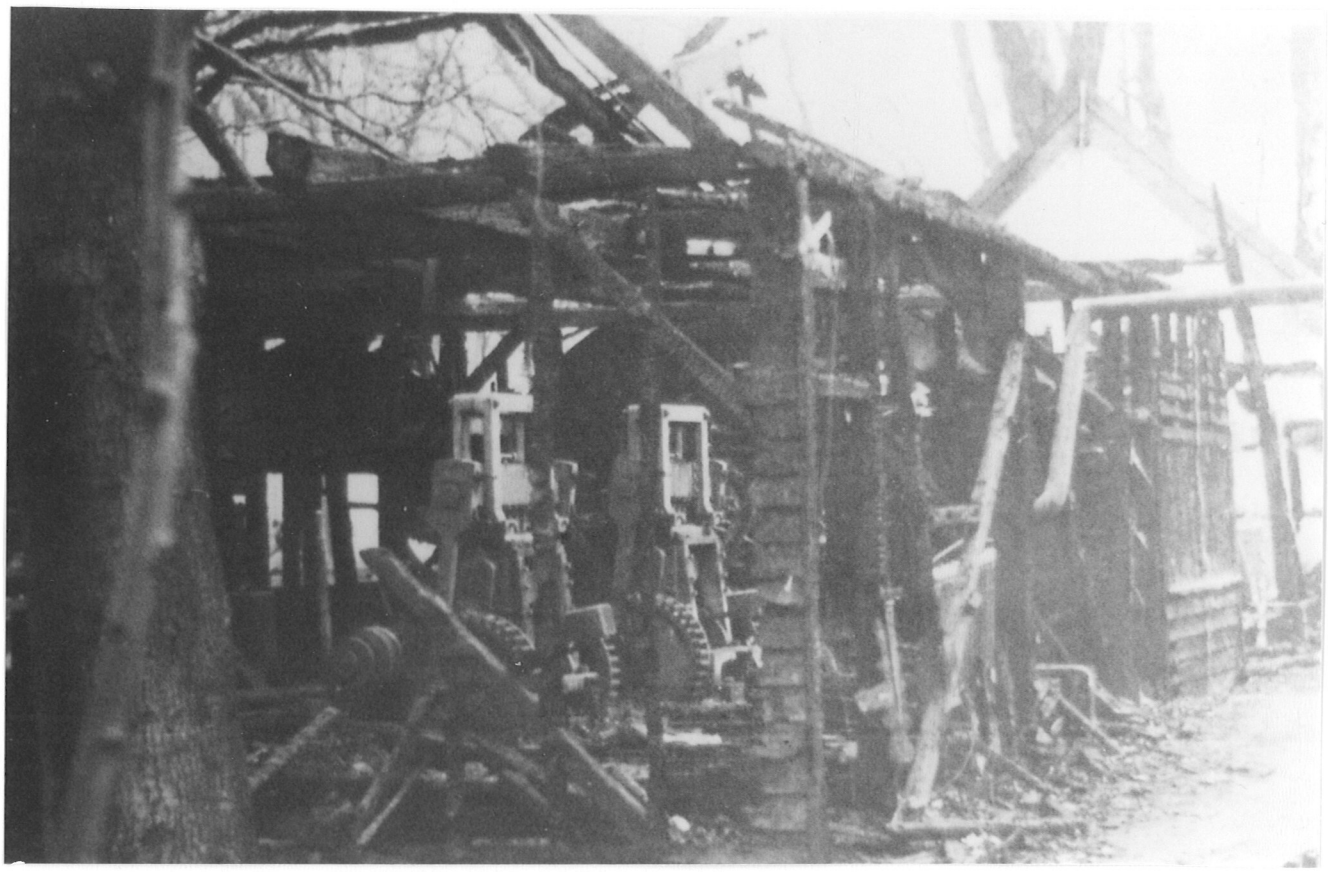
1899, the bridge is raised, the barge loaded and ready to go down river.

Powder Boat.

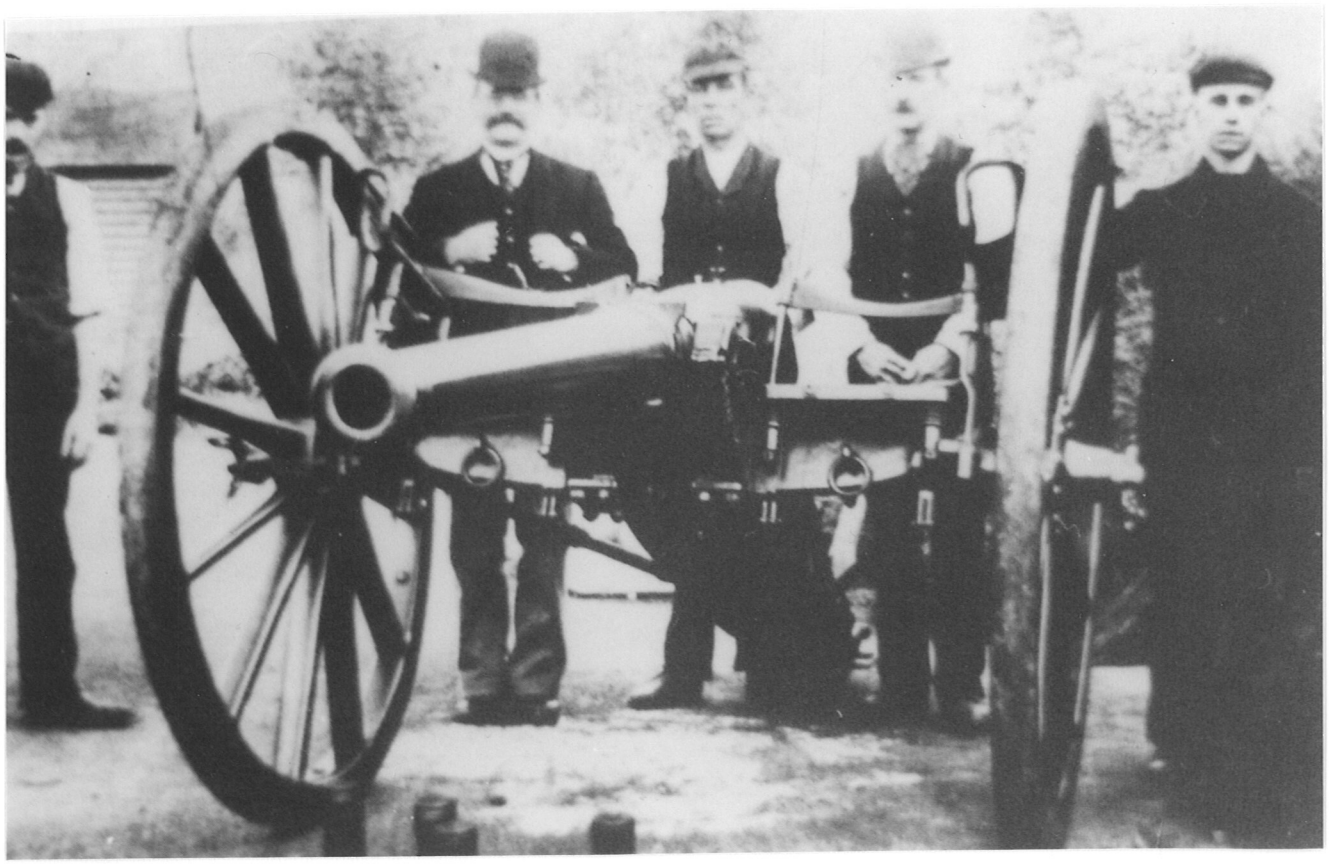
The finished powder was conveyed to Purfleet and Woolwich in barges like this,flying the red flag. In an emergency the boat could be sunk in five minutes.

One of the several barges with sails,that were used to transport explosives from the factory,up until 1945.
This picture shows,'The Lady of the Lea',the last wooden sailing barge to be made. It was built in Rotherhitde,by Hyam and Oliver in 1931,for service between the Waltham Abbey factory and Woolwich Arsenal. The barge has been preserved.

Damage,caused by an explosion at 2.35 am,13th December 1893,in No.2 Cam House. 9 men lost their lives in this diameter.

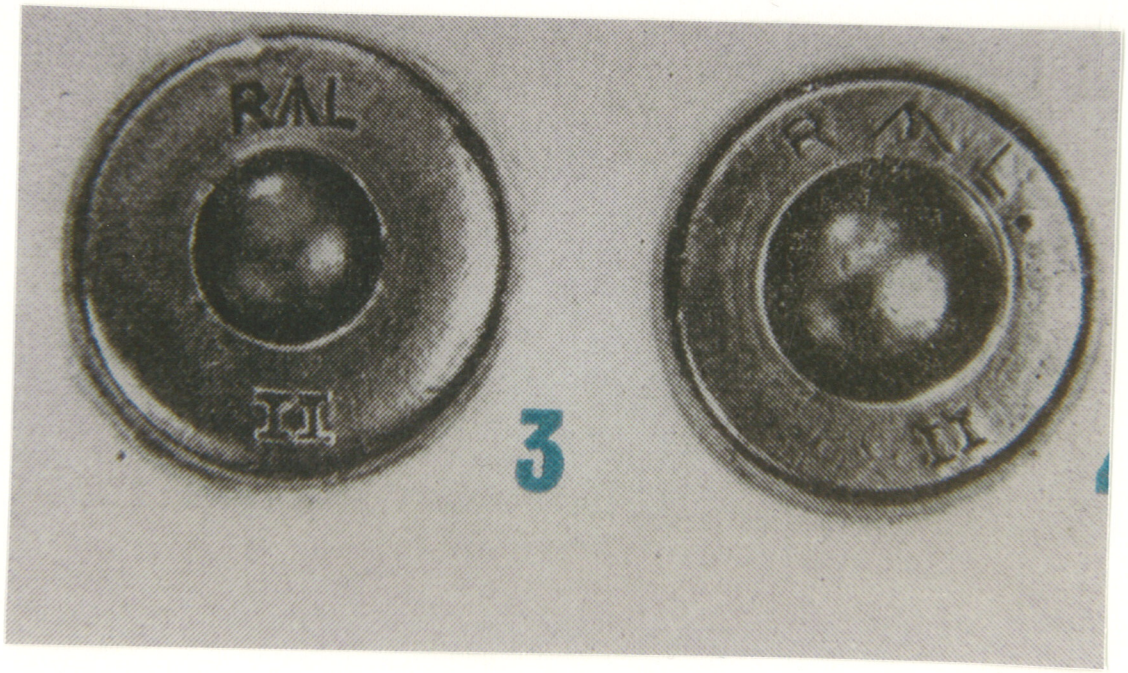


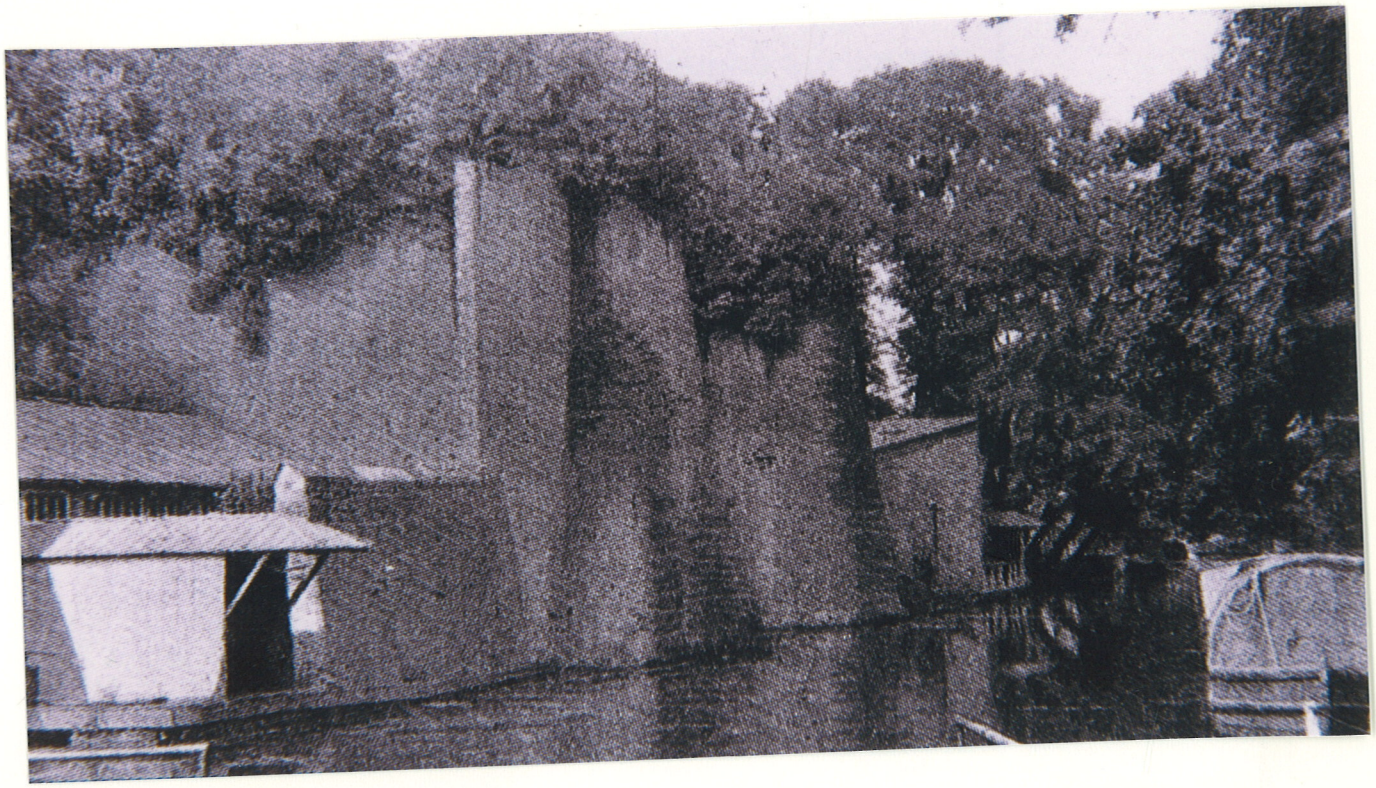
Proof testing at the gun bitts,in the early 1900's. Local residents became accustomed to the sound of gunfire,when testing was in progress,at the R.G.P.F. and the R.S.A.F. at Enfield Lock.



.303-inch 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.





The End of Blackpowder.

By the late 1830s when the first serviceable smokeless powders were starting to become available,most armies and navies could scarcely contain themselves in the rush to rearm. The main controlling factor was cast; at one stroke almost their entire stock of weapons had been relegated,at best,to second-line service with the militia or reserves. Another very large expense was that of erecting the necessary plants to make the new powders together with supporting services for manufacturing nitric and sulphuric acids,refining etc. For many it was their first essay into modern chemical technolgy and hence even more expensive and traumatic. Another option was of course to buy the NC from a friendly more advanced neighbour,but the problem then was to decide just who was friendly,to what extent and for how long-a problem which remains today.

Certain economies could be made with small arms,in particular where it was possible as a stop-gap measure to merely load the old ammunition with a reduced charge of smokeless poeder to duplicate the original ballistics,thus reaping the benefits of a massive reduction in smoke and in fouling while gaining time to consider the next move.

By this stage,repeating rifles,machine guns and automatic light cannon had been around some time but had not caught on to any great extent since blackpowder posed a very severe limitation on their operations.

There had also been a continuing pressure for even greater reductions in the bore of military small arms in order to further flatten the trajectory,reduce the recoil and to lighten the load that the infantry was forced to carry. Once again,blackpowder was no help,for it was a simple geometric fact that as the diameter of the bore was reduced,so the ratio of the surface area of the bore to its cross-sectional area was increased,and hence the deposition of solids in the bore was also increased. The average bore of military rifles was at the time around .40 to .45-inches and further reduction seemed impossible if a worth-while rate of fire was to be maintained.

Such was the rate of progress at this stage however,that within very few more years,all the major powers of the world were equipped with small calibre-about .30-inch-repeating rifles firing a smokeless powder of their choice,France with a derivative of Poudre B,Germany with a derivative of Ballistite and England with Cordite Mark 1.

The End of Blackpowder.

It was also quickly discovered that the new smokeless powders were much harder to ignite than their predecessors,and that the large charges needed a fair-sized blackpowder igniter as well as a primer to get them going uniformily. Within a few years it was noticed that the Cordite sticks near such igniters began to show signs of pitting and spots of discolouration,which was attributed to localised degradation catalysed by the sulphur in the blackpowder. The official title of such spots was 'sulphur corrosion' but other more graphic slang terms were much more common. The cure was obviously to remove the sulphur,thus leading to yet another,and possibly the last,grade of blackpowder-the sulphurless series which were generally designated by prefixing their normal title with the letter 'S'.

Apart from a few minor uses in igniters or pyrotechnics,blackpowder was finished.

William Congreve.

William Congreve was born in 1772 and entered the Artillery as his father had done,after being educated at the Royal Military Academy Woowich. He was attached to the Royal Laboratory in 1791 and in 1805 invented the Congreve Rocket,a weapon which,though far from completely successful,remained a service weapon for many years and was the forerunner of all rockets.

GUNPOWDER.
Mixing and Making.

Although varying from place to place,gunpowder consists of about 75% of saltpetre,10% sulphur and 15% charcoal. The saltpetre was brought to Battle from the East in its crude state. It was refined or purified in a large building called the refining house in extremely large cast-iron furnace pans. Water and saltpetre were boiled together for several hours. When it had stopped boiling and cooled down,the water was drawn off. The saltpetre crystals were then placed in smaller pans and heated to a liquid state and poured into moulds,in readiness for use.

A small amount of saltpetre was produced near the mills,but this was a slow and stinking process. It consisted of layers of decaying animal and vegetable matter,earth and sand,piled to a thickness of two to three feet on floors of clay. It was periodically dampened with blood. After two years the layers were opened and the saltpetre extracted.

The charcoal for ordinary gunpowder was made from alderwood,which was brought to the works and turned into charcoal in pits. The charcoal for finer or sporting powder was made from blackdog wood. This was converted into charcoal in cylinders somewhat like gas retorts.

The mill in which the ingredients were mixed was constructed of stout framing with light roofing and boarded sides,the idea being that in the event of an explosion there would be slight resistance. The circular stones,by which the grinding and mixing was done,were made of marble. These stones were about 8-feet in diameter,20-inches thick and weighed 9-tons. A pait of these millstones were mounted on an axle in a circular trough of smaller diameter than the stones.
The amount being ground under each pair of stones (there being fifteen pairs of stones) was 100-lbs and took about eight hours to complete grinding into dust. Water was automatically sprinkled on the powder to keep it damp and safe from explosion.

Compressing the Dust.
The gunpowder dust was taken from the grinding mills to the presses which were set out in an isolated building. The dampened powder dust was placed on three and a half foot square copper plates to a thickness of 2-inches. When the plates were loaded they were placed one above another until 600-pounds was in position,the pressure was then applied by means of a manual capstan.

The powder was reduced to a thickness between the plates of about three-quarters of an inch and resembled slate. The manually operated presses were discontinued with the installation of a beam engine about 1810. With the steam engine in use a pressure of 400-tons was obtainable on the plates.

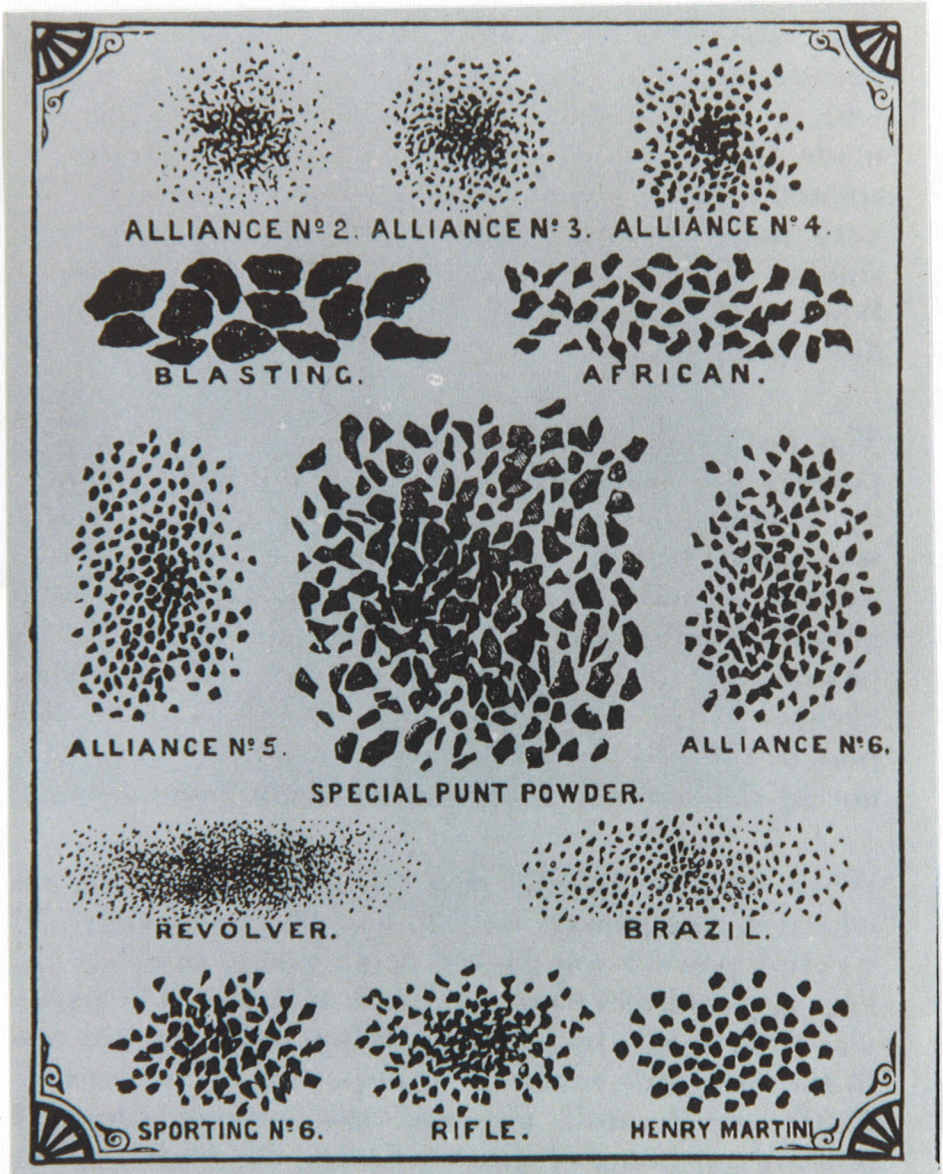
For gunpowder of special types (e.g. blasting and cannon pellets) instead of pressing in trays the gunpowder dust was pressed in mould of the shape wanted. The granulation of the powder was the next process when it came from the presses. It was first passed between cogged zinc rolers and reduced to pieces the size of marbles.

Then through plain brass rollers for the various rough sizes required. Then the powder was sifted through meshes of various sizes-the coarsest for duck punt guns to the fine grain sporting powder.

Glazing the Product.
After the granulation of the powder came the glazing. The glazing house was a large building with a wooden shaft running through the whole length of the building. The shaft ran through the centre of wooden barrels and some gunpowder was placed in each together with a small amount of graphite. The barrels were rnade to turn slowly,the powder and graphite being rotated together,which in time turned the grains from a very dull brownish colour to the characteristic black shining colour. It was then taken to yet another building to pass through the dusters to extract all the fine dust powder.

The last stage before packing was the drying. The powder was taken to a large brick building which was the drying house and the heat from a nearby furnace was passed to it by flues. The trays of powder,in racks,were arranged in the centre and around the walls with a gangway in between. When the weather permitted the powder was dried outside in the sun. Not only was it cheaper outside,but since this was the most delicate part of the process,in the event of an explosion it was not so damaging to building and equipment.

When dry,the powder was taken to the packing shop where it was packed into 28 and 56 pound kegs. The sporting powder was packed in one pound canisters. The kegs and canisters were also made at Battle. The packing was done mostly by women. When packed it was taken to the magazine ready for transporting. The closing of Battle powder-mill followed the general disuse for military purposes of gunpowder as the main explosive element...the end of an era.i



Pigou, Wilks and Laurence's Gunpowders.

Curtiss and Harvey's Gunpowders.