

How Explosives are Made.

BY WILLIAM G. FITZGERALD.

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 sundial, 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 principal entrance of the factory, one cannot help admiring the pastoral scenes of woodland and meadow, which render it difficult to believe that the

most dangerous industry in the world is carried on within a few hundred yards. Passing in at the gate we beheld an avenue of stately poplars, at the end of which the Union Jack floated proudly from a flag-staff. This gave rise to a train of thought from which we were rudely aroused by a sharp challenge from the inspector of police. We were then requested to enter the police quarters, where we were plied with questions as to our business, and whether we possessed any matches, pipes, or steel implements. Then we turned out our pockets, just as Lord Sandhurst had to do when he



NO. 1.—"ANY MATCHES?"

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. Our illustration (No. 1) shows one of the sergeants of police searching the men at the main gate.

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.

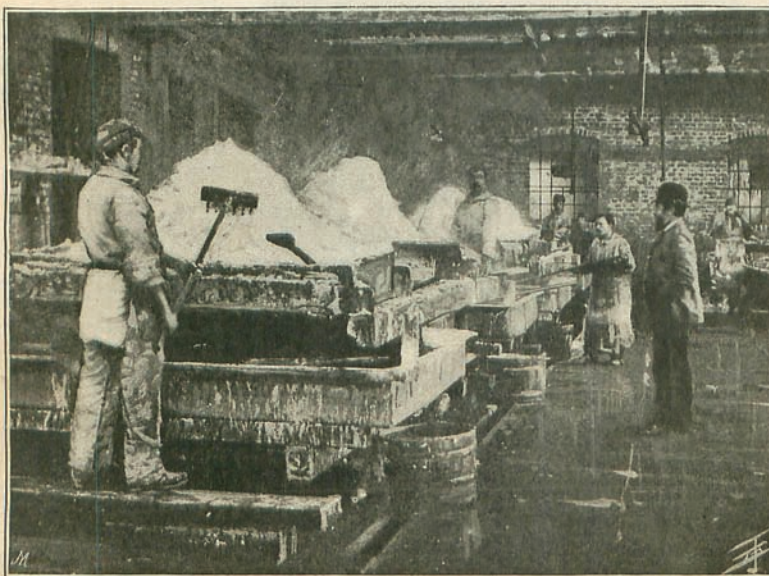
But we must commence *ab initio*. The first place we visited—and we were calm and appreciative then, not knowing the extent of the appalling task that lay before us—was the saltpetre refinery shown in No. 2. To the right in the photograph is Mr. Knowler, the “father of the factory,” as he is called from the fact of his forty-three years’ service. The saltpetre comes from Scinde in bags of 100 lb., and in this state it contains about 5 per cent. of impurities. It is dissolved in large quantities in water heated to 230 degrees, and, after careful skimming, the solution is pumped into the coolers shown in No. 2. The saltpetre crystallizes in these coolers, and is then raked from the bottom in the form of wet snow, which is piled up, and subsequently undergoes a wash-

ing 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 per cent. of water. The saltpetre refuse is bought by farmers for from 8s. to 12s. per ton. We next called at the sulphur refinery (Illus. No. 3), but found it almost impossible to breathe within its evil-smelling precincts.



NO. 3.—THE SULPHUR REFINERY.

As regards the worthy man we found there, he was as unconcerned as though he were inhaling the ozone on Brighton Pier; more, he proceeded to give us, out of the fulness of his twenty-six years’ experience, a few details concerning his own department in quite a graphic manner. Six hundredweight and a half of Sicilian sulphur is shot into the retort, seen to the right in the picture, 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. Our friend is seen ladling this viscous matter into the casting tubs, in which it is left for about eighteen hours. Next morn-



NO. 2.—THE SALTPETRE REFINERY.

ing 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.

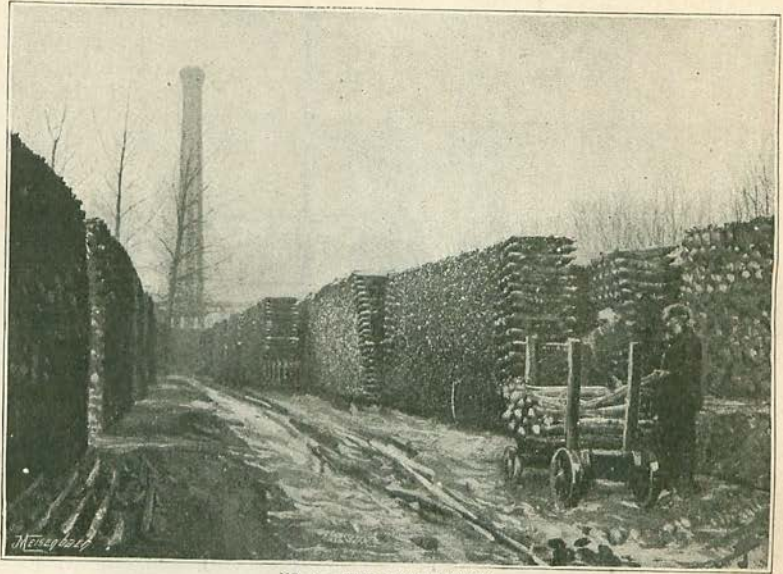
There remains one other constituent of powder to be investigated—namely, charcoal. Why, we asked, are there such extensive groves and forests of willow, dogwood, and alder within the boundaries of this strangest of factories? One reason is that the wood is converted into charcoal; and another, that a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

No. 4 is a view of the wood stacks, many of which are from three to ten years old.

Now let us see what these workmen are going to do with the seasoned branches they are loading on to the trolley.

No. 5 is a view of the charcoal-room. The wood is placed in the cylindrical

drums, and the latter are then run into furnaces shaped to receive them, by means of travelling cranes. After from three to eight hours of very great heat, during which time the very gases from the burning wood



NO. 4.—THE WOOD STACKS.

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 sulphur is ground so as to pass through a sieve having 36



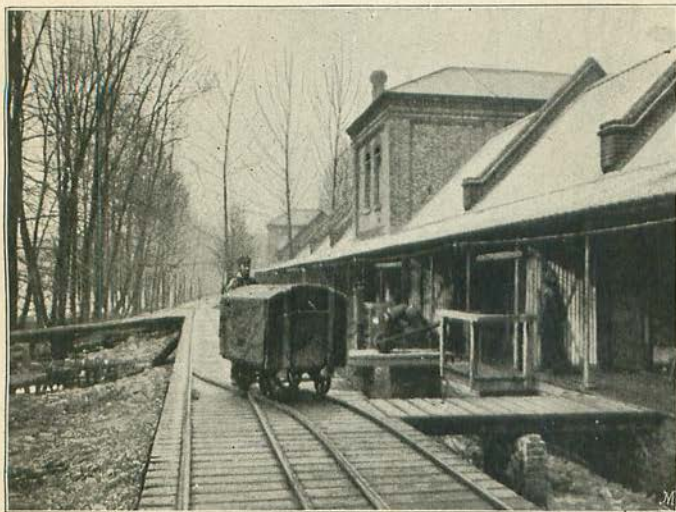
NO. 5.—MAKING CHARCOAL.

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

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'être* 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.

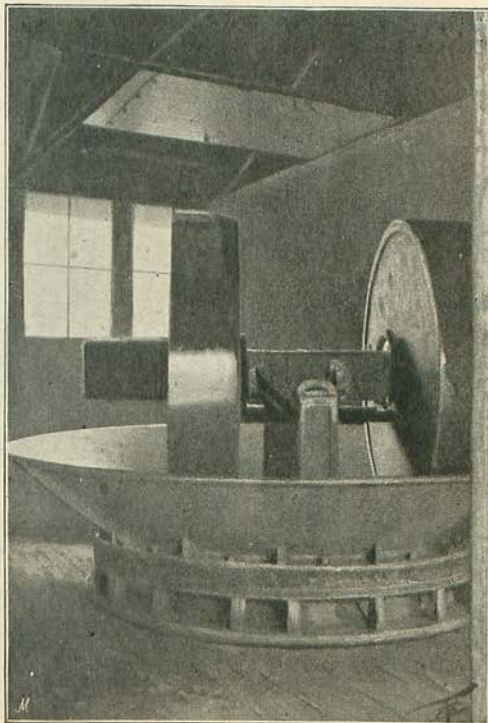
Indeed, the risk is so great, that in order to



NO. 6.—INCORPORATING MILLS: EXTERIOR VIEW.

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 60lb. and sent to the incorporating mill—the first of the "danger buildings."

In No. 6 is shown a set of incorporating mills, which are built in groups of six, and are worked by independent 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. 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. As will be seen from No. 7, there is nothing in the place but a big, circular iron bed, round



NO. 7.—INCORPORATING MILL: INTERIOR.

start the incorporating mill, the operator prudently draws down the flaps of his cloth helmet, puts on his gauntlets, and retires outside, as is shown in No. 8. The man is



NO. 8.—STARTING THE INCORPORATING MILL.

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, harmless 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 120lb. each are allowed in this house at one time.

The next department is the press-house, an exterior view of which is shown in No. 9. 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; 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 750lb. 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 congregated 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 thoughtfully provided



NO. 9.—THE PRESS-HOUSE, SHOWING "TRAVERSE."

deep wells outside each danger building, into which men who have been badly burnt may plunge. No more than 900lb. of powder may be kept in the press-house at one

time. No. 9 also shows a covered powder boat on the left. There are thirty-six of these boats altogether, and no one is allowed to go over a bridge while one of them is passing beneath, lest any dirt or grit should fall upon the immaculate deck.

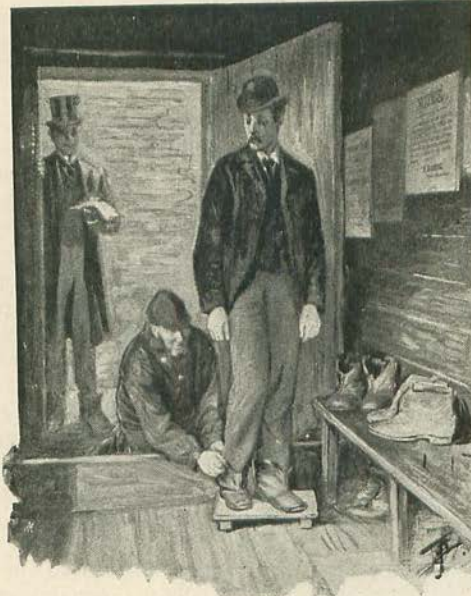
The press-house is the parting of the ways, so to speak, of the various kinds of powder, which are made from press-cake treated in different ways. For pebble powder the press-cake—which, by the way, resembles thick black slate—is cut into strips, and these strips are further cut into “ $\frac{5}{8}$ cubes.” The rest of the cake is reduced to coarse powder by three pairs of graduated rollers.

All sorts of fear-some notices and cautions abound in the retiring-room of the press-house, which is depicted in No. 10. A rigorous line of demarcation is formed by an upright board, before passing which every visitor, from the Government inspector downwards, is compelled to put on a pair of enormous boots over his own. In No. 10 the chief foreman is seen undergoing this operation. 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 shamefacedly 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.

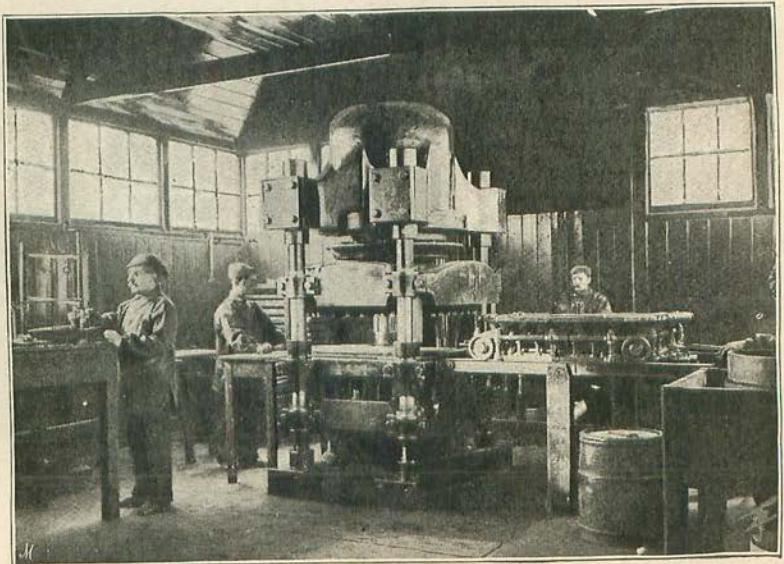
The glazed and granulated powder (the dust from which has been removed by another process and sent back to the incorporating mills) is now ready for moulding into prisms for the built-up charges used in

big guns. The interior of the moulding-room is shown in No. 11. Coarse-grained powder is fed into the compartments of the wheeled tray to the right, and it is then pushed under the hydraulic press, which has corresponding plungers. The hexagonal prisms emerge in batches of sixty-four, or 13,000 per day. To the left in our photograph (No. 11) a skilled workman is seen weighing 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 twenty-four to forty hours to dry, and S.B.C. (“slow burning cocoa”), for 110-ton guns, about sixty hours.



NO. 10.—ENTERING A DANGER BUILDING.



NO. 11.—THE MOULDING-ROOM.



NO. 12.—A POWDER BARGE.

The last-mentioned powder is proved in 11in. guns with a charge of 360lb., and gives a muzzle velocity of from 2,010ft. to 2,050ft. per second. Finished powder of all

of each kind are blended so as to give uniformity, and the powder is then conveyed to Purfleet and Woolwich in special barges, which fly a red flag and can be sunk in five minutes. One of these craft, together with a typical view of the Waltham Abbey establishment, is shown in No. 12.

Altogether there are about 900 men employed in the factory, and the annual wages bill comes nigh unto £70,000. One thousand four hundred tons of saltpetre are stocked; 100 tons of sulphur; and enough wood to make 40,000 barrels of powder. The annual consumption of coal ranges from 8,000 to 10,000 tons. Very significant is the photograph we reproduce (No. 13). It shows the interior of the little hospital opened by Lord Sandhurst quite recently. The hospital stands close to one of the myriad streams that intersect the vast grounds of the factory, and is intended solely for the benefit of injured workmen. By the way, it seems strange that, in spite of innumerable precautions and all that science can do, frightful explosions should take place—explosions as disastrous as they are inexplicable. Truly, these grave, quiet men, who are turning out by day and by night material for the defence of our country, “know not the day nor the hour.”

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-field of



NO. 13.—INTERIOR OF THE HOSPITAL.

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

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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 1,850ft. per second. A cordite charge of 30 grains gives a velocity of 2,000ft. Again, the powder charge for the 12-pounder gun is 4lb., while the cordite charge for the same weapon is $15\frac{3}{4}$ 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. In No. 14 the girls are seen picking 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

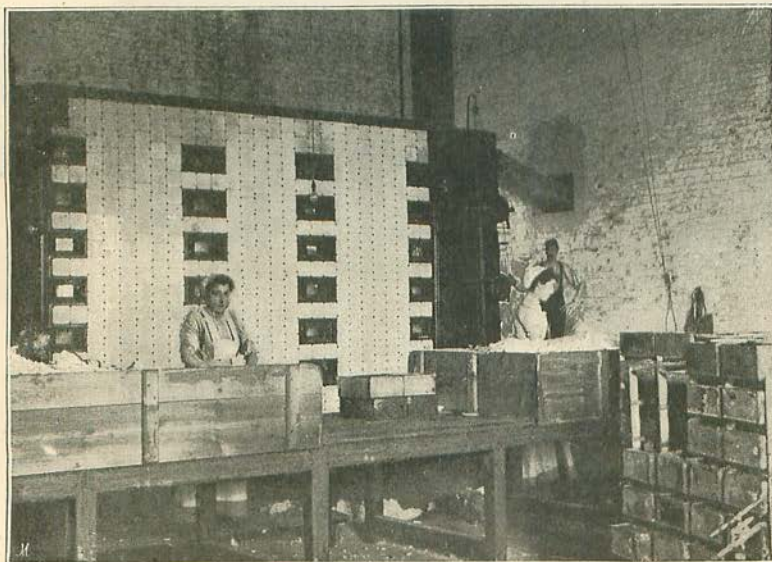


NO. 14.—PICKING COTTON FOR CORDITE.

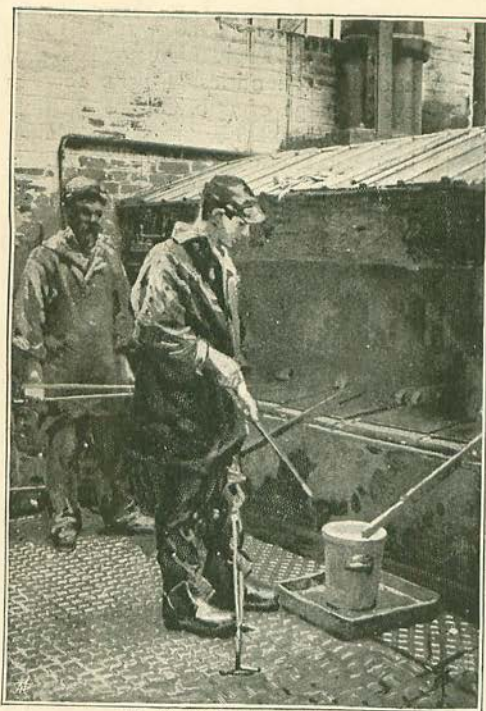
it is cut up by another machine, and then it passes on an endless band into a drying-room heated to 180 degrees. The cotton is then weighed up into lots of $1\frac{1}{4}$ lb., and each lot is placed in a tin cooling box; these operations are shown in No. 15. After twenty-four hours, the lots, or charges, are ready for dipping. Each dipping pan contains 220lb. 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 $1\frac{1}{4}$ lb. will have absorbed $13\frac{1}{2}$ lb. of acid.

The workman now takes his implements from the cold water in which they are kept immersed, for fear that repeated contact with the acid should corrode them, and he proceeds to remove the saturated cotton from the bath or pan. As will be seen from No. 16, he has an



NO. 15.—THE WEIGHING AND DRYING ROOM.



NO. 16.—THE DIPPING TANKS.

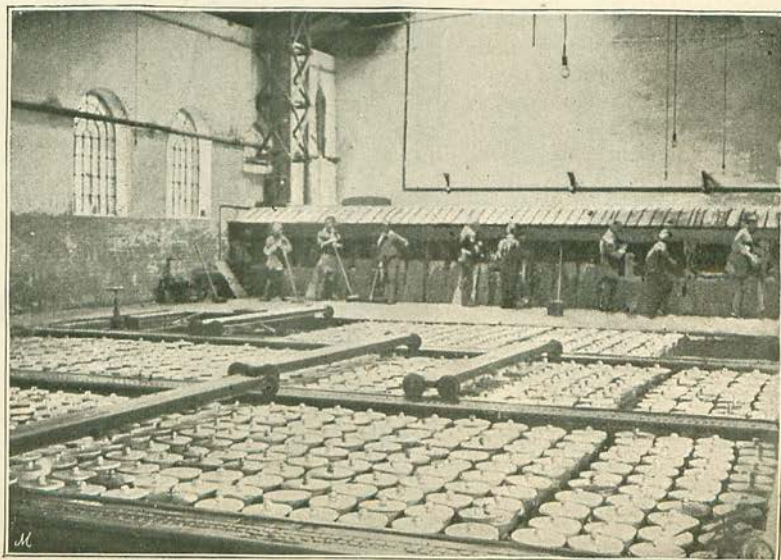
earthenware pot ready to receive the charge. The earthenware vessels containing the charges are then allowed to stand in shallow water for some little time. No. 17 is a general view of the cooling tanks, with the dipping baths in the background.

From the earthenware vessels the cotton is shot into a centrifugal machine, whirling round

at a speed of 1,200 revolutions a minute. In a very short time the cotton is comparatively dry; and the waste acid removed by the machine is allowed for by a contractor. The next operation is the washing of the cotton in a wooden tank full of water, which is agitated by a revolving bladed wheel. When the foreman thinks this washing has gone on long enough, he *tastes* the cotton, and if no flavour of acid remains, it is taken out by a man who wades in in big boots. The water is wrung out and the cotton is then removed to the vat-house, where it is boiled in monstrous vats for four or five days. Each vat holds about 18cwt. of cotton; and the interior of this department is shown in No. 18.

From the vats the long-suffering cotton comes out like wet oatmeal; then comes more churning and washing, until at length the moulding process is reached, and the cotton is pressed into big cubes of $2\frac{1}{2}$ lb. These cubes are veritable gun-cotton, and when pressed flat and furnished with a dry cylinder and a fulminate of mercury detonator, they are quite ready for torpedo work. The gun-cotton press-house, depicted in No. 19, is furnished with what is called a protective rope mantelet, or wall of rope, such as is used in fortifications.

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 are



NO. 17.—THE COOLING TANKS.



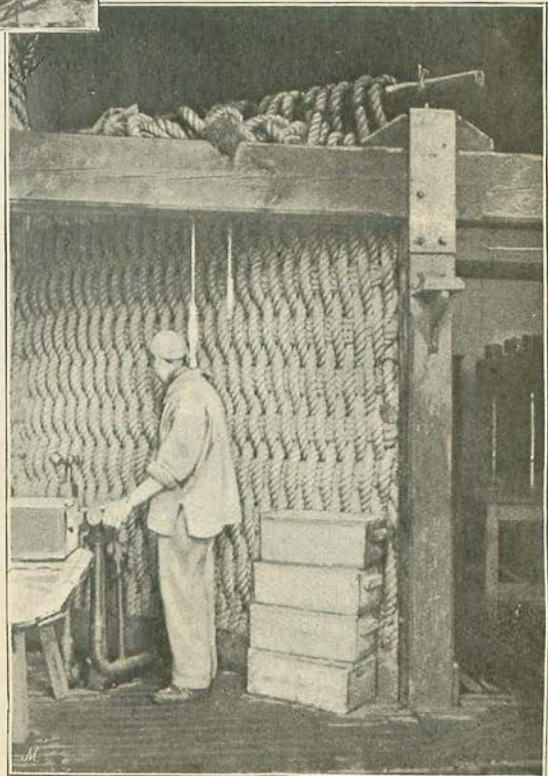
NO. 18.—THE BOILING VATS.

shown in No. 20. 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, which is shown in No. 21. The men, as may be seen from the photograph, wear curious respirators as they bend over the sticky mass, which gives forth nauseous and deadly fumes. When thoroughly kneaded, the dough is sent to the incorporating-house and placed in drums, which have slow revolving screw blades; this mixing process goes on for seven hours. The 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 15lb. 100z. to every charge of 75lb. One of the final operations takes place in the moulding-house. There $1\frac{1}{4}$ 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 2,000ft. of what looks like brown twine, with a diameter of $\cdot 0375$ in. This is finished cordite, and it is wound upon a reel. For 6in. quick-firers, cordite with a diameter of $\cdot 3$ in. is turned out, and as it emerges from the machine it is cut into 14in. lengths.

No. 22 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 our 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

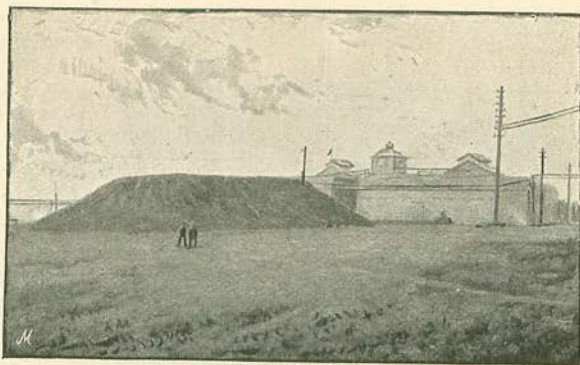


NO. 19.—THE CORDITE PRESS-HOUSE.

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 reel; 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.

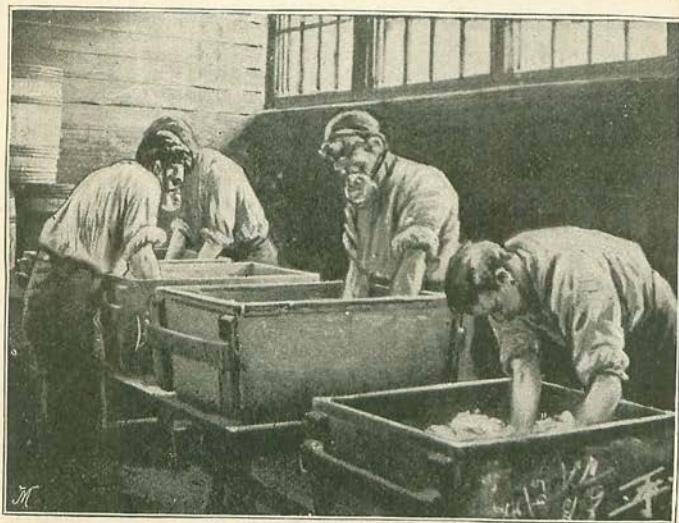
A pool adjoining the cordite works is



NO. 20.—THE NITRO-GLYCERINE WORKS.

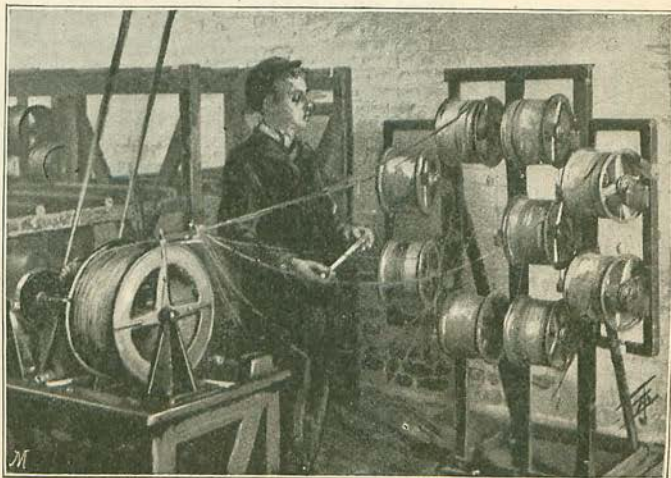
particular blowing-up. A glance will reveal the tremendous force of the explosion, which blew holes 20ft. deep around the pond.

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 6in. 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;

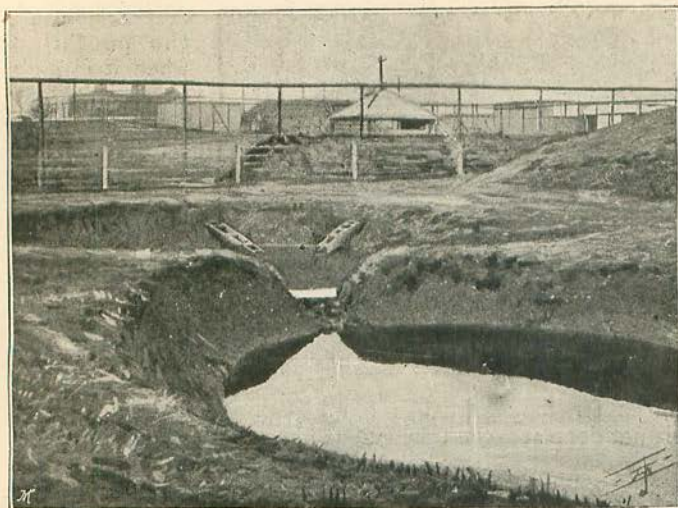


NO. 21.—MIXING CORDITE DOUGH.

shown in No. 23. 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. 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



NO. 22.—"TEN-STRANDING."



NO. 23.—THE SETTLING POND.

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.

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 abso-

lutely 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 ap-

prehension, 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 10ft. thick; so we came away.



NO. 24.—THE POND AFTER AN EXPLOSION.