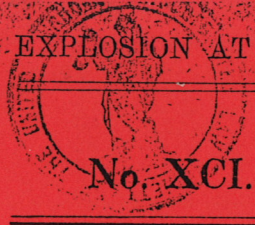


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REPORT

TO

THE RIGHT HON. THE SECRETARY OF STATE FOR THE HOME
DEPARTMENT

ON THE

CIRCUMSTANCES ATTENDING AN EXPLOSION OF GUNPOWDER,

WHICH OCCURRED AT THE

ROSLIN GUNPOWDER FACTORY, NEAR EDINBURGH,

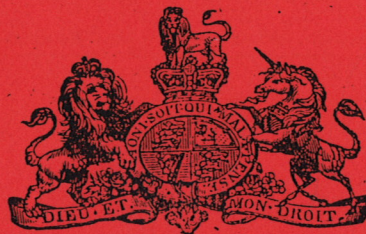
On the 22nd January 1890;

BY

COLONEL A. FORD,

H.M. INSPECTOR OF EXPLOSIVES.

Presented to both Houses of Parliament by Command of Her Majesty.



LONDON:

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BY EYRE AND SPOTTISWOODE,
PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY.

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HODGES, FIGGIS, & Co., 104, GRAFTON STREET, DUBLIN.

1890.

[C.—6000.] Price 5d.

undergoing the process, or 24 cwt. in all. Formerly it was of a massive construction, being substantially built of stone; but it has recently been pulled down and rebuilt of light materials, in consonance with more modern opinion as to the proper construction of working powder buildings. This construction consists of Willesden paper, wire-wove roofing, painted canvas or other similar material on a framework of wood, the sides being lined with wood. Wire-wove roofing, which admits light and appears suitable for the purpose, is employed, instead of glass, for the windows. In buildings, however, in which heavy machinery is used, substantial beams of wood, or, by preference, iron girders covered externally with woodwork are required to support such machinery. The object of this method of construction is to reduce to a minimum the resistance and the amount of projected matter in the event of an explosion, and thus minimize the chance of the explosion being communicated to other buildings. As, however, pieces of the framework of the building, and of the beams supporting the machinery, as well as parts of the machinery itself, are still liable to be projected (though, as less resistance is offered to the explosion by the building, perhaps not to such distances as they might be in a heavier building, in which the resistance offered to the force of the gunpowder must necessarily be greater), a light construction does not, of course, remove all danger from this source.

The lower press-house also existed before the passing of the Explosives Act, but was then used as a glazing-house, a class of houses to which no limitation of gunpowder was assigned by the former Act. Its appropriation was altered to a press-house by amending License No. 289 on the 15th January 1886, the usual press-house limitations, viz., 10 cwt. of gunpowder under pressure and a similar quantity not under pressure, or 20 cwt. in all, being assigned to it, and the number of workpeople in it at one time being limited to four. Like the corning-house, it was formerly a stone building, and has recently been rebuilt of light construction. Both of these buildings, therefore, have been much improved since the passing of the Explosives Act in respect of structure, and in one a limit of 2,240 lbs. of gunpowder and four workpeople has taken the place of an unlimited amount of gunpowder and an unlimited number of workpeople.

These buildings were both situated at the bottom of the valley, close to the river, and on the north side of it, and unfortunately, as was the case with many buildings in factories established under the former Acts, they had been placed too near to each other, being only about 40 yards apart. A mound of earth, planted with trees at the side of the corning-house, was interposed some years ago to form a partial protection against the communication of explosion in one to powder in the other, and on the 24th of May, 1872 an explosion actually took place in the corning-house, and extended to a waggon-load of powder standing at the door of that building without being communicated to the other building, which was at the time, as above stated, a glazing-house. When the glazing-house was changed to a press-house, the mound of earth between the two buildings was supplemented by a strongly-built screen wall, placed near to and as high as the eaves of the press-house, and a former charge-house, then disused, part of which stood between them, was converted into a further mound and planted with trees. These buildings have thus been fairly well protected from one another since the date of the amending License No. 289. It will be seen that the condition of this part of the factory was generally very much improved by these alterations.

The new mixing-house was added to the factory by amending License No. 397 on the 15th of January 1889, for the purpose of carrying on a new kind of mixing in revolving drums, with balls of lignum vitæ in contact with the ingredients of the gunpowder.

The output of a gunpowder factory depends on the number of incorporating mills and the time that the mixed charges (60 lbs. or 80 lbs.) are run upon the mills. Mixing in revolving drums has been recently adopted to enable the charges to be put on the incorporating mills in a more advanced state than when ordinary mixers are employed, and the time of incorporation is thus considerably reduced, and the out-turn of the factory proportionately increased.

The limits assigned were 2,240 lbs. of gunpowder and ingredients, and three workpeople. It was excellently situated in a high narrow gully, and the mouth of the gully was closed by a screen of earth, held in its place by sheets of corrugated iron, so that it was quite invisible from the other buildings of the factory. It was about 50 yards from the lower corning-house, which stood on a level about 60 feet below, and a strong stone parapet by the side of the main road of the factory intervened between them, in addition to the screen at the mouth of the gully. Several fine trees, some of which

had probably been growing there long before the factory came into existence, surrounded the building and formed a further protection against the communication of explosion to the other buildings of the factory. Beyond the lower corning-house, and at a distance of about 80 yards from the new mixing-house, was the lower press-house. This was still more effectively screened by the intervening ground and by trees.

The new mixing-house was of the same light construction as the other two buildings. It was about 20 feet square, and in front of the building at one side was a small annexe for an engine for driving the machinery. The engine was worked by steam generated in another part of the factory. Between the annexe and the building proper, there was a glass window to enable the workmen when in the annexe to see that the drums were revolving properly. A verandah covered a "clean" platform, which ran along the remainder of the front of the building and extended to the door of the annexe, to enable the men to pass from one to the other without changing their powder shoes. The annexe was commonly called the engine-house, and will be so designated in this report.

The factory is lighted by electricity, generated by a dynamo near the centre of the works. Two main lines, one running eastward and the other westward, are employed for lighting those respective parts of the factory. A description of the lamp employed, &c. will be found below.*

The working hours in the factory are from 6 a.m. to from 4 to 5 p.m., depending on the work in hand in the several buildings. In the case, however, of the new mixing-house there was a day-shift and a night-shift, the latter working from 4 p.m. to 6 a.m. There were two men in each shift, and they took the day shift and night shift in alternate weeks.

About 5 o'clock on the afternoon of Wednesday, the 22nd of January 1890, an explosion occurred in the new mixing-house. The two night-shift men were at work at the building, and had been there about an hour, in accordance with the usual custom. The report was heard by several workpeople still in the factory, and is described as dull, the general opinion being that a mill had exploded.

Circumstances of explosion.

In about three or four seconds a much louder report followed, and proved to be that of the explosion of the powder in the lower corning-house. This building was locked up and the men had left it only a few minutes before, none of them having yet reached the factory gates on their way homeward.

In about a second more there was another loud report, the powder in the lower press-house having exploded. In this building six men had been employed on that day, and they were about to close the building for the day when the explosion happened.

The latter reports were heard for some miles round, causing great consternation, especially among the residents in the immediate neighbourhood, where the relatives of those employed in the works live. Mr. Johnston, the manager, was at his house, about 120 yards off, and, hearing the report of the first explosion, went to the window, where he saw the flash and smoke of the succeeding ones. He at once ran to the factory. The foreman, John Black, was in the office at the time, and with other men, joined Mr. Johnston in the work of searching for the killed and injured.

As regards loss of life and personal injury, the effects of these explosions was as follows:—The two men employed in the new mixing-house, viz., Archibald Penman, 20, in charge, and Peter Byrne, 21, were both blown into the air and carried in the direction of the lower corning-house. Penman fell about 40 yards from the mixing-house and about 10 yards from the corning-house. He was quite dead when found shortly afterwards, and his body was much mutilated, either from contact with the wooden framework of the building or the trees through which he passed. It would appear that Byrne must have been projected much higher into the air than Penman, as he did not come into contact with the trees, and, that as he was falling beyond the lower corning-house, the explosion in that building in all probability carried him further, for he ultimately fell high up on the steep bank on the other side of the river, about 100 yards from the new mixing-house. There is little doubt he must have been on the platform outside the building at the moment of the explosion. When he was found, shortly afterwards, his powder clothes were all burnt off. He was not dead, and was able to give his name, but he died during the night at the Royal Infirmary at Edinburgh, to which he was removed after his injuries were attended to in the factory. Both of the above men were unmarried.

Effects of the explosions. Loss of life and personal injury.

* See page 11.

One man, James Cuthill, who was working in the lower press-house, and ran out of that building and up a bank near it when the explosion in the new mixing-house occurred, was thrown down by the explosion in the lower corning-house, and was slightly injured in his head and one of his arms. No one else sustained any injury by the explosion in this building, excepting Byrne, who, as above stated, was in all probability passing over the building in the air at the moment, having been blown from the new mixing-house.

Six men were working in the lower press-house on the day of the explosion, and indeed had been working there for six days previously (four only being allowed by the terms of the amending License No. 289). Three men were usually employed in it, and during the preceding week, the upper press-house being out of order, the foreman of the factory, John Black, sent the three men who were engaged in that building to work in the lower press-house. The names of the six men were: John Blackie, 30, in charge; Archibald Chisholm, 63; Samuel Neil, 30; Robert Proudfoot, 24; Thomas Morgan, and James Cuthill. Blackie, Chisholm, and Neil belonged to the upper press-house, and Blackie was put in temporary charge in the absence of the usual leading hand through sickness. When the explosion occurred they had just completed the day's work, and were preparing to leave; one, indeed (Morgan), had already left, and had got about 100 yards from the building on his way home-wards. Cuthill escaped, as already stated, by running out at the door; and the four others were killed. Blackie's body was found in a mill-lead between the building and the river to the south-west, while Proudfoot's body was found in the same direction partly in the river. They were both killed instantaneously. Chisholm was found to the north and Neil to the west of the building, both mortally injured, but Neil lingered for about three hours before he died. Blackie and Neil were married, the other two unmarried.

In addition to Cuthill's wonderful escape above mentioned, it may be here stated that the carter, employed in removing the powder to and from the working buildings, was at the time of the explosions engaged in putting some refuse powder from the lower corning-house into a charge-house, distant only about 20 yards from the lower press-house. Fortunately this charge-house was excellently screened by a good mound with trees growing on it, and he escaped without injury, not even being blown down by the force of the explosion so near to him. He had just handed the powder to a man inside the building, and the door was still open.

Damage to
buildings,
&c. of the
factory.

Compared with this large loss of life, the damage to the buildings of the factory was almost insignificant. So far as I could ascertain, the amounts of gunpowder in the three buildings were:—In the new mixing-house, 1,440 lbs. of undrummed charges, the ingredients, saltpetre, sulphur, and charcoal, being merely in contact in the proper proportions, in 18 bags containing 80 lbs. each, and not even mixed together, and 480 lbs. of drummed charges, that is, charges which had gone through the process of drumming or preliminary incorporation for three hours, in six bags, of 80 lbs. each, ready for removal to the incorporating mills. In addition there must necessarily have been a not inconsiderable quantity of drummed powder adhering to the lignum vitæ balls in the drums, and to the interior of the drums. In the lower corning-house there was about 1,800 lbs. of finished pebble powder which had been brought into the building that evening before closing it, in readiness to be corned into grain powder the next day, as the pebbles were not quite of the required size to be included in a consignment to be despatched from the factory. In the lower press-house there was about 2,000 lbs., probably the whole being mill-cake; part of it, however, was between press-plates ready for pressing, but had not, it seems, yet been placed under the press.

The three buildings in which the explosions took place were, of course, entirely destroyed, the foundations of the lower corning-house and lower press-house being much damaged also. The machinery was completely wrecked in all of the buildings. The explosion in the new mixing house was necessarily not of such a violent character as that in the other two buildings, as the gunpowder was not in such a finished state, and, indeed, the greater part of it consisted merely of the ingredients, weighed out in the proper proportions, and unmixed. It was evident from the position of the wreckage that the bags containing the charges must have been near the front of the building, and probably some of the undrummed charges were still in the truck outside the building. The range of flash was very limited, extending to from 10 to 15 yards only, except in the upper part of the gully, where it was carried by the wind, and where, moreover, it was more confined. In this direction the trees were blackened up to about 25 yards.

The explosion at the lower corning-house was very violent, the heavy rolls having been projected to considerable distances, some of them even as far as the site of the new mixing-house. The range of flash was about 20 yards in each direction. A portion of the machinery fell only about six yards from the new glazing-house, a building about 80 yards off, high up on the other side of the river.

That at the lower press-house was also very violent, heavy pieces of machinery having been scattered about. Many of the press-plates were projected to the other side of the river. The range of flash here was about 10 yards.

The structural damage to the other buildings of the factory consisted, for the most part, of displacement of roofs and doors, blowing out of windows, &c. A complete list of the damaged buildings will be found in Appendix A. The buildings are placed in order as they stood in the factory, from west to east. The larger portion of the factory buildings sustained no injury.

The new glazing-house had a wonderful escape, the roof having been perforated in several places by the fallen *débris*. There was some gunpowder in process of glazing in the building at the time.

The value of a mound or intervening hill was also well illustrated by the protection afforded to No. 1 stove, which was distant only about 38 yards from the new mixing-house. It sustained practically no structural damage, except in respect of the slates of the roof.

The *débris*, consisting of large pieces and splinters of the woodwork of the buildings, large fragments of machinery and pieces of iron, press-plates, lignum vitæ balls in great numbers, branches of trees, bricks, and stones, covered the ground about and between the wrecked buildings, and extended all around up to from 150 to 170 yards from the lower corning-house. A large birch, about 60 feet high, standing on one side of the entrance to the gully, was blown down, and, remaining suspended by the roots, stopped all traffic on the main road of the factory. A sycamore on the other side of the gully was broken off about 30 feet from the ground.

A stone parapet, about five feet high, on one side of the road at this point, was demolished. This was caused by the explosion in the lower corning-house. It had been entirely covered with ivy, no trace of which remained. It was about midway between the new mixing-house and the lower corning-house, but entirely screened from the former.

A bridge across the river from the lower corning-house to the new glazing-house was merely lifted at one side of the lower end, and could be easily re-lowered into its proper position. Five large pieces of the machinery of the lower corning-house fell on the bridge. The hand-rails of the bridge were, of course, carried away in parts.

There were very few traces of burning, except at one corner of the new mixing-house, and here the fire was extinguished without difficulty. Neither the Willesden paper, the painted canvas, nor the wire-wove roofing of which the buildings were constructed appeared to carry fire in any instance. There were pieces lying in all directions. Many pieces of wood, and especially the lignum vitæ balls, must have been on fire, but they led to no conflagration.

The general appearance of the factory will be seen from the accompanying photographs,* of which No. 1 shows the main road through the factory, blocked by the fallen tree, with the charcoal and saltpetre stores; No. 2, one of the same buildings, and the screen at the entrance to the gully; No. 3, the wreck of the new mixing-house; Nos. 4, 5, and 6, the wreck of the lower corning-house; No. 7, the wreck of the lower press-house.

It will be noticed from No. 3 that the engine which stood in the annexe to the new mixing-house sustained very little damage. The bulk of the powder was in all probability at the further end of the new mixing-house. The position of the steam-valve showed that the engine was not working at the time.

A good many splinters and large pieces of wood, metal, &c. were stopped by the trees, but a much larger number passed through and over them. It is clear, therefore, that trees, particularly in winter, cannot be relied upon to prevent the communication of explosion from one building to another by *débris*. That they supplement the protection afforded by mounds, however, in many cases, is beyond doubt. The narrow escape of the charge-house above referred to is a good illustration of the advantage of planting mounds thickly with trees.

* These photographs are not reproduced in the printed Report.

Damage to buildings outside the factory.

As complete a list of the damage to buildings outside the factory as it was possible to obtain will be found in Appendix B. It will be noticed that it was generally of the most trivial character. The far-famed chapel at Roslin did not entirely escape, three of its windows having been blown in.

Cause of the explosion.

There is conclusive evidence that the explosion originated in the new mixing-house, and there can be no doubt that the explosion in that building was communicated, after an interval of from three to four seconds, to the lower corning-house. Whether the lower press-house was one second later fired directly by the first explosion in the new mixing-house, or indirectly by the second explosion in the lower corning-house, I was unable to ascertain. Although, *prima facie*, it might be concluded that, as the lower press-house was much nearer to the lower corning-house, and as, moreover, there was a very thick growth of trees between the lower press-house and the new mixing-house, the lower corning-house must have done the mischief; yet, on the other hand, several *lignum vitæ* balls from the new mixing-house doubtless perforated the roof of the building, and it is at least equally probable that the explosion was communicated directly by one of these or by some other piece of projected *débris* from the new mixing-house.

What caused the explosion in the new mixing-house will never, in all probability, be ascertained with certainty, both of the men engaged in the building at the time having lost their lives. But I am able to state, from the effects of the explosion, and from a knowledge of the routine of the work, as it was ordinarily carried on (derived from the evidence of the two men who worked in alternate shifts with those who were killed), what was actually going on in the building at the moment of the explosion, and thus remove from the list of possible causes a large number of causes which would otherwise have found a place in it!

The night-shift, consisting of the two deceased, Penman and Byrne, relieved the day-shift at four o'clock that afternoon. The drums were then running, and the charges were ready for removal. This operation usually took about 45 minutes, and the procedure was as follows:—The engine was stopped, and the bungs were removed from the drums, small sieves being placed over the bungholes to allow the powder to fall out into bins placed below the drums, and at the same time retain the *lignum vitæ* balls inside the drums. As the powder would not pass through the sieves while the drums were at rest, the engine was again started very slowly, and during each revolution some of the powder fell out as the bungholes came round to their lowest positions. The emptying of the drums thus necessarily occupied some considerable time, and while the emptying was going on the air in and at the door of the building was filled with dust, which rose from the powder as it fell into the bins. The building was therefore at that time an exceedingly "dusty" one; but when the new charges had been placed into the drums, and the building had been swept down, and the drums re-started, it was fairly free from powder dust.

As soon as the drums were emptied the charges were re-weighed and put into 18 bags, containing 80 lbs. each, ready for removal to the incorporating mills. They were placed on the floor near to the door, so that they might be readily transferred to a covered truck which was brought up to the building on wooden railings, close to the platform outside.

When this had been done, the two men left the new mixing-house and went outside the gully to a charge-house, from which they obtained 12 undrummed charges (all that could be carried in the truck at one time), brought them in the truck up to the building, and placed them on the floor near the 18 drummed charges.* They then re-loaded the truck with 12 of the 18 drummed charges, took them to the charge-house, and brought six more undrummed charges and put them into the building by the side of the 12 previous ones, and then removed the remaining six drummed charges to the charge-house, where the truck was left.

Finally, they returned to the new mixing-house, loaded the drums, swept down the building, and re-started the engine. Then they had to wait for about three hours, when the process of unloading the drums again commenced. The times of unloading were 4, 8, and 12 o'clock, day and night. The men were not allowed to leave the vicinity of the building, and appear to have spent the greater part of their time in

* It will be noticed that, as there were then 18 drummed charges and 12 undrummed charges, or 30 in all (=2,400 lbs.), there was habitually an excess of gunpowder in the building at this particular period of the operation, the amount allowed by the amending License No. 289 being 2,240 lbs. only. Moreover, there was in addition, necessarily, some small quantity adhering to the *lignum vitæ* balls and the interior of the drums—a sensible amount, as the effects of the explosion showed.

engine-house, where a bench was provided for them to sit upon. From this point they could watch the drums revolving through the glass window between the new mixing-house and the engine-house. They took their meals in the engine-house. The floor of the platform and the engine-house were "clean," so that they had not to change their shoes in passing from one to the other.

At the moment of the explosion 12 of the 18 drummed charges had been removed, and there were still six drummed charges remaining in the building. The truck with the six undrummed charges to replace these had arrived, and, as it would appear, for the reasons above stated, that one of the men was inside, but between the bulk of the powder and the door, and the other outside the building—in all probability they were engaged in unloading them from the truck, one of the men handing the bags to the other. The appearance of the truck shows that one or more undrummed charges were probably still upon it, but certainly no drummed charges, or the destruction of it would have been more complete. The wreck of the building was such as might have been expected from the explosion of six drummed charges (480 lbs.), the undrummed charges being but feebly explosive. I think, therefore, that there can be no reasonable doubt that the handing in of the undrummed charges was going on at the moment of the explosion. The only objection which can be urged against this view is that, if it be the correct one, the work must have taken longer that afternoon than it usually did, the explosion not having occurred till 5 o'clock. But there is nothing to show that the night-shift commenced to change the drums immediately after their arrival, and if they had been strictly up to time, the engine ought to have been running again at that time, and from the position of the steam valve after the explosion, this undoubtedly was not the case.

Assuming then that the six undrummed charges were being taken into the building at the moment, what could have originated the explosion?

As the machinery was not running at the time, a large number of causes which would have otherwise been possible may be at once struck out. Further, owing to the situation of the new mixing-house, fire from an external source, such as an adjacent chimney, could not have reached the building. Again, there was no lightning at the time. And, lastly, there was nothing whatever to lead to the supposition that the building was wilfully ignited by one of the two workmen engaged in it at the time, nor could the powder have been ignited by anyone outside the building, as no one except these two workpeople were within the radius of the explosive effects.

But it is quite possible that the explosion may have been caused by—

- (a.) The fall of a tool or implement in or outside the building.
- (b.) Matches brought in by the workmen or others.
- (c.) Grit on the platform or inside the building.
- (d.) A defect in the electric lighting of the building.

I may add that it is, of course, not impossible that the powder in the building may have been wilfully exploded by means of a fuze or other contrivance, but nothing in the course of my Inquiry tended to show that there was the slightest reason to suppose that the explosion was brought about by this or any similar agency. There was no quarrelling or disaffection among the men, who were well paid and contented, so far as I could ascertain, and I at once dismissed this cause as one not possessing any degree of probability.

As regards (a), fall of a tool or implement, I may say that, as one man was in all probability handing the bags containing the undrummed charges to the other man inside the building, tools or implements would not be required at the moment, and this cause cannot, therefore, be considered a probable one.

With respect to (b), matches brought in, it came to light, during my Inquiry, that on the 31st December 1889, Penman (one of the two men in the new mixing-house killed by this explosion) picked up an ordinary (non-safety) lucifer match on the tramway in the gully leading up to the new mixing-house. He at once took it to Mr. John Merricks, who is a shareholder in the Company, and acts as assistant to the manager. Penman was then on night duty, and work in the factory generally was over for the day. The foreman and manager inquired into the matter without discovering by whom it had been dropped. Only safety matches are allowed in the factory, and there can be little doubt that this match must have been brought into the factory by some one engaged in it. The next morning all the men were summoned unexpectedly to the office and searched, but nothing was found upon them.

As the proprietors of the factory did not wish their process of mixing with lignum vitæ balls to be made known to the trade generally, only the four

workmen employed in the new mixing-house, the foreman, and Mr. Merricks were allowed by the manager to enter the gully in which it was situated, and a notice prohibiting the workmen from entering was attached to one of the trees at the entrance. At first sight, it appeared, therefore, that, if the match had been dropped accidentally, it must have been so dropped by one or other of these six persons. But as a matter of fact, it came out that some of the other men, prompted probably by curiosity, had occasionally gone into the gully to see what was going on in the "Hidie-house," as it was generally called by the workmen, from the air of mystery or secrecy attaching to it. It was thus impossible to fix the blame of bringing in that particular match definitely on one of these six persons, though obviously suspicion points strongly in that direction.

I made careful inquiries as to the system of supervision and search in force in the factory to prevent any of the men bringing unauthorised articles, such as pipes, tobacco, and matches, on to the premises, and I regret to have to report that the arrangements under this head prove to have been lamentably defective. In the first place, I discovered that the powder hands were in the habit, each evening, of taking off their working jackets, and leaving them in the buildings in which they had been engaged, putting on an overcoat which had been hanging up all day in the porch of the building or in some other convenient place near at hand, and at once going home without washing themselves, as is usual in gunpowder factories, or even taking off the trousers in which they had been working. It is, of course, needless to point out the danger to the men of such a practice; each of them may, in fact, be compared to a squib or other firework with the composition outside, instead of being enclosed in a case, and the slightest contact with a spark or fire might at any moment result in an explosion, the effect of which, under ordinary circumstances, would be death or very serious injury to the wearer. There was, again, no proper searching of the men at the entrance gate, as they passed into the factory, and some of the overcoats which they wore had pockets in them. These overcoats, and the working trousers and jackets were supplied by the proprietors of the factory.

It will be seen, therefore, that, although smoking was forbidden in the factory, it was no difficult matter for the men engaged in the new mixing-house to provide themselves with pipes, tobacco, and matches for the purpose of smoking in the engine-house when waiting there during the several periods of about three hours each while the charges were being drummed. They had nothing to occupy them during these periods except reading such newspapers, &c. as they brought in with them, and talking to one another. Three out of the four employed there were known to smoke, and it is, therefore, not at all improbable that they smoked in the engine-house, where, also, they took their meals. For this purpose they must have had matches or fuses, as the only light was an incandescent electric light.

In view, therefore, of the general laxity in the factory in respect to searching the men, the unusual position of the new mixing-house as regards its isolation, and the secrecy observed as to the process carried on in it, which rendered detection very unlikely, and further, the finding of a lucifer match on the tramway inside the gully only a short time previously, I am of opinion that it is very probable that this disaster may have been primarily due to illicit smoking in the engine-house; and it is possible that a match (probably brought in for that purpose) again dropped outside the building may have been the actual cause.

As to (c), grit on the platform or inside the building, it will be remembered that the men had just returned from the charge-house, and it is, of course, quite possible that they either went to the charge-house in their powder shoes, or omitted to take off their ordinary boots on returning to the new mixing-house. If they neglected their duty in this matter it is unnecessary to seek further for an explanation of the explosion; but I am unwilling to believe that two efficient powder hands, as these men were supposed to be, could have been so unmindful of their own safety as to omit to take such an elementary precaution as the changing of their powder shoes. Still, we know that they did not take a precaution which is equally elementary, viz., change their powder clothes before leaving the factory; and if they could be guilty of breaking the rules in this respect they may also have disregarded the rules as to changing their shoes.

As to (d), a defect in the electric lighting, my opinion is that the explosion was not caused by any such defect. But a careful examination of the system of lighting adopted in the factory disclosed a very serious cause of possible danger from that source, and as the same deficiency may exist in other factories it is desirable that I should call prominent attention to it in this Report.

The light in use for the danger buildings in Roslin Factory is an incandescent lamp suspended in a "fish-globe" of water, as shown on the accompanying plan. The light is obtained from a filament of carbonised cotton thread attached to platinum wires in the vacuum glass. The platinum wires are held in position in plaster of Paris, which closes the mouth of the vacuum glass, the ends being soldered to short pieces of ordinary insulated copper wire. The lamp is put into circuit by means of the thumb-screws shown on the plan; exposed ends of the lamp wires and of the circuit wires are brought into contact and screwed down tightly together. The thumb-screws are then covered over with caps of wood, each being held in position by a screw as shown. The object of this arrangement is to enable a vacuum glass to be readily removed when the filament is burnt through (probably after giving light for about 1,000 hours) and a new one substituted. The lamp is suspended by means of the brass handle shown on the plan from battens, &c. outside the danger buildings, so as to give light through the windows to the interior, many of them being in verandahs to the buildings.

The wires are of three sizes, and they are insulated by india-rubber covering, with an outer coating of hemp or jute. The main and branch wires are supported on earthenware insulators on poles, trees, &c., six inches and upwards apart, the branch wires being conducted to the lamps along the external woodwork, or under the verandahs of the buildings, at the same distance apart. Each building can be put into circuit separately by means of a switch attached to a suitable tree or other support at a safe distance from the building.

The system is arranged to work with 100 volts pressure and one ampere quantity. The lights are 16-candle, which, with 100 volts, require only .6 ampere; hence it is unnecessary to work to the full pressure, and the voltmetre usually indicates from 90 to 95 volts.

When these lamps were first introduced at Roslin, in those exposed to the sun, one half of the globe was painted white to prevent a possible explosion of powder dust near it by the concentration of the sun's rays. Subsequently some of these lamps were placed into wooden boxes with two sides of glass, the boxes, where necessary, being hung on hinges to admit of their being turned when the sun was shining on them. The lamps in these boxes are suspended from a small slot in a batten of wood fixed to the top of the box, and hang an inch or two clear from the bottom of the box.

It is evident that if contact is made or broken in either of the thumb-screws when the lamp is in circuit, a spark will pass from the lamp wire to the branch wire in the thumb-screw. Now, in the verandah of a dusty building there is no doubt that the whole of the lamp must be more or less covered with powder dust, some of which necessarily finds its way into the thumb-screws under the lids, and through the holes in them for the branch and lamp wires. Hence, in the event of a spark from broken contact at one of these points, an ignition of this powder dust and an explosion of the powder in the building might readily be the result.

It seemed to me, therefore, that it was very possible that the explosion in the new mixing-house might have been brought about by this agency. There was one lamp in the verandah outside the building, on the left of the door, not enclosed in a box. From an examination of other lamps in the factory, I ascertained that the ends of the branch wires are much weakened from being screwed up tightly with the thumb-screws, and it appeared that, in the event of the fall of a lamp, as its weight would come with a jerk on those weakened ends, a fracture of the wire, if the wire itself were not pulled out from the thumbscrew, could only be expected. In either case the spark necessary to determine an explosion would result. I also found that the handles of the lamps were exceedingly weak, and liable to be broken, no less than four of them having been broken in the factory by the shock of the explosion (90 to 100 yards distant). If, therefore, the lamp outside the new mixing-house fell, either from being dislodged from its support, or from the fracture of the handle, the cause of the mischief was apparent. But I was informed that the handle was securely fixed in a slot in the batten by a piece of wood screwed down over it; hence the possibility of its having been knocked off the batten by the man outside the building while carrying in a charge bag was removed. It is just possible that he may have struck the lamp with a charge bag, and so broken the handle; but against that theory it may be urged that he would in the usual way have been on the right-hand side of the door, as the truck came up to the platform on the side near to the engine-house, and, therefore, not near the lamp; and, again, it would be most unlikely that he should raise the charge bag to the height of the lamp above his head in order to hand it from the truck to the man inside the building. As already stated, therefore, I do not consider that this explosion was due to the electric lighting of the factory.

But another source of danger to the buildings of a factory from this or a similar system of lighting must not be passed over. I have said that the handles of no less than four lamps in other buildings were broken by the explosion. Fortunately they were all contained in boxes, and the lamp merely fell on to the bottom of the box and there remained, the circuit in no case being broken. In fact, there was no strain on the wires at all. Now, it is, of course, not unlikely that when an explosion takes place in one building of a factory where similar lamps are in use, the explosion may be extended to other buildings merely by the fall of the lamps. It occurred to me that the explosion may have been communicated to the lower press-house in the present case by this means. But I found that the lamps outside that building were all in boxes, and it was much more reasonable, therefore, to conclude that the explosion was communicated by falling *débris* in the ordinary way. All of the four lamps which fell were in incorporating mills.*

Mr. Johnston's boxes, therefore, which were intended as a safeguard against the rays of the sun, proved most efficacious in arresting the fall of the lamps they contained. Another great advantage resulted from their use, viz., that the lamps inside were not nearly so dusty.

In connexion with the possibility of a spark in a thumb-screw at breaking contact, I should add that it is not wholly impossible that a spark may pass between the two wires at this point at other times, especially when the current is switched on or off.

It is obvious that lamps of this kind cannot be considered safe for use in or about danger buildings. The risk may be got rid of either by removing all possibility of a spark near a danger building, or should one arise, by preventing its contact with powder dust. As regards the exclusion of powder dust, I do not think any covering, however closely fitting, can be wholly relied upon to secure this object in the case of a very dusty building. But there is no difficulty in removing the spark, viz., by substituting long lamp wires for short ones, and placing the thumb-screws in all cases at safe distances from the danger buildings. This latter course should, therefore, be adopted. The extra expense entailed will be almost *nil*, as I presume the lamp wires in use with former lamps can be attached to new ones. Even if they cannot be used more than once, it will be quite inconsiderable.

Reviewing the above possible causes of the explosion, I may briefly say that the weight of evidence tends to the conclusion that matches brought into the factory was the most probable cause, but I cannot of course express any decided opinion that the explosion was so brought about. In cases where, as in the present case, the men in the building are all killed, it is rarely possible to assign the cause of the disaster with absolute certainty.

As to blame
to be
attached.

When the factory passed in 1877 into the hands of the limited company, and Mr. Johnston became the manager, it was practically in a starved and neglected condition. It was some time before any very great improvement in its working was observed, and a large number of irregularities were noticed by us at our several inspections, until finally in 1882 we decided to institute proceedings against the company for certain illegalities noticed on the 8th of May of that year. They were convicted and fined, and at a subsequent inspection during the same year it was found that a marked improvement had taken place; and, again, during the five succeeding years, although we had causes for complaint, the main result was more and more satisfactory. The proprietors were now in more prosperous financial circumstances, and on the whole a general smartness was apparent where before we had met with neglect and want of care; and we could not fail to notice a general disposition on the part of the management to give prompt effect to such suggestions for the improvement of the factory as we felt it desirable to make from time to time. Old buildings of an antiquated type were gradually replaced by those of a modern character, and other great improvements were effected, until finally, in 1887, we were able to classify the factory as an extremely satisfactory one. Since that time the advance has not fallen off, and in three inspections made in 1889 it has received the character of excellent, there being practically nothing of importance to find fault with. Mr. Johnston has thus, during the 13 years he has held the position of manager, entirely transformed the factory, in a manner which reflects the highest credit upon him.

But of course there are many irregularities in the working of a gunpowder factory which may never come to the knowledge of a Government inspector in the course of the comparatively infrequent visits which it is possible to make, and it is only when an accident or some other unsuspected event happens that these are likely to be brought to light.

* The lamps at the lower corning-house were not burning at the time.

As an example in the present case, I may instance the neglect by the powder hands to take off their powder clothes before leaving the factory. In the special rules submitted by the limited powder company, and approved by the Secretary of State on the 7th February 1877, there is the following provision: (Rule 3). "The workpeople are to put on in the house for this purpose the clothing provided for them before entering any house, mill, or waggon. . . . The shoes and clothing are not to be worn off the factory." The change of clothing takes place when the men begin work in the morning, and again when they leave in the evening, at times when an inspection of the factory would not be made in the ordinary course. This rule, it is now clear, has never been enforced in the factory, the men being allowed to please themselves in the matter. A few of the men observed it, and the majority, including the new mixing-house men, did not observe it. I am unable to say definitely, as above stated, that this neglect to enforce the rule brought about the explosion and led to the death of the men, but Messrs. Hay, Merricks, & Co., Limited, and their manager, are undoubtedly much to blame for allowing their rules to be thus disregarded.

As I have already pointed out, there was habitually a slight excess of gunpowder in the new mixing-house at the times the drums were re-charged. This could easily have been avoided, by bringing up the undrummed charges in two lots of nine charges each, instead of 12 charges first and six charges afterwards. By this carelessness in the working, the Company were rendered liable to a penalty of 50*l.* and forfeiture of the gunpowder in the building, under section 9 of the Explosives Act.

I do not consider that there was any irregularity in connexion with the explosion in the lower corning-house. No blame, therefore, can be attributed to anyone in respect of it. Fortunately the men had closed the building just before, and had left it.

I regret, however, to have to report that the same cannot be said of the lower press-house. Here there were six men, while by the terms of the amending License, No. 289, only four were allowed. I have already stated the circumstances under which the three men from the upper press-house were allowed to work in the building. All of these three men were killed.* Two of the men belonging to the building escaped, one having left, and the other having run out when the first explosion occurred.

It came incidentally to light that one of the men who escaped from the lower press-house, and who was a powder hand only on occasions when his services were required, had been allowed to work in that building wearing a pair of powder trousers over his ordinary trousers and his waistcoat, in both of which there were pockets.

It will be seen from the irregularities which have been brought to notice by this explosion, that, although the improvements in the factory during recent years have been so marked, there are still directions in which a further advance and greater stringency of control are needed. It appeared to me, in the course of my Inquiry, that Mr. Johnston did not fully recognise his responsibility as manager in respect of all the working details of the factory, and that John Black, the foreman (who has held that position for the last 20 years), looked after the powder work and powder hands without realising that he had any substantial responsibility in the matter. As regards the extra men in the lower press-house, Black stated, "At the request of Blackie, I let the men go to the lower press-house, without giving it a thought, instead of sending them home."

The occupiers were required to post up in the building the number of men allowed to be in it at one time, and I cannot doubt that the men and the foreman were fully aware that the number in the lower press-house was limited to four.

Mr. R. Stuart, the Procurator Fiscal of Midlothian, visited the factory on one of the eight days during which I was holding my Inquiry. I drew his attention to the illegalities which I had observed in the factory.

Visit of the
Procurator
Fiscal.

It only remains for me to add that I received every possible assistance in the course of my Inquiry from Mr. Johnston, the manager, who was most anxious that the matter should be fully investigated; and on the part of everyone connected with the factory, I found every disposition to facilitate my Inquiry.

I have the honour to be,

Sir,

Your obedient servant,

(Signed) A. Ford, Colonel,
H.M. Inspector of Explosives.

The Right Honourable
the Secretary of State,
Home Department.

* See page 6.

APPENDIX B.

DAMAGE TO BUILDINGS OUTSIDE THE FACTORY.

Wood End Cottage, distant 500 yards :

Tile roof damaged ; number of tiles off. No windows broken ; two doors burst open and ceiling cracked.

Roslin Chapel, distant about three-quarters of a mile :

Three Gothic window frames partially blown inside, some of the small diamond green cathedral glass broken.

House adjoining Roslin Chapel (Old Inn), distant about three-quarters of a mile :

A few panes of glass broken.

Two cottages at the north end of Roslin village, on the Edinburgh Road, distant about one mile :

One large pane of glass broken in each.

Esk Lee House, above Roslin Castle Station, distant about half a mile :

One large pane of glass broken.

Roslin Castle Station, distant 500 yards :

One pane of glass broken ; was cracked previously.

Roslin Castle Station-master's house, distant 500 yards :

One pane of glass broken, but was cracked previously.

Carpet factory, distant about a quarter of a mile :

Three small panes of glass broken in factory, and two in Leabank House.
Most of the gas-lights went out.

House at Slatebarns, distance not stated :

Ceiling cracked.

Eskhill House, distant about 120 yards :

Between 60 and 70 panes of glass broken ; greenhouses damaged.

No. XC.

REPORT

TO

THE RIGHT HONOURABLE THE SECRETARY OF STATE FOR THE
HOME DEPARTMENT

ON THE

CIRCUMSTANCES ATTENDING AN EXPLOSION

WHICH OCCURRED AT

THE FACTORY OF
NOBEL'S EXPLOSIVES COMPANY (LIMITED)
AT REDDING, WEST QUARTER, NEAR FALKIRK,

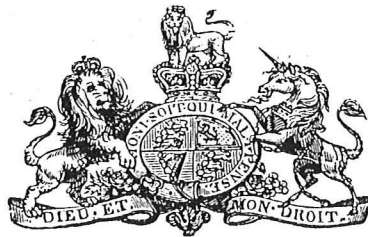
On the 15th November 1889 ;

BY

COLONEL A. FORD,

HER MAJESTY'S INSPECTOR OF EXPLOSIVES.

Presented to both Houses of Parliament by Command of Her Majesty.



LONDON:

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BY EYRE AND SPOTTISWOODE,
PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY.

And to be purchased, either directly or through any Bookseller, from
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1890.

REPORT

TO

THE RIGHT HONOURABLE THE SECRETARY OF STATE FOR THE
HOME DEPARTMENT

ON

The Circumstances attending an Explosion of Detonators which
occurred at the Factory of Nobel's Explosives Company
(Limited) at Redding, West Quarter, near Falkirk, on the
15th November 1889;

BY

COLONEL A. FORD,

HER MAJESTY'S INSPECTOR OF EXPLOSIVES.

SIR,

Home Office, 28th December 1889.

I HAVE the honour to report that, in obedience to your Order (1542B) of the 19th November 1889, made under the 66th section of the Explosives Act, 1875, I have held an Inquiry into the circumstances attending an explosion of detonators, which occurred at the factory of Nobel's Explosives Company (Limited) at Redding, West Quarter, near Falkirk, on the 15th November 1889, by which two of their workpeople, Mary Ann Bremner, aged 22, and Helen Galbraith, aged 20, lost their lives.

In accordance with the provisions of the above-mentioned section of the Act I beg to render the following Report.

The factory in which the explosion occurred is situated near the line of the North British Railway Company, which runs between Edinburgh and Glasgow, and about a mile from Polmont Junction station. It consists of about 20 sheds and two factory magazines, the explosives authorised to be manufactured being detonators, electric fuzes, and electric detonator fuzes. The sheds are about 20 yards apart, and are generally well screened from one another. They are connected with each other, and with the factory magazines, by means of wooden platforms.

Factory in
which the
explosion
occurred.

The factory exists in virtue of a continuing certificate (No. 18, dated 11th April 1876), and no less than eleven amending licenses have since been granted under the Explosives Act to modify the terms of the continuing certificate in order to adapt them to altered conditions of manufacture. When the tenth amending license (No. 339, dated 13th August 1887) was granted, the opportunity was taken to repeal the whole of the terms of the continuing certificate and the previous amending licenses then in force and to re-enact them in the new amending license. This was done for convenience, as with such a large number of amending licenses, many of the terms of which had been repealed, it was difficult to ascertain readily which terms were actually in force, and which were not in force at the time being. The eleventh amending license (No. 410, dated 17th April 1889) merely permitted the storage of electric detonator fuzes in both of the factory magazines instead of one only as previously, and need not be further referred to in this Report as it has no bearing on the present accident.

The manager of the factory is Mr. George Smith. He has held that position for the last 10 years.

Detonators.

A detonator is a cylindrical tube of metal about an inch in length and a quarter of an inch in diameter. It is open at one end, and contains at the other end a small charge of fulminate. In the detonators now manufactured at this factory there is a small hole in the end which contains the fulminate, in order to intensify the effect of the explosion in the direction of the length of the detonator. This hole is closed with waterproof copper-bronzed paper placed inside before the fulminate is inserted. The tubes of these detonators are made of steel coated externally with copper. They are of the size known as quadruple, each containing a charge of 10 grains of fulminate, consisting of a mixture of 80 per cent. of fulminate of mercury and 20 per cent. of chlorate of potassium.

Working arrangements of the factory for the manufacture of detonators.

The present authorised uses of the several buildings of the factory appropriated to the manufacture of the detonators were assigned on the understanding that (1) the empty tubes were to be placed into plates preparatory to filling them (to be done in the shed marked G on the plan); (2) those tubes were then to be filled with fulminate (in one of the three sheds, 4, 4A, or 5); (3) the filled tubes were then to be pressed singly (in shed 6 in which there are two compartments), being removed from the plate for this purpose; (4) the detonators were to be sieved to remove any adherent composition, and subsequently rumbled to clean them (in one of the sheds 7 or 8); and (5) they were then to be packed in suitable packages (in one of the three sheds 9, 9 (a), or 9 (b)) before being finally deposited in the factory magazine.

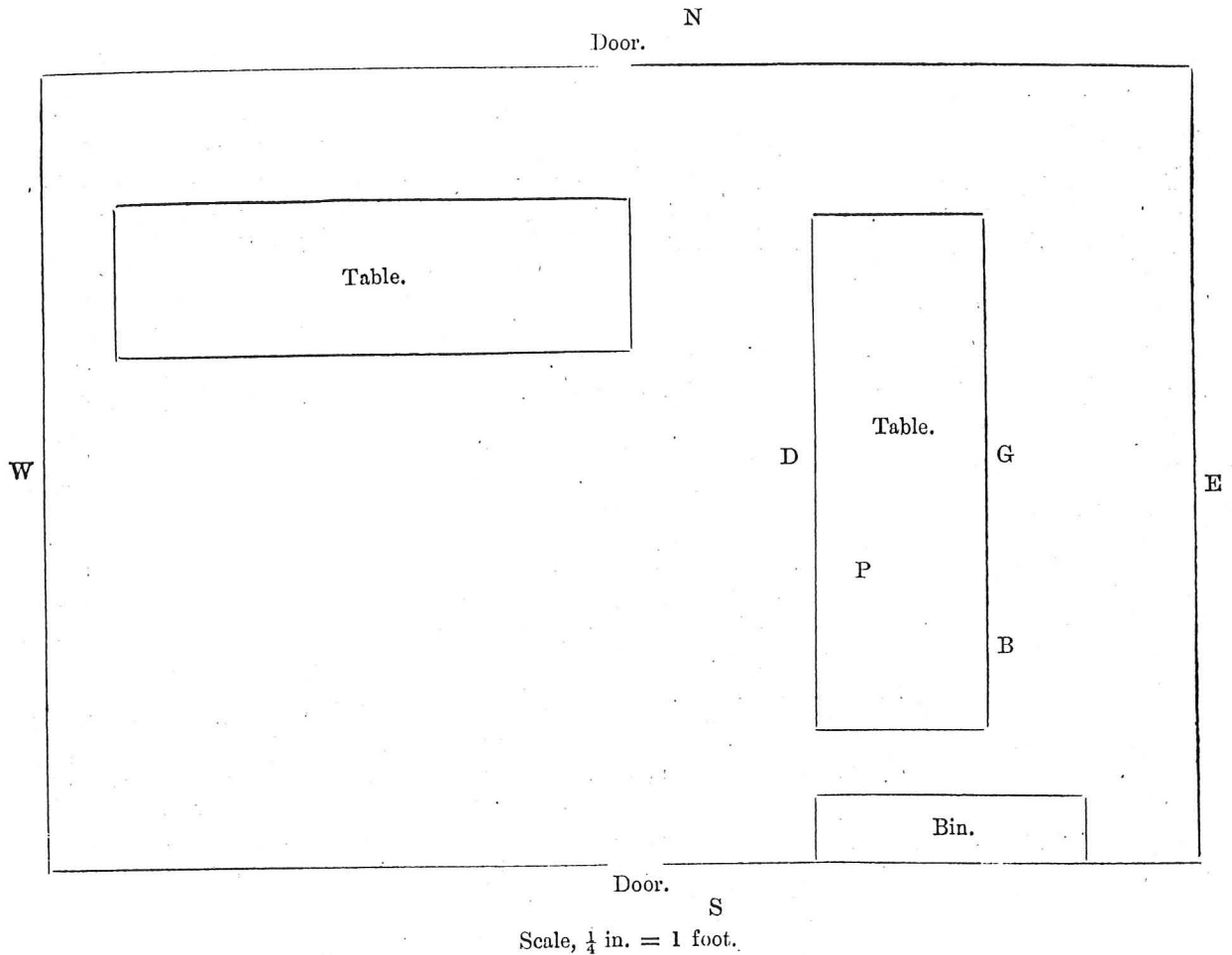
When, however, the new kind of detonators above referred to, with the small hole in the end containing the fulminate, was introduced about a year ago the system of manufacture was considerably modified. Since that time the uses of the buildings have been approximately as follows:—(1) the empty tubes have been placed into plates preparatory to filling them, and the small holes at the ends have been closed with the waterproof paper (in the shed G); (2) the tubes have been filled with fulminate (in one of the three sheds, 4, 4A, or 5); (3) the filled tubes have been pressed 100 at a time in the plates instead of singly (in 6), a different kind of pressing machine having been substituted; (4) the detonators have been removed from the plates in which they were pressed and packed (in 9, 9 (a), or 9 (b)), the operations of sieving and rumbling having been abandoned, and the sheds 7 and 8 having remained in disuse during that time. Occasionally, when it was found that a detonator could not be readily removed by hand from a plate (in 9, 9 (a), or 9 (b)), the plate was sent back to the pressing shed (6) and the detonator was removed in the "shelter" or outer part of that shed by means of a long pair of pliers, the operator being placed behind a screen to secure him from danger in the event of an explosion occurring.

Shed in which the explosion occurred.

The explosion to which this Report relates occurred in the packing shed, No. 9. By the terms of the license the operations allowed to be carried on in that shed are—packing detonators; air-drying the same; and air-drying the wrappers of the packages. The amount of fulminate contained in detonators in the shed is limited to two cwt., and the number of workpeople to six. This amount of explosive and the number of workpeople were those specified in the continuing certificate when the factory was certificated as legally existing prior to the Explosives Act.

A packing shed may be looked upon as the least dangerous of all the danger buildings in a factory. If the operations of putting the explosive into bags, cases, canisters, boxes, or other packages are carried on under suitable conditions and with proper care, no accident is likely to occur. We have no record of any previous accident in a building used for this purpose.

The shed, No. 9, is a large one, the interior dimensions being about 26 ft. by 20 ft. It is of wood, the roof being covered with felt, and it is lined throughout with match-boarding, the ceiling being a deck-ceiling. The interior arrangement will be seen from the following plan:—



The system of work was as follows:—The plates containing the detonators were brought into the shed, four to eight at a time, by the service waiter or “runner,” David Duncan, at the south door, in a wheeled truck, which he placed near the table in the position marked D on the plan. He then took the plates out of the truck and carefully laid them on the table near P, so that they might be about equidistant from the two workpeople engaged in the packing, who sat at the places marked G and B, facing the table. Behind G and B there were two stools on which the plates were placed after the detonators had been removed from them; from these Duncan took the empty plates that were ready for him, put them into his truck, and wheeled it out of the shed.

Each of the two workpeople took up a plate from P as she required it, lifting it with both her hands, and placing it in a convenient position in front of her; then, removing the detonators singly from the plate with her right hand, she packed them into “tin” boxes holding 100 detonators each. A plate would thus exactly fill a box; but occasionally defective detonators were met with, and to supply the deficiency each of the workpeople had an extra plate on the table near her, from which she took one or more detonators from time to time as might be required. The workpeople were very careful to retain the detonators in a vertical position while removing them from the plates and putting them into the boxes, in order that any loose fulminate which might remain in the tubes might not fall out on to the table. The bottom of each box was covered with a piece of felt for the detonators to rest upon.

The workpeople placed the boxes on the table as they were filled, B on her left and G on her right, the lids of the boxes not being put on; and as soon as the work of pressing for the morning or afternoon was completed and the runner ceased to bring any more plates into the shed to supply them, they removed the boxes to the further table, filled up the open ends of the detonators with sawdust (a supply of which was kept in the bin), placed another piece of felt on top and put the lids on the boxes, labelling them outside. The detonators were filled with sawdust in order that any small quantity of loose fulminate remaining in the tubes might be mixed with it, and thus practically rendered harmless.

The runner removed the tin boxes when they were finished to another building, to be further packed into cases or cylinders for transmission from the factory. The work

was so arranged that all the detonators should be removed from the shed before the workpersons left at the dinner hour, and again before they finished work in the evening.

Plates for
pressing the
detonators.

The plates in which the detonators are pressed are made of brass with two handles attached by screws as shown in the accompanying sketch. They are $6\frac{1}{2}$ inches long, by $4\frac{3}{4}$ inches wide, and 1 inch in thickness; and weigh when filled with 100 detonators a little over $8\frac{1}{4}$ lbs. In addition to 100 holes for the detonators, there are four holes for fitting on an upper plate (also with 100 holes) on top, in order that the tubes may be held exactly in a vertical position during the operation of pressing. A further advantage is derived from the use of the upper plate, viz., that when it is placed on the plate containing the detonators a tube, which is not quite of the correct dimensions, or is otherwise defective, may be detected from the upper plate not fitting readily.

The holes in the upper plates are of course cylindrical, passing through the plates, while those in the plates containing the detonators are closed at the bottom excepting a small escape-hole in each to serve as a vent for the gas in the event of an explosion of a detonator occurring during the process of pressing. The escape-holes are closed with shellac putty. Explosions of detonators during pressing frequently occur, and are confined to the single detonator, not being communicated to others in the same plate. They are attended with no risk to the operator, who is placed behind an iron screen while he applies the pressure by means of a ratchet wheel to which a lever is attached, and usually little or no damage to material is effected.

Circum-
stances of
explosion.

On Friday, the 15th November 1889, two women, Mary Ann Bremner and Helen Galbraith, were working in the shed No. 9. Bremner was at the place marked B, and Galbraith at that marked G on the plan of the building. Bremner had been working in the factory since August 1885, and Galbraith since January 1887. They were both experienced in the work of the packing house under the new system, and were quiet and well-behaved; Bremner was engaged to be married. Bremner had at first worked in the pressing shed (during the old *régime*, when the detonators were pressed singly), and on the 7th December 1885 had lost the top joints of the thumb, and first and second fingers of her left hand through the explosion of a detonator while so employed.*

On the day above mentioned, viz., the 15th November, all the detonators had been removed from the shed in accordance with the usual custom before the dinner hour, and Bremner and Galbraith returned to their work at 12.45 p.m. The runner Duncan supplied them with filled plates, and removed the empty plates at intervals until about 3.30 p.m. in the ordinary way. During that time he took about 7,000 detonators, containing about 10 lbs. of fulminate, into the shed. On the last occasion he took in four plates (400 detonators) and placed them on the table in the usual position P. He observed that Bremner and Galbraith were then working steadily, but he did not notice them particularly, and so far as he recollects he did not speak to either of them. He took some empty plates from the stools behind them and put them into his truck. He was then preparing to leave the shed when Lilius [Knox, a workperson employed in the drying shed, came to the door and asked him to remove a box from her shed. He therefore went with Knox, leaving his truck inside the shed No. 9.

About two minutes afterwards, and while the runner was still at the drying shed, an explosion occurred, the report being a "sharp" one and not very loud. The smoke which ascended from No. 9 indicated the building in which it had taken place. Mr. Smith, the manager, Mr. Corrie and Mr. Kelly, the two assistant managers, all of whom happened to be near at hand, the foreman, the runner, and other workpeople at once hastened to render assistance. By the time they reached the shed it was nearly clear of smoke. It had not been set on fire. The two women were found lying on the floor near their respective places with their heads towards the east end of the shed, very seriously injured and quite unconscious. In a short time they were removed and placed on stretchers outside the shed; medical assistance was obtained in a few minutes†; a

* Explosion, No. 129 of 1885.

† The medical officer of the works was speedily summoned by means of a siren (a special kind of steam-whistle) which can be heard at a long distance. It had been arranged with him that his immediate attendance was required, when this whistle was blown. At the time of the explosion he happened to be on horseback not far away, and rode at once to the works. Similar whistles are used by steamers on the Thames and elsewhere during fogs.

train due shortly afterwards to pass *en route* for Edinburgh was stopped at the factory and they were conveyed, in the guard's van, to Edinburgh, Dr. Wickham, the medical officer of the works, accompanying them; and finally they were carried on the stretchers from the station to the Royal Infirmary. All, however, was of no avail, for Bremner died soon after 7 o'clock the same evening, and Galbraith lingered only for about four hours longer.

The injuries to the two workpeople were as follows:—Bremner had her left fore-arm shattered, her left knee destroyed, the joint having been opened out, her left eye destroyed, a cut on the left side of her neck, superficial injuries from pieces of metal and splinters of wood. Galbraith had her right eye destroyed, and received superficial injuries similar to those of Bremner; the tips of her thumb and two fingers of the right hand were also blown off (showing that she actually had a detonator in her hand at the moment). Both of them died from the shock, from which indeed they never rallied. There was a large quantity of blood on the floor near where they were lying. It will be remembered that Bremner placed the boxes of detonators as she filled them on the table on her left side, while Galbraith placed her boxes on her right.

Effects of the explosion.

The damage to the building was of a very slight character. Externally the only effect was the bulging out of a few boards at the east end. There are four windows in the north side and a similar number in the south side, and out of 168 panes of glass in these windows seven only escaped being broken. Some of the frames of the windows were also a little damaged. In the interior, about half of the top of the table at which the work was going on was blown away, and the framework of the table at one end was broken; there were two holes in the floor, one, about 18 inches by 12 inches in size, under the end of the table where Bremner had placed her boxes of detonators, and the other, about 35 inches by 18 inches, under Galbraith's boxes. Two rafters (6 inches by 2½ inches) in the ceiling above the table were broken across, and the planks forming the deck were detached, some the whole length of the shed. The match-board lining at the east end was displaced, but it was very little damaged. Débris, consisting of splinters of wood, plates, empty tin boxes, &c., was lying all over the floor. In some of the woodwork there was pitting caused by fragments of metal from the detonators and boxes.

There was no damage to the platform outside, or to any other building of the factory.

Among the débris on the floor of the shed after the explosion there was lying, just under the part P of the table on which the runner had placed the plates, a broken plate within which it was evident that detonators had exploded under confinement. A small piece of this plate was found very near to the opposite (west) end of the shed, and another piece was found in the shed, but at what part of the shed I could not ascertain. The broken plate and the two pieces are shown in the photographs annexed. Four other plates in which detonators had exploded, but not under confinement, were found also among the débris. In these the fulminate had discharged itself through the open ends of the tubes (in the same manner as gunpowder in a gun) without a similar disruption of the plate. In a few holes near the edges of the plates where the metal was weak the force of the fulminate had caused it to give way. An examination of the broken plate showed that it was quite filled with detonators at the time, and that only a part of the detonators it contained had exploded under confinement, the fulminate in the remainder having discharged itself through the open ends as in the other plates. An examination of the other plates found in the shed showed that at the time of the explosion two (in addition to the broken one) were quite filled with detonators, two were partly filled, and eight contained no detonators.

Cause of the explosion.

As before stated, the runner had brought four plates into the shed and placed them on the table in the position P, about two or three minutes before the explosion. He did not notice whether there were any other plates there at the time. From the number subsequently found, however, it appears that these four were the only ones. Also it seems clear that Galbraith must have finished the plate she had in hand when the runner was in the building, and have taken one of the four brought in by him. On this she was engaged at the moment of the explosion. There were thus three plates containing detonators still remaining near P, and one of these Bremner would require soon afterwards. To obtain a plate she had to reach over the table a distance of about 2 feet, and sometimes she got up from the stool on which she was sitting, and leaned on the table in order the more conveniently to lift it with her two hands, one of which, as before stated, had been previously injured.

Bearing in mind (1) that the broken plate was found after the explosion under the table near the position P; (2) that something must have been on a part of the top of this broken plate, of sufficient weight to give the necessary confinement to the detonators, at the moment of the explosion; (3) that Bremner's left fore-arm was shattered, and that she received such extensive injuries on her left side generally (evidently from detonators in the boxes being quite close to her at the time); and (4) that Galbraith was engaged in her ordinary work of packing at the moment, as the injury to her thumb and fingers of her right hand testifies; I can come to only one reasonable conclusion as to the cause of this accident, viz., that Bremner in attempting to lift a plate containing detonators from the table near P dropped it on to another plate, and that the concussion thus caused exploded some of the fulminate in the detonators, or, more probably, some loose fulminate which since the processes of sieving and rumbling have been abandoned must have been upon the plates and the outsides of the detonators.

One of the plates found among the débris in the building was seen to be bent and more damaged than the others. It was filled with detonators when the explosion took place. In all probability this was the plate which fell from her hand and caused the mischief. It is shown in the photographs below the broken plate.

After I had expressed my opinion as to the cause of the accident to Mr. Smith, the manager, he ascertained that Bremner had been sitting up the previous night and did not go to bed till after 3 a.m. She got up again soon after 6 that morning. She was doubtless therefore tired when she was working in the afternoon. It was thus not at all unlikely that she should let a heavy plate (8½ lbs.) slip from her hands when stretching across the table, more particularly as she had lost the tops of the thumb and two fingers of her left hand. No one, however, who saw her at work that afternoon observed anything unusual in her manner or appearance, so far as I could ascertain. It is the custom at the factory to give the workpeople holidays at the times when fairs, &c., are held in the neighbourhood, so that they may not come to work when liable to be tired, and I was assured by the manager that had it been known that Bremner had been sitting up the previous night she would not have been allowed to work in the factory that day.

There is not the slightest reason to suppose that Bremner threw down the plate intentionally with a view to committing suicide.

Question as to blame to be attached.

Assuming, then, that the fall of one plate containing detonators upon another brought about the explosion (and I have no doubt that that is the correct explanation of the occurrence), we have now to consider to whom blame attaches for the loss of these two lives.

It has already been stated that the manufacture of detonators in the factory has been recently carried on under conditions other than those contemplated when the license was granted. In fact, a new kind of detonator has been introduced, and the old conditions no longer apply in all respects. The sieving and rumbling which were employed to remove adhering composition from, and to clean, the detonators with a solid end have been abandoned with those of the present make. The process of rumbling is impracticable with the new detonators in which the end containing the fulminate has a small hole protected by waterproof paper only; and when it had to be given up, the process of sieving also fell into disuse, as it was considered that any loose fulminate which might adhere to the detonators would, so to speak, become so diluted with the sawdust in which they were packed as to be rendered harmless. The plates, doubtless with more or less loose fulminate adhering to them and to the detonators which they contained, were, as a result, taken to the packing shed to have the detonators removed, and thus a new source of risk, and that a serious one, was introduced into the building.

It is obvious that the present limitations (viz., 2 cwt. of explosive contained in detonators, and six workpeople) for the packing shed are altogether inapplicable to a building in which this additional danger exists. Such limitations are reasonable only for a building which may be looked upon as one of the "safest" of the danger buildings of a factory. I was glad, therefore, to find in the course of my Inquiry that Mr. Smith, the manager, had fully recognized the necessity of reduced limitations under the altered conditions, and had allowed only two women to be employed in the shed, while the amount of fulminate contained in detonators never exceeded a few pounds. In fact, the work of the factory was being carried on under quite as great restrictions as would have been imposed had the license been originally prepared to meet the new method of manufacture, and it appeared to me that every possible precaution was taken for the safety of the workpeople.

I consider, therefore, that Nobel's Explosives Company (Limited), made the best possible arrangements in their factory to meet the altered conditions of their manufacture, and that no blame attaches to them or to their manager, Mr. Smith, in respect of this accident. In view of the risk to the workpeople in the packing shed, it is proposed to resume the process of sieving, and thus all chance of a similar accident will, it may be hoped, be obviated.

I may here bear testimony to the excellent order in which at our inspections we invariably find this factory; at the last 10 inspections made between 1884 and the present time, we have observed no irregularity of any kind and no want of precaution for the safety of the workpeople. It is only due to Mr. Smith that I should draw attention to the admirable management which has prevailed in the factory since he had charge of it. I need hardly add that I received every assistance from him and all engaged in the factory in my Inquiry into this accident.

As illustrations of the general order which prevails in the factory, I may instance the arrangement made by Mr. Smith for summoning medical assistance in case of need,* and the expeditious way in which the injured women were attended to and sent to the infirmary in Edinburgh, a train being stopped near to the factory for the purpose.† Everything that could be done, when the accident had happened, was done, as it appeared to me, with foresight and judgment, and with an entire absence of disorder.

As regards Bremner's share in causing the explosion, the fall of the plate from her hand was doubtless purely accidental. I have already pointed out that in accordance with the custom at the factory she ought not to have attended at all that day, after sitting up the previous night.

Mr. W. K. Gair, of Falkirk, the Procurator Fiscal, visited the factory on one of the two days I held my Inquiry with a view to obtaining particulars as to the accident. I told him the result of my investigation so far as I had then carried it.

Visit of the
Procurator
Fiscal.

I have, &c.

(Signed) A. FORD, Colonel,
H.M. Inspector of Explosives.

The Right Hon. the Secretary of State,
Home Department.

* See note, p. 6.

† See p. 7.

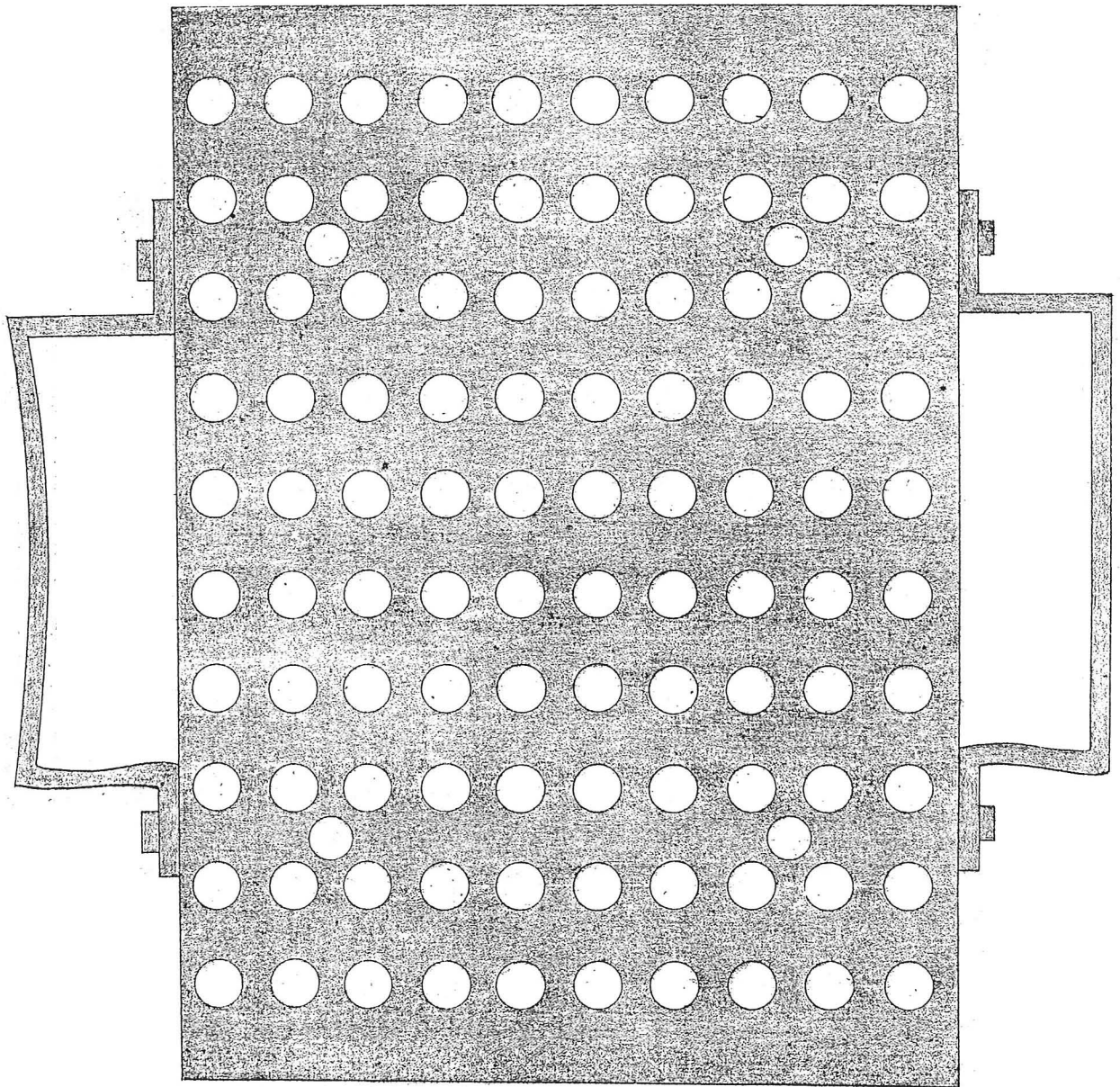
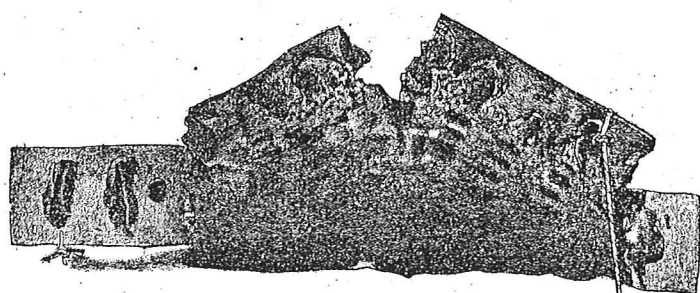
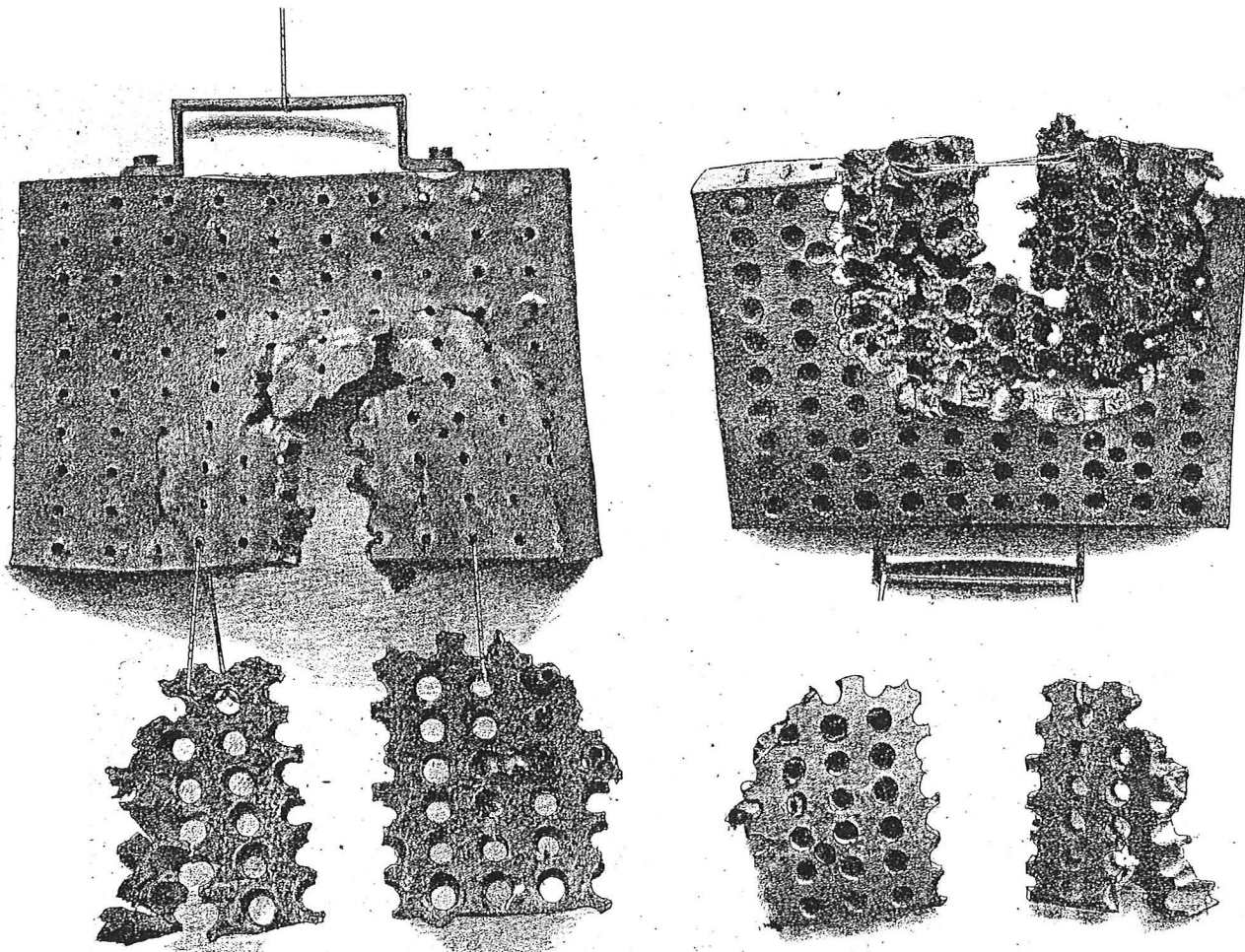
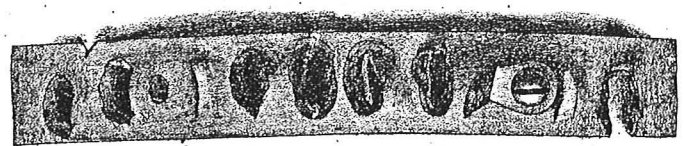


Plate for pressing detonators.

(Full Size.)



The broken plate in which the explosion of Detonators under confinement took place



The plate bent by the Explosion.

