

EXPLOSION OF A GUNCOTTON STOVE AT FACTORY No. 163, ESSEX.

ACCIDENT No. 104, 1913.

No. CCVII.

REPORT

TO THE

RIGHT HONOURABLE THE SECRETARY OF STATE FOR THE
HOME DEPARTMENT

ON THE

Circumstances attending an Explosion which destroyed a Guncotton
Stove in the Factory of the British Explosives Syndicate,
Limited, at Pitsea, in the County of Essex, on the 28th March,
1913,

BY

CAPTAIN R. A. THOMAS, R.A.,

H.M. INSPECTOR OF EXPLOSIVES.

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



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HOME OFFICE,
WHITEHALL, S.W.,
1st May, 1913.

SIR,

I HAVE the honour to report that in accordance with your Order (Home Office Papers, No. 115,431/28) I have held an inquiry into the circumstances attending an explosion (No. 104/1913) which destroyed a guncotton stove in the factory of the British Explosives Syndicate, Limited, at Pitsea, Essex, on the 28th March, 1913, and by which three lives were lost, namely :—

J. Crosse (48).
H. J. Hanna (29).
A. Bayles (21).

and one person, F. E. Harrison, was injured, though not seriously, while others were slightly cut or hurt by broken glass or falling plaster, &c.

The factory was licensed under Licence No. 108 on the 12th November, 1894, and since that date 20 amending licences have been granted.

The factory is situated on the Thames Marshes, about half a mile South of Pitsea Station, on the London, Tilbury, and Southend Line.

No previous accident involving injury to any person or building has occurred in the factory.

THE STOVE.

The stove (S₂) in which the explosion occurred was licensed in the following manner :—

Distinguishing number, letter, or name of building, room, or place on plan attached to licence.	Application of building, room, or place or process to be carried on therein.	Explosive allowed or ingredients or articles liable to spontaneous ignition or inflammable, or otherwise dangerous, and limitation of quantity to be in each building, room, or place.	Limitation of number of persons to be in each building, room, or place.
S ₂	Drying nitro-cotton.	Nitro-cotton, 3,000 lbs	2

It was lightly constructed of wood, with brick foundations set in concrete. The roof was made of sheet zinc, and the close-joined wooden floor was covered with lead. The interior was lined with sheet zinc, and all lining joints, joints with the hot-air pipes, and heads of tacks were soldered to prevent dust from getting behind the lining. A substantial clay mound, 3 feet thick at the top and 9 feet at the bottom, revetted with corrugated iron sheets, surrounded the building to the height of the eaves.

The stove was heated by hot air which entered the building through large gauze covered pipes at intervals round three sides, and on the fourth passed out through ventilators fitted with traps for catching dust. The hot air, heated by steam-heated radiators, was supplied by a steam-driven fan situated in a small heater house about five yards from the stove on the other side of the mound. There were no steam pipes in the building.

PROCESS OF DRYING GUNCOTTON IN S₂.

Loose wet guncotton was spread on trays (2 ft. 10 ins. by 2 ft. 3 ins.) made of brass wire gauze framed in wood. The trays were placed in wooden racks and arranged two abreast in six tiers. The racks, 6 ft. by 2 ft. by 6 ft. high, were not fixed to the floor or walls. The temperature of the stove was kept as nearly as possible at 110° F. and was not allowed to go above it, which necessitated the incoming air being at about, but not above, 144° F. Readings of both thermometers were taken and recorded at frequent intervals.

The time taken for drying was about 40 hours. The heat was then cut off by turning off the steam entering the heater house, and according to a Special Stove Rule made by the Syndicate, the doors had then to be left open for at least an hour before the work of unloading was begun, in order to allow the guncotton to cool down, and to reabsorb a small amount of moisture; since, when hot and very dry, it is especially sensitive to ignition by friction and percussion, and also becomes electrified by friction when in this condition. The trays were then carefully lifted from the racks and the contents poured into bags, each bag being held upright, and having its mouth held open by a three-sided wooden frame or stool. Another Special Stove Rule laid great stress on the fact that the trays were on no account to be dragged from the frames. The bags were filled close to the door, and remained there until the "runner" brought his bogie for their removal, when they were placed in succession on a "clean" platform in the porch so that the runner could reach them without having to enter the porch or stove. After unloading had been completed the stove and racks were swept down ready for the next charge of wet guncotton. Sometimes, however, the custom of the stovemen seems to have been to sweep down an unloaded section and bring in wet guncotton before the whole of the unloading was finished.

CIRCUMSTANCES AND EFFECTS OF THE EXPLOSION.

The stove was blown to pieces, and the mound, except at the corners, was completely flattened. A fire followed the explosion and was put out by the staff.

Hanna's body was found within the mound enclosure; the legs were gone and it was much charred.

Crosse's body, crushed by the mound and masonry of the air tunnel leading to the stove, was found in the wrecked heater house.

The trunk of Bayles' body torn open in front, was picked up at no less than 99 yards from the large crater. It had been projected over the neighbouring stove and mound.

The doctor who examined the bodies certified that all three deaths must have been instantaneous.

There was a large crater about 18 feet by 20 feet by 4 feet 6 inches deep formed near the site of the door, its centre being the position where filled bags of dry guncotton were usually placed. A small crater was formed on the opposite side of the building at what would have been the position of the end of one of the passages between the racks. A considerable quantity of wet guncotton was found along the position of one of the passages.

Harrison, the runner, was approaching the stove with a bogie load of wet guncotton and had just reached the corner of the mound when the explosion occurred. Had it happened a few seconds later he would have been opposite the opening in the mound and would, no doubt, have been killed. As it was he was flung down, and his trousers were split up to the waist, but his injuries were no worse than shock and bad bruises.

Many of the factory buildings were seriously damaged—in almost all cases by the force of the explosion, and not by projected débris—and a detailed list, prepared

by the manager, Mr. Nicol, is given in Appendix I. It will therefore be sufficient to give here a short account of the damage of greater interest.

Two stoves, 60 yards and 120 yards distant, were very seriously damaged. The former contained 500 lbs. of dry nitro-cotton in bags, which escaped injury; the empty racks and trays were thrown about and broken. The latter contained 1,250 lbs. of nearly dry guncotton on trays, but in spite of the injury to the building, none of the racks or trays were displaced.

In the case, however, of a third stove, 150 yards away, which contained 2,000 lbs. of partly dried guncotton, although the building was only slightly damaged, six racks were thrown down, strewing the trays and guncotton on to the floor.

In the mixing house 93 yards away, the mixing machines were at work on nitro-glycerine and nitro-cotton paste. Windows were shattered and paraffin oil illuminating lamps and broken glass were thrown into the building, glass falling into all the pans. The machines were injured, and the mixing blades were twisted and brought into contact with the bottom of the pans. Moreover, they continued to run, mixing the broken glass with the explosive. The bottom of the pans were found to be deeply scratched with glass.

The nitro-glycerine washing house, 255 yards distant, which contained about 3,000 lbs. of nitro-glycerine, although situated in a deep cutting, had the sides pulled out at the bottom—as much as 9 inches in one place—joints in steam pipes were sprung, and a large clock was thrown down from a shelf on to a bag of cordite paste.

In the cartridge huts, 110 to 250 yards distant, shelves and boxes of explosives were thrown down and the buildings were more or less seriously damaged. All the work-people fortunately escaped unhurt. The women's mess-room, 135 yards away, built of brick, was very extensively damaged. The door and a window were torn from their fastenings and thrown into the room, the roof was smashed in, and the wall facing the stove was cracked and displaced. Fortunately no one was present.

Outside the factory windows were broken to a distance of $3\frac{1}{2}$ miles, while there were cases of walls cracking and ceilings collapsing up to distances of about a mile.

A considerable amount of heavy débris, consisting of roof-joists and timber used in revetting the mound, was projected to great distances. A detailed list, also prepared by Mr. Nicol, showing the distances at which the heavier pieces were found, is given in Appendix II.; but it may be said here that pieces of mound stays about 6 feet long and 6 inches by 4 inches in section were picked up about 500 yards away, while a ceiling joist 24 feet long and 6 inches by 2 inches in section was found lying 110 yards, and another 15 feet long of the same section 150 yards, from the large crater. The latter and several other heavy pieces were standing upright, having landed point foremost. Fortunately the wind was blowing away from the majority of the factory buildings otherwise the effects of the explosion would probably have been still more serious.

PROBABLE CAUSE OF THE EXPLOSION.

No direct evidence of the cause of the accident was forthcoming as is generally the case after an explosion of this kind. It was possible, however, to ascertain what the deceased men were most probably doing at the time of the accident, and from certain indirect evidence obtained, a probable cause is suggested. At 7 a.m. that morning drying was completed in S₂ which contained 3,000 lbs. of guncotton (for cordite). Steam was then turned off. An examination of the temperature record book showed that the temperature in the stove had not been allowed to exceed 110 F°. It seems clear from the evidence that unloading was begun at about 7.15 a.m., contrary to the stove rule quoted above, which lays down that at least an hour must elapse. At about 10 a.m. Harrison brought up a bogie load of 1,200 lbs. of wet guncotton, which was taken into the stove, and he removed 700 lbs. of dry guncotton, leaving 2,300 lbs. of dry guncotton in the stove. This procedure was, at any rate, a technical breach of the licence, since the licensed quantity was exceeded. It should be added, however, that wet guncotton is not regarded as an explosive during manufacture and storage, but an excess of wet guncotton should not have been brought to a stove, and the management would not have countenanced the procedure had they known it to be taking place. Had the dry guncotton detonated, and had it at the same time been in actual contact with the wet guncotton, the latter might have been detonated also.

Hanna appears to have left the stove at about 10 a.m., and did not re-enter it until a few minutes before the explosion.

Bayles, between 10 a.m. and 11.40 a.m. (the time of the accident), would, in the normal way, have filled seven or eight bags, which would have occupied the position of the large crater, and Harrison, the runner, was just approaching to remove them.

It seems clear from the distance to which Bayles' body was projected that he was in close contact with, and most probably leaning over, a large quantity of explosive, and since parts of a guncotton tray were found inside his body, he was, in all probability, holding a tray between himself and the explosive.

The above conditions would have been fulfilled had he been in the act of emptying the contents of a tray into a bag.

From the position of Hanna's body it is probable that he was some little distance from the bulk of the explosive, and as his body was in the vicinity of that part of the building which had been emptied, he was, it is thought, probably sweeping down the emptied area ready for the wet guncotton which the runner was then bringing up. The small crater might very possibly indicate the position of a bag of swept-up guncotton dust.

Crosse, the third man who was killed, was engaged in painting the interior of the heater house.

The above was, it seems, the probable position of affairs at the time of the accident.

The explosion took place $4\frac{1}{2}$ hours after the heat had been cut off, and it is considered therefore that any cause connected with heating the stove, spontaneous ignition of deposited dust, &c., can be dismissed, since an accident due to such a cause would be far more likely to happen when the stove, hot air pipes, and radiators were hot, and the guncotton very dry. The fact that unloading was begun at once on the hot and dry guncotton does not appear to have had any direct connection with the accident.

The results of the analysis and heat tests obtained by our Chemical Advisers on a sample of guncotton taken from the stove a few hours before the explosion do not reveal any cause for the accident. Messrs. Dupré, in their report on the sample, call attention to the danger that would arise from a heated, exposed iron pipe, owing to the rapid decomposition of guncotton by the iron carbonate formed at one stage of rusting. In the present case, however, there were no iron pipes in the building except the mouths of the hot air pipes, and special precautions appear to have been taken to prevent dust from getting behind the lining and on to any hot pipes leading from the heater house.

Outside causes have also been considered and appear to be quite inapplicable.

Work was undoubtedly going on in the stove at the time of the accident, and in view of the well-recognised danger of working with dry guncotton owing to its sensitivity to explosion by percussion or friction, the most probable cause, in the absence of any evidence to the contrary, would appear to be some act done by one of the workmen by accident, or through carelessness in unloading the stove, thereby causing the explosion of a thin film of guncotton dust between two hard surfaces. As illustrations the following are suggested:—striking a tray on the "bag-filling stool"; pushing the stool (which without a bag weighed 14 lbs.) along the floor; stumbling with a tray, &c.; or possibly dragging a tray roughly from a rack, though the position and state of Bayles' body does not suggest this as a very likely cause. It would be possible, also, to cause an accident by roughly handling a broom in sweeping down, especially if it had been in the condition of one taken from another stove, to which reference is made below.

Whether accident or carelessness was the more likely cause it is impossible to say, though several points brought to notice after the accident indicate that a certain amount of carelessness in working the stoves did exist. For instance, the neglect of the important rule to allow the guncotton to cool down before starting work on it—which rule, evidence indicates, had rather been allowed to fall into abeyance—and also the following:—brushes taken from a neighbouring stove were considerably abraded, apparently by being knocked against other hard objects during use, and a hair broom had been very crudely repaired with two galvanized iron nails, the head of one projecting from the wooden face, and the other projecting an inch from the bottom of the handle among the hairs of the broom, and the brass screws in the brooms, moreover, were not countersunk. In an adjacent stove the "bag-filling stool," which also showed signs of rough treatment, had been placed on top of a loaded guncotton rack. All these points go to show that the two men had either become too familiar with their work or did not fully realise the dangers of working with dry guncotton.

Evidence was given by Hanna's wife that he had frequently spoken of Bayles' carelessness, and that he once said to her that Bayles would one day blow up the stove. Bayles' sister also gave evidence that her brother had always been, and was by nature, clumsy and careless. On the other hand, Hanna, when he had a chance of getting another assistant, preferred to retain Bayles, and never complained of Bayles' carelessness to the management, though he appears to have done so to one of the other workmen.

To summarize :—

I consider that the most probable cause of the accident was some act on the part of one of the workmen in unloading the stove. Whether such an act was done through carelessness or by pure accident it is impossible to say, but the evidence indicates that some carelessness did exist, and suggests this as being the more probable cause of the two.

QUESTION OF BLAME.

Since the cause of the accident is not known it is not possible, nor desirable, to attempt to fix blame on anyone for having brought it about.

We have for many years found the factory in a very efficient state, and its condition has been reported on as excellent. Its immunity from accident for so long a period bears witness to the same effect. Both Hanna and Bayles were regarded by the Company as steady, reliable men. Hanna especially, who had been for four years in his position as foreman, was considered thoroughly trustworthy and reliable in every way. The evidence, however, shows that some carelessness in the stove department existed, and that some, at any rate, of the stove rules were not strictly enforced. I am inclined to think that the fact that no serious accident had happened in the factory for so long a time largely contributed to the above state of affairs and led the management to place too great reliance in such subordinates as Hanna, owing to the long successful management of their departments, and consequently to relax supervision. And I feel bound to say that if the accident was due to an act of carelessness on the part of one of the workmen, not only was he to blame, but the management also for allowing this unsatisfactory state in the working of the stoves to exist. It would also seem from the evidence that Bayles, although of good character, was not a suitable man for employment in a guncotton stove.

RECOMMENDATIONS AND SUGGESTIONS.

The death of the third man, Crosse, who was in the engine house, although involving no breach of the licence, was particularly unfortunate, since his work was in no way connected with that taking place in the stove, and it is recommended that in future a rule should be made to prohibit the presence of any work-person in the engine house while the work of unloading the stove is being carried on.

It is considered that in buildings of the nature of guncotton stoves a "use list" of all implements should be kept, and the implements systematically inspected.

The possibility of lamps being blown into danger buildings from the outside, and of glass falling into machines, will no doubt be guarded against in future.

It has been stated that although the stove was of light construction large pieces of heavy debris were projected to considerable distances. And it would appear, therefore, that this type of light construction is not entirely satisfactory, since it is neither proof against the danger of projecting debris in the case of an explosion in the building, nor is it strong enough to resist heavy projected debris, distortion or fracture from the force of an explosion in its vicinity. In the present case it is difficult to see how an explosion in the neighbouring stove could have been avoided had the trays been loaded up with dry guncotton. It is fortunate also that no explosion occurred in the mixing house, and it is quite conceivable that one might have happened in the nitro-glycerine washing house, 255 yards, and the stove, 150 yards, distant.

In the recent Ardeer accident the explosion in one guncotton stove was communicated to all the neighbouring stoves, and my colleague, Major Cooper-Key, in his Special Report (No. CCVL.), has gone into the question of construction for danger buildings of the nature of stoves.

The heavy timber used in the construction of the mound proved to be objectionable for the reason that large pieces were projected to very considerable distances.

The management, it is understood, have decided to introduce the system of drying guncotton in compressed slabs, which dispenses with the use of trays and largely reduces the quantity of dust.

INQUEST.

I attended the inquest held by Mr. C. E. Lewis, Coroner for the Southern and Western District of Essex, on March 31st, and my thanks are due to him for the facilities he gave me of cross-examining the witnesses. The jury returned an open verdict, with which I entirely agree—"that the men met their death as the result of an explosion of guncotton, but that there was no evidence whatever to show what caused the guncotton to explode."

In conclusion, I have to express my thanks to Mr. Nicol, the manager, and to Mr. Jones, the deputy manager, for the great assistance they gave me in carrying out my inquiry.

I have the honour to be,

Sir,

Your obedient Servant,

R. A. THOMAS, Captain, R.A.,

H. M. Inspector of Explosives.

The Right Honourable the Secretary of State
for the Home Department.

APPENDIX I.

NOTES OF DAMAGE SUSTAINED WITHIN THE FACTORY BOUNDARIES.

- S. 2 Stove*.—Main Building, traverse and heater house destroyed ; heating plant seriously damaged.
S. Stove, 60 yards distant.—Main building damaged beyond repair ; heater house destroyed.
S. 1 Stove, 120 yards distant.—Main building very seriously damaged ; heater house considerably damaged ; slight damage to heating plant.
S. 3 Stove, 150 yards distant.—Building and heater house only slightly damaged.
Z. 1 Mixing House, 93 yards distant.—Building very seriously damaged, and plant and machinery more or less damaged.
X. Magazine, 80 yards distant.—Building seriously damaged structurally.
Gate House and Guard Room Range, 180 yards distant } Very serious damage structurally, and other-
Office Range, 160 yards distant ... } wise much damage to plant and furnishings.
Women's Messroom, 135 yards distant.—Practically wrecked.
Women's Search Box, 85 yards distant.—Badly wrecked.
Q. Magazine, 110 yards distant.—Sustained serious structural damage.
P. House, 60 yards distant.—Wrecked.
Cartridge Huts.—F. 1, 110 yards distant, wrecked ; F. 2, 128 yards, seriously damaged ; other huts all more or less damaged, distances from 153 to 250 yards.
G. House, 295 yards distant.—Considerable structural damage.
C. House, 255 yards distant.—Considerable structural damage.
E. 2 House, 160 yards distant.—Slight structural damage.
E. 3 House, 115 yards distant.—Considerable structural damage.
O. House, 280 yards distant.—Slight structural damage.
Acid Sheds, 310 yards distant.—Considerable damage to roofs, structural and otherwise.
I. House, 275 yards distant ... }
E. 1 House, 200 yards distant } Slight damage, mostly broken glass.
Search Box, 300 yards distant }
 Other buildings at distances up to 460 yards sustained slight damage.

APPENDIX II.

NOTES REGARDING DÉBRIS.

From the centre of the crater to a distance of 320 yards, travelling in a North-West by North direction (a strong wind was blowing from S.W. by S.), the ground was littered with débris of all kinds, composed of wood, zinc linings from the roof, pieces of lead, remnants of bags, trays, and clothing, and scraps of wire gauze, &c. Up to this distance the débris extended to a breadth of 400 yards.

Notes on the larger pieces found.

- At 110 yards, a ceiling joist, 2½ ft. long by 6 in. by 2 in. (this was the largest piece found).
 150 „ a ceiling joist, 15 ft. long (landed point foremost), 6 in. by 2 in. in section.
 160 „ a very large piece of timber, 6 in. by 2 in. in section.
 180 „ several heavy splintered timbers, several many feet long and 6 in. by 2 in. or 5 in. by 2 in. in section.
 130-230 yards, many large pieces of timber.

