

On Her Majesty's Service

WASC 1529

EXPLOSION OF TRI-NITRO-TOLUOL AND AMMONIUM NITRATE AT FACTORY NO.7, KENT.

Accident No. 110/1916.

NO. CCXVII.

REPORT

to the
RIGHT HONOURABLE THE SECRETARY OF STATE FOR THE HOME DEPARTMENT
on the

CIRCUMSTANCES ATTENDING THE EXPLOSION, WHICH
OCCURRED ON THE 2nd APRIL, 1916, AT THE
FACTORY OF THE EXPLOSIVES LOADING
COMPANY, LIMITED, AT UPLESS
MARSHES, FAVERSHAM, IN
THE COUNTY OF KENT

by

MAJOR A. COOPER-KEY, C.B.

H.M. Inspector of Explosives.

17th April, 1916.

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To the Secretary of State,
Home Office.

Sir,

I have the honour to report that in accordance with your Order dated April 3rd, 1916 (H.O. Papers 109,118/109) I have held an Inquiry into the circumstances attending the explosion which occurred on Sunday 2nd instant at the factory of the Explosives Loading Company Limited, at Uplees Marshes, Faversham.

By this explosion, the most disastrous in the history of my Department, no less than 106 persons were killed on the spot or died later from their injuries, and 97 were injured. Of those killed 20 were employees of the Cotton Powder Company and 4 belonged to the military guard.

Description of the factory.

The factory at which the accident occurred was established in 1912 under an Amending Licence granted to the Cotton Powder Company whose works immediately adjoin. The original purpose for which the factory was erected was the compression of tri-nitro-toluol into charges for shells, torpedoes and mines, and until the outbreak of war no other explosive substance was in use at these works. Since that time, however, the management has been called on to fill shells and bombs with "amatol", a mixture of tri-nitro-toluol and ammonium nitrate.

Circumstances of the Accident.

At about 12.10 p.m. on Sunday, the 2nd instant, it was noticed by Mr. Underwood, Clerk of Works to the building contractors, that a heap of empty linen bags recently used for T.N.T. and resting against the matchboard wall of building No. 833 had caught fire and was burning at one corner. He at once gave the alarm at the office and Mr Palowker, the assistant manager who was in charge during the absence of Mr George Evetts, the manager, at his mid-day meal, took immediate steps to deal with the matter by means of a hose and manual engine supplemented by fire-buckets. These failed however to have the desired effect and by the time Mr Evetts arrived the fire had obtained a good hold, and he had to decide whether to make an attempt to save a disaster by removing a number of cases of T.N.T. lying in the immediate vicinity of the building or to order everyone to retire to a safe distance and let the fire do its worst. After full consideration he decided that unless these cases were removed to a safe distance there was a considerable probability that the fire would spread to other buildings and that the consequences might lead to a disaster involving not only his own factory but also the cordite buildings belonging to the Cotton Powder Company, and that it was therefore his duty to prevent the fire spreading.

For over an hour water was poured on the fire without effect and at about 1.20 p.m. shortly after Mr Evetts had given the order to retire the contents

contents of the building detonated with appalling results to the crowd of
n congregated around, very few escaping death or serious injury.

Damage to Material.

Simultaneously with the explosion of this building the two final washing and filtering houses belonging to the recently erected nitro-glycerine plant of the Cotton Powder Company situated at a distance of about 120 yards and each containing a considerable quantity of nitro-glycerine blew up in sympathy, and about twenty minutes later one of the buildings used for moulding "amatol" charges, and after another twenty minutes a fifth containing filled primers for naval mines also exploded after having been set on fire by debris projected by the previous explosions. Of these five buildings no trace was left, the crater formed at the site of the original explosion being no less than 50 yards in diameter and ten to fifteen feet deep. A plan prepared for me by the management, but which I have not thought it necessary to reproduce with this Report, shews very clearly that within a circle of 225 yards radius drawn from the site of the first explosion as centre every building of ordinary light construction was totally destroyed, whereas outside that circle no building was completely wrecked although many of them were so damaged as to be incapable of repair. In one of the shell-filling buildings erected prior to the war and situated within the fatal ring the reinforced concrete partitions were, however, not even cracked.

In spite of the fact that the buildings belonging to the Explosives Loading Company are well spaced at distances from 60 to 70 yards apart not more than three or four out of a total of about 30 escaped serious structural damage, but it must be noted that, with the exceptions mentioned above, all these buildings were lightly constructed of wood and were not screened by mounds.

In the adjoining works of the Cotton Powder Company the damage was widespread but by no means regular. In addition to the six buildings within the 225 yard radius which were totally demolished not more than five were so damaged as to be incapable of repair and a further five seriously shaken but capable of repair. A very large number, however, amounting approximately to 150 to 200 received minor injuries or slight structural damage, a somewhat noteworthy feature being that the new magazines at the Harty Ferry extension in the extreme south-east corner of the factory area and therefore further away from the explosion centre than any other part of the works were more seriously damaged than the large majority of the intervening buildings. It has been suggested as a probable explanation that the greater part of ^{the} factory is built on a floating crust above the marsh whereas these magazines were on practically the only solid ground in the area. As they were built right into the hill and well screened by mounds this explanation attributing the damage to the earth wave as distinct from the sound wave is very possibly correct.

So far as I can ascertain, although the effect of the explosions was felt many miles away, the damage outside the factory seems to have been limited to broken windows, falling ceilings, and removal of roofing slates, but here again, as is so usual in the case of a big explosion the wave seems to have been subject to no rule. Faversham, only four miles away, escaped almost entirely

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whereas Southend and Shoeburyness at fifteen to twenty miles suffered considerably, and I am informed that 2 windows were broken at Farlow in Essex fifty-two miles away.

Cause of the Accident.

There is little doubt in my mind that the original fire in the heap of empty bags was due to a spark from the neighbouring boiler house. The three flues of this were each fitted with a spark-catcher, but this at best is of doubtful efficiency and the wind was blowing almost directly from this house towards the heap of bags. It is possible of course that a workman had been smoking and had thrown a cigarette end or a glowing match on to the bags which, impregnated as they were with T.N.T. dust, would easily ignite, but having regard to the time at which the fire was first noticed, viz. just before the dinner hour, and to the strict regulations against matches and smoking which had only recently been emphasized by prosecution and fine, it is extremely unlikely that any employee even if he had so far infringed the rules as to smoke on the premises would have failed to take the precaution of completely extinguishing his match or cigarette before throwing it away.

The theory of spontaneous ignition of the heap of bags has also been raised but from the description given by Mr Underwood of the first appearance of flame low down at one corner I consider this an improbable explanation, although having regard to the period of time, about three months, during which these bags had remained undisturbed it cannot be entirely disregarded. Lastly, it is not inconceivable that a mischievous person may have put a match to them on his way to the mess room, but in view of the precautions taken to prevent the entry of unauthorized persons and of the fact that no one could have foreseen that the ignition of these bags would have had such serious consequences an unsupported surmise of this nature amounts at most to the vagest suspicion. The arrangements for preventing the entrance of unauthorized persons appeared to me to be very strictly carried out and in addition to the military guard 128 strong, no less than 24 civilian patrolmen are employed at the combined factories.

All things considered then I am, as already stated, firmly of opinion that a spark from one of the flues of the boiler house offers by far the most probable explanation of the fire. The boiler was situated at a distance of about 50 feet from the building against which the bags were lying, and contained three boilers, the flues of which were 37 feet high. The spark arresters were of a type consisting of a succession of baffle plates against which the flue-gases impinged and were fitted in consequence of the former frequency of visible sparks. In spite of these, however, sparking from the flues seems still to have occurred at times and only the night before the explosion two of the patrolmen reported that they had extinguished an incipient fire from this cause between the boiler house and the T.N.T. store.

Had the building contained T.N.T. only, it is possible that no explosion would have occurred but that the fused material would have spread over the ground and burnt away quietly. Unfortunately, however, owing to the alteration

the loading arrangement, to which reference has already been made, this building had for some time been used as a store for Ammonium Nitrate and about 150 tons of this substance were present in it at the time. As the building was only licensed for T.N.T. the use of it for Ammonium Nitrate was, strictly speaking, a contravention of the terms of the licence but, had the matter ended there, the substitution of a practically non-explosive ingredient for a compound which, although particularly insensitive to friction or shock undoubtedly possesses explosive properties would be regarded merely as a technical irregularity to be covered by an amendment of the licence at the first opportunity. But owing to the excessive quantity of T.N.T. delivered at the works the magazines specially erected for the storage of this material were all full and of the surplus about 15 tons were deposited in the ill-fated building and the remainder appears to have been lying on the open ground outside it. As therefore, the theoretically most efficient proportions of these ingredients are about 20 per cent of T.N.T. to 80 per cent of Ammonium Nitrate there were present in the building alone the makings of at least 75 tons of high explosive.

But although the management cannot be completely exonerated from blame for allowing this departure from the conditions of the licence, it must be remembered that at the present time rapidity of output is of the first importance, and from this point of view it is extremely difficult, if not impossible, strictly to adhere to the exact letter of a licence. Changes are called for almost daily and have to be met in the way that appears best at the time with due regard to the essential matter of output. This particular combination of ingredients even when intimately mixed to form Amatol, an explosive now commonly used for the bursting charges of shells and bombs, is regarded more as a fire-risk than as an explosion risk, and it may well be that the responsible officials failed to appreciate the danger they were running in keeping these two ingredients in the same building or that appreciating the risk they considered it justified by the urgency of the national requirements.

That in moderate quantities a mixture of these two ingredients constitutes a fire-risk only would seem to be indicated by the length of time the fire was burning prior to the explosion. In fact according to the evidence of the Works Manager it had passed its maximum fierceness at the moment the explosion occurred.

On first realizing the serious nature of the fire the manager was placed in a most difficult position. In the immediate vicinity of the building there was a large number of boxes of T.N.T and it was a question whether an effort should be made to remove these and thereby possibly reduce the effect of any explosion that might occur or to let them be involved in the fire and order the workpeople to retire to a safe distance. Mr. Ewetts, as already stated seems to have decided, not hastily but with full appreciation of his responsibility, that in view of the proximity of the Cotton Powder Company's Cordite Works and of the importance of these to the nation the proper course was to make every effort to limit the destructive effect of an explosion to the smallest possible area by removing to a safe distance all the T.N.T. that could be handled by the men at his disposal. In this he was, I understand, loyally supported by his men, and although the loss of life

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is most deplorable it may truly be said that those who thus died at their posts gave their lives for their country in the fullest sense. Some of them possibly were unaware of the risk they were running as seems to be evidenced by the presence of a certain number merely as spectators who declined to retire in spite of repeated instructions, but many there were who, while fully appreciating the danger, threw themselves heart and soul into the struggle to prevent what could only be described as a national disaster, and it is some satisfaction to feel that their efforts were partially successful. An examination of certain of the guncotton drying sheds in the neighbouring works shewed that a very slight increase in the force of the explosion would have caused more than one roof to fall on the guncotton on the racks below and the explosion of even one of these sheds would probably have put the cordite plant out of action for a considerable time.

The behaviour of the manager, Mr. George Evetts, calls for special mention. At the time of the first explosion he was about 40 yards from the building and was knocked senseless by the concussion, his coat being torn off his back. On coming to himself he found his offices were on fire and he made an immediate attempt to save his books and papers. While so engaged the roof and walls fell in on him. He then ran to the main gate to summon medical assistance and ambulances and there met Mr. W. E. Bethell, Works Manager of the Cotton Powder Company. Accompanied by him Mr. Evetts then returned to the site of the explosion which was now a mass of flames, and while assisting to remove the injured narrowly escaped death or injury from the second and third explosions. After the last of these it was seen that the roof of the nearest magazine containing 25 tons of T.N.T. was on fire, and as by this time the scene was so terrible that they could get no one to follow them these two gentlemen alone climbed on to the roof of this building and extinguished the fire thereby possibly preventing another explosion. The gallantry of both these gentlemen deserves the highest commendation, more especially as a very slight addition to the shocks already experienced would almost certainly have caused the explosion of one or more of the guncotton stoves to which reference has already been made.

Remarks.

The immediate neighbourhood of the matchboard wall of a building appropriated to the storage of even Ammonium Nitrate alone was an unfortunate place to select for the deposit of a heap of inflammable bags but, without in any way desiring to relieve the Company's officials of responsibility rightly resting on them it is only fair to point out that owing to the pressure at which the work was being carried on and to the vast amount of material delivered to or stored at the factory with no regard to the space available or to the protests of the management, it was practically impossible to maintain the orderliness and method considered so essential in normal times. No less than 250 tons of T.N.T. and nitrate had been delivered during the previous month and although 14,000 empty packages had been despatched since the 1st February, there still remained a large accumulation of these. This congestion is indeed a matter which is very generally causing me considerable anxiety and to which I have already called the attention of the Ministry of Munitions on more than one occasion, but in view of the immense scale on which the manufacture of munitions is now of necessity carried on it is

difficult to see how it can be entirely avoided.

In view of the very large quantities of T.N.T. and Amatol now stored throughout the Kingdom this accident cannot fail to be extremely disquieting, but on the other hand it would be a mistake to assume that a fire involving either of these materials will invariably develop into an explosion. In the case of T.N.T. I think there is good ground for the belief that owing to its low melting point it would in the event of fire spread itself over a large area and burn away quietly. Explosions have occurred no doubt, notably those at Penrhyndeudraeth and Ardeer, but in each case the detonation was preceded by a fire of considerable duration, or the T.N.T. was strongly confined, or both these conditions were present. Amatol also, or rather a blasting explosive of the same composition, has been known to burn away in considerable quantities without explosion, but this is at the best merely negative evidence and must not be taken to imply that in very large quantities its behaviour will be equally satisfactory.

The circumstances attending this accident are curiously similar to those connected with an explosion which occurred at Witten in Westphalia in 1906. In this case also a detonation took place in the course of a fire which fused the two ingredients and thus caused them to come into contact, and it is to my mind by no means impossible that the conditions under which a large quantity of Ammonium Nitrate and T.N.T. stored in the same building might combine in the event of a fire might be more likely to lead to a violent reaction than if the two ingredients had been previously mixed to form "Amatol". In the present series of explosions at any rate, nothing occurred to prove conclusively that unconfined Amatol can be exploded by fire alone. The mixing and moulding house which caused the second explosion contained at the time a considerable amount of unmixed ingredients, and the "primer" house which caused the third and last explosion contained T.N.T. in stout metal cylinders primed with pellets of "tetryl", - and incidentally many of these cylinders were picked up later unexploded.

To ascertain if there were any probable foundation for the view that the unmixed ingredients might be more dangerous than the mixture the Messrs. Dupre carried out at my request a few tests in their laboratory but as they unfortunately have no open ground available, the scale on which they were able to conduct the experiments was too small to give any definite results and they were only able to show that when heated in a test tube, i.e., under slight confinement, "Amatol" is distinctly more violent in its explosive properties than T.N.T., whereas when ignited in a platinum dish the latter burns the more fiercely. They pointed out, however, that Ammonium Nitrate when heated produces large quantities of nitrous oxide (N₂O) a gas which in its property of supporting combustion does not differ materially from pure oxygen and that although when the two ingredients are combined in the form of "Amatol" this oxygen equivalent would be consumed as soon as produced it is not impossible that if large quantities of the nitrate were separately heated there might be an accumulation of this gas which on suddenly coming into contact with burning T.N.T. might give rise to

a reaction of unforeseen and exceptional violence. It is also conceivable that the sudden precipitation of a mass of the nitrate into burning T.N.T. might produce a similar result.

In any case however it is clear that it is most essential to store these two materials in different buildings so situated that even in case of a fire involving both they cannot come into contact with one another.

I attended the adjourned Inquest held on the 11th instant by Mr. C. B. Harris, Coroner for the Sittingbourne District of Kent. The jury returned a verdict of accidental death and acquitted the management of all blame in the matter, adding a rider suggesting that the Home Office should require more efficient fire appliances to be established in explosives factories. In regard to this I would point out that the provision of ample means to deal with incipient fires is a matter to which special attention is paid in explosives factories but during the present emergency it is frequently impossible to carry out the necessary work of laying watermains and that this had not been done at these works was due to no lack of effort on the part of the management. In the absence of a high pressure water supply the best substitute was at hand in the form of a four-man manual supplemented by fire-buckets and over one hundred chemical extinguishers.

In the course of my Inquiry I received valuable assistance from the officials of both Companies concerned.

I have the honour to be,

Sir,

Your obedient Servant,

A. COOPER-KEY,

Major.

H.M. Chief Inspector of Explosives.