

WAsc 1993

Report on Bishopston  
Explosion 20-4-45

ROYAL ORDNANCE FACTORY  
REGISTRY  
- 6 DEC 1945  
BISHOPTON

Decision

R.O.F. .... Report No. ... **M.72.** .....

Title:- Report on an Explosion in a Cordite Incorporating House at R.O.F. Bishopton on 20th April, 1945.

Authors:- D. Cross.

Submitted by:-

- Decision:-
1. That the addition of "Wet Waste" before the addition of "Dry Paste" is to be prohibited, for all types of cordite to which the incorporating process applies, at all R.O.F's.
  2. That in future the mounting of electric light bulbs in Incorporating Houses is to follow the recommendation of H.M. Inspector of Factories as outlined in Appendix VI of this report.

*McKinnon*

~~D.D.C.O.F. (X)~~  
D.O.F. (X)

Superintendent,  
R.O.F.,  
Bishopton.  
Attention Mr Cross.

Will you please arrange for the above decisions to be ~~reproduced and~~  
~~circulated for attachment to the report. We have retained two copies of~~  
~~the decision for attachment to headquarter's copies of the report.~~

*McKinnon*

~~See D.D.C.O.F. (X)~~  
D.O.F. (X)

H.72

Report on an Explosion  
In a Cordite Incorporating House  
at R.O.F. Bishopton  
on 20th April, 1945.

Reported by: D. Cross.

Date: October, 1945

Report on an Explosion in a  
Cordite Incorporating House at  
R.O.F. Bishopton, on 20th April, 1945.

General Statement.

At 11.12 a.m. on 20th April, 1945, explosions occurred at Cordite Incorporating House 28/304E in Factory 3, Bishopton, in which were involved the contents of bay number 3 of the incorporating house and the contents of a truck of paste for W.M. Cordite which was standing opposite to number 3 bay but on the other side of the traverse. There were within the traverse at the moment of explosion 4 process workers and a paste trucker and of these, three process workers and the trucker were killed instantly while the fourth process worker was seriously but not fatally injured; in addition, the acting assistant foreman who had just left the house received fairly severe injuries. Particulars of the killed and injured are given in Appendix I. By the explosion the incorporating house was for all practical purposes destroyed but the damage to surrounding buildings was very minor. Details of the damage are given in Appendix II and illustrated in Plan No.1 and photographs 1 - 4.

Following the explosion an enquiry was held by a court consisting of

Dr. H.E. Watts (Chairman)	H.M. Inspector of Explosives.
M.C.S. Bryant	For C.S.A.R.
Major J.W. Henderson	For C.S.O.
Mr. D. Cross	For D.O.F.(X)
Mr. E.P. Evans	Supt., R.O.F. Wroxham.

Mr. W. Carmichael )	Workers' Representatives.
Mr. W. Cornfield )	

Mr. R.A.J. Granville (Secretary) Safety Officer, Bishopton.

The court sat on 21st April and 8th May and during the latter sitting a deputation of the court visited Glasgow Royal Infirmary to take the evidence of the two injured men. The chairman presented his report to the Director General Ordnance Factories on 27th June, 1945. His recommendations and the decisions reached in regard to them are given in Appendix III.

Description of the Incorporating House.

The dimensions and general lay-out of the building are shown in Plan No.2. The brick walls, as shown, were 18" thick but the bonding of the walls between the bays to the main back wall of the house was imperfect. The roof was of 8" thick concrete reinforced by  $\frac{3}{8}$ " diameter rods at 6" centres transversely and by  $\frac{1}{2}$ " diameter rods at 6" centres longitudinally. As a result of this construction, when the partition walls of Bay 3 were demolished by the explosion, the roof behaved as if it were a single carpet of concrete and collapsed on to the floor of Bay 3 without breaking.

In each of the 6 bays in the house there were two Baker Perkins incorporators. The machines were water-jacketted and the two shafts in each machine ran at 5.7 and 11.0 r.p.m. respectively. The shafts were of mild steel on which were mounted blades of cast iron. The clearance between the blades and the body of the incorporator was 15 thousandths of an inch.

Normal Working of the House.

The building is normally operated by 4 workers under a charginan. The workers operate in pairs, each pair attending to the machines in the 3 bays forming one half of the house. In general the two pairs are loading or unloading machines at the same time and the work is so arranged that there is/

is at least one bay between the bays in which the workers are engaged during loading. The normal course of operations in the house is detailed in the Special Rules and Operating Instructions which, together with the Use List and Limits are given in Appendix IV.

The actual procedure in use in the house at the time of the explosion differed slightly from this and was as follows:-

The incorporator was started, 3 to 4 lb of solvent, from one of the 5 cans provided for the mix, was sprayed on to the blades and a half charge (30 lb) of waste from the press house added. (Note - The quantity added depends on the amount of waste available; the normal charge is 60 lb).

A bag of paste was placed on the leather-covered table and its contents transferred by hand to the incorporator, the remainder of the solvent in the first can being sprayed over it as it is added.

This operation was then repeated with the remaining 4 bags of paste and 4 cans of solvent.

Each bag of paste contained 39 lb gun-cotton and 17 lb 14 oz nitroglycerine and each can of solvent contained 17 lb 5 oz acetone and 2 lb 8 oz water. The time taken to add one bag of paste was about 5 minutes.

When loading of the paste was completed, 6 lb  $1\frac{1}{2}$  oz carbamite and 12 oz chalk were added and the lid fastened on the incorporator, which was then allowed to run for 2 hours. At the end of this time 10 lb 9 oz mineral jelly were added, the blades run in reverse for 2 minutes and incorporation continued for a further 2 hours. The blades were run in reverse for 10 minutes then stopped and the machine wound up into the unloading position. After the incorporated dough was unloaded into bags the machine was wound down and was ready to commence a new cycle.

#### Course of Events Prior to the Explosion.

Work on the shift during which the accident happened started as usual shortly after 7.00 a.m. and apparently proceeded normally. At approximately 10.00 a.m. the 4 press workers, Horne, Mitchell, Fulton and Hill, and the paste trucker, Mullen, went for their meal, leaving the charginan, Hondry, in the house. There were only 5 of the 6 bays in use and, at 10.00 a.m., all the 10 machines in these bays were fully loaded and working. Shortly afterwards incorporation was completed in machines 53 (Bay 3) and 57 (Bay 5). Hondry stopped these machines and wound them up ready for unloading by the workers when they returned.

At about 10.45 a.m., loading hand Horne returned and Hondry, after telling him that machines 53 and 57 were awaiting unloading and that mineral jelly was to be added to two other machines at 11.30 a.m., left the house and proceeded to the canteen.

The remaining three processmen returned very shortly afterwards, unloaded machines 53 and 57 and wound them down into the loading and mixing position.

The bags of dough from these machines were collected and taken to an adjoining press house by the dough trucker, Fisher, who, as he was leaving the incorporating house, observed acting assistant foreman Whitson approaching the house.

Whitson was engaged in adjusting clocks in the section and spent about 10 minutes on the clock in this house. When he was leaving by the top exit (between/

(between Bays 5 and 6) he met Mullen coming in with a bag of paste, presumably for Horne and Mitchell in Bay 5. As Mullen would normally have given the first bag to Fulton and Hill in Bay 3, Whitson assumed this was only Mullen's second bag as the paste trucker had not arrived when Whitson entered the house. Whitson confirmed this as he passed Mullen's truck, noting that it still contained 8 of the normal 10 bags. He had only got about 30 yards beyond Mullen's truck when the explosion took place.

The foregoing account is based on the evidence given at the Court of Enquiry.

#### Discussion of the Circumstances of the Explosion.

In addition to the evidence furnished by the witnesses at the Court of Enquiry, the considerations in this section are based on the Medical Officer's report on his examination of the human remains, on examination of the site after the explosion and on knowledge of the general routine of manufacture.

A summary of the relevant evidence of the witnesses and of the relevant points in the Medical Officer's report is given in Appendix V.

Apart from the fact that various persons in the vicinity were able to distinguish two separate detonations, it is quite clear that at least two detonations took place, one inside and one outside the traverse of the building, and that the second explosion resulted from the first. It is obviously important to determine, if possible, which of these explosions happened first. The medical evidence shows that all the workers concerned (i.e. the four processmen and the paste trucker) were inside the traverse at the moment of explosion. At that time the paste truck had been standing outside the house for about 5 minutes and the nearest person to it was the Assistant foreman who had passed it a few moments earlier; by his own statement, confirmed by the nature of his injuries, he was, at the moment of explosion, walking towards the main narrow gauge road way and had his back to the paste truck. There was, thus, no person in the vicinity of the truck who could have done anything to cause the explosion and no evidence could be found suggesting an exterior agency (e.g. something falling from a passing aeroplane). As the paste on the truck was quite normal material, it is impossible to suppose that it detonated spontaneously and without warning. It is, therefore, concluded that the explosion could not have originated at the truck but must have originated inside the traverse. In so far as the cause of the explosion is concerned, the explosion of the paste on the truck can, consequently, be ignored and attention concentrated on determining as definitely as possible the course of events inside the traverse of the building.

The medical evidence enables the bodies marked A and B on Plan No. 2 to be identified definitely as those of Mitchell and Mullen, respectively. No identifying characteristics are available in the case of the body C and the remains DD, but, by considering the medical evidence in the light of normal operating procedure, it is possible to say which represents Hill and which Fulton with reasonable certainty. The demolition of the body of machine 53 shows that dry paste detonated inside it and confirms that the operation of loading was in progress at the time. In carrying out that operation the loading table would be placed at the side of machine 53 nearest to machine 54 and one of the workers would stand alongside it and feed the paste into the machine; the other worker would stand at the opposite side of the machine - that is, between machine 53 and the side wall of the bay - and manipulate the solvent spray can. In normal routine the two workers do not do both jobs indifferently but each has his own job and sticks to it fairly rigidly. In the case of Fulton and Hill, the former normally fed in the paste and the latter handed the solvent can and it may reasonably be accepted that that was the case on this occasion. In the same way paste is normally taken from the paste trucker by the worker feeding the paste - that is to say by Fulton in this case. If Hill were in his normal position between the machine and the wall when/

when the explosion occurred, his body might be expected to be found where Body C was found: although he could not avoid being relatively close to the incorporator, the quantity of explosive was relatively small - probably less than 60 lb - and the walls of the incorporator itself would provide sufficient protection to prevent the body from disintegration. On the other hand the position of body C is inconsistent with any position in which Fulton might have been. It is, therefore, concluded that C is the body of Hill. From this it follows that the body which was disintegrated was that of Fulton and the position of the remains D is not quite consistent with the assumption that he was at the loading table (this would also, of course, apply to the remains D1 but, on the whole, it seems more probable that they belong to body C.). Moreover, as presumably a considerable part of the first bag of paste had already been fed into the incorporator, it is improbable there would have been enough left on the loading table so completely to disintegrate his body; from the effects of the explosion in the incorporator his body would have received the same protection as that of Hill - even more, in fact, for Fulton was 3" less in height than Hill. The second bag of paste might have been brought in and put on the loading table which might possibly have provided sufficient explosive to give the result produced. In this connection, however, the medical report afforded valuable information. The medical officer draws attention to the fact that, in addition to the body of the fourth man being disintegrated, the chest wall was completely broken up. This suggests that the man was very close indeed to a mass of explosive and it is, hence, concluded that Fulton had received the second bag of paste and was carrying it clasped to his chest in the normal way when the explosion occurred. The position of Mullen's body is consistent with the view that he had just handed over the bag of paste as he was obviously not carrying it at the moment of explosion and was not more than 3 yards from the door of the bay when it happened. As there appears to be nothing Fulton could do to cause the detonation of the paste in the bag while he was carrying it, it must be concluded that the original explosion took place in the incorporator, involving first the bag of paste Fulton was carrying and later the paste on the truck outside.

Starting from the established time of the explosion, 11.12 a.m., and working backwards, allowing appropriate time for the various operations, the following time table has been worked out to cover the period from the time Hondry left the house up to the time of the explosion:-

10.43	Hondry leaves the building.
10.44	Fulton, Hill and Mitchell arrive.
10.45	Workers start to unload.
10.51	Fisher arrives and starts to remove dough.
10.55	Unloading complete.
10.57	Machines ready to re-load.
10.59	Fisher leaves; Whitson arrives.
11.7	Mullen arrives
11.8	Mullen delivers paste to Fulton.
11.10	Whitson leaves and meets Mullen entering with second bag of paste for Horn and Mitchell.
11.11	Mullen finds no one in Bay 5 so proceeded to Bay 3 to give bag to Fulton. Hands bag to Fulton and starts
11.12	to leave. Explosion occurs.

There is nothing very abnormal about the course of events as indicated in this time table. It does show that an interval of 10 minutes elapsed, after the workers were ready to reload, before the paste trucker arrived, yet obviously neither Horn nor Mitchell were ready for him when he did arrive, with the result that he had to take the second bag of paste to Bay 3. This, however, could not affect the occurrence or otherwise of the explosion as that happened in machine 53 before the second bag of paste was added, unless the arrival of the paste trucker at Bay 3 earlier than he was expected caused either or both of the workers in that bay to do something which led to the explosion.

Although/

Although the operation of incorporation has been in use for over half a century this was only the second occasion on which an explosion had happened, the previous instance being at Waltham Abbey on 15th December, 1902. The two cases occurred at approximately the same stage of the operation and were attended by similar results. In neither case was there any indication of the existence of any exceptional factor. Nevertheless, in the period of over 42 years between the two accidents, the operation of loading was performed quite safely probably over 3,000,000 times.

### Cause of the Explosion.

The various possible causes are discussed in the following paragraphs:-

#### 1. Lightning.

There was no lightning in the vicinity at the time nor was there any evidence of unusual electrical atmospheric conditions.

#### 2. Static Electricity.

The machines are carefully earthed and recent tests had shown the earthing to be satisfactory. The conditions thus do not favour the production of static and it has not been a source of trouble in incorporating houses.

On five occasions in 1943 "blue flashes" were reported to have been seen in incorporating houses: in the first four cases no satisfactory explanation was reached but on the fifth occasion it was concluded to be due to a light bulb short circuiting while burning out. About 2 weeks before the explosion a blue flash was reported to have been seen in Bay 1 of the house in which the explosion happened and here again it was traced to a lamp short circuiting while burning out. The matter was referred by the Chairman of the Court of Enquiry to H.M. Senior Electrical Inspector of Factories and a copy of his report is given in Appendix VI. It will be seen that he agrees with the explanation arrived at by the factory electrical staff and makes a suggestion to avoid repetition.

It can be concluded that the explosion was not due to static electricity.

#### 3. Fire.

##### (a) Spark from a Chimney or other source.

There was no source in the vicinity from which a spark could reach the incorporator.

##### (b) Spontaneous Ignition.

There was not, so far as is known, any article in the house capable of spontaneous ignition.

##### (c) In the Adjoining Incorporator.

Fires in incorporators have occurred but only very infrequently. It is to be supposed that if such had happened in this instance, the workers would have had time to make at least an attempt to escape whereas there is no indication that they had any warning whatever.

(d)/



(d) Traces of Incendiary Mixture.

During 1944 a certain amount of an incendiary composition had been made in various incorporating machines, including the one in which the explosion occurred. At the time the machines had been thoroughly cleaned but not disassembled. After the explosion one of the other machines was disassembled but only negligible traces of aluminium were found. This was not a probable cause in any case and may be dismissed.

(e) Dry Paste or Guncotton under Apron.

Each machine stands on a lead apron and it was suggested that dry paste or guncotton might have got underneath and become ignited. The aprons of six of the remaining machines in the house were lifted but in no case was there any appreciable quantity of explosive dust.

4. Deliberate Action.

(a) Smoking.

There is no ground for suspecting smoking in circumstances of the Danger of which the workers were well aware.

(b) Malice.

The workers were quite normal prior to the explosion and there is no reason to suggest that any of them would do anything deliberately to cause an accident in which he would almost inevitably be fatally involved.

(c) Sabotage.

The presence of the workers in the house rules out the possibility of such action by an outside person.

5. Spontaneous Decomposition.

Examination of the stock from which the paste had been drawn showed it to be of good quality and, therefore, not liable to decompose spontaneously.

6. Carelessness of Workers.

The two workers in Bay 3 were experienced men, well aware of the necessity for care in handling dry paste.

7. Fault of Workers.

It was suggested at the Court of Enquiry that if workers were in a hurry they might tip the contents of a whole bag of paste into the incorporator at once instead of putting it in gradually, in accordance with the rules, and so desensitising it by wetting with solvent. Such an action would not of itself cause an explosion but it would leave the paste for a time in a condition in which it would be much more sensitive to shock and friction than after the normal spraying with solvent and it would, therefore, represent a considerable risk and one which in practice is quite unnecessary.

The incorporator workers can load in the paste correctly as quickly as the paste trucker can supply the paste and there is thus nothing to be gained normally by taking the risk of being found breaking the regulations. One could imagine a worker taking the risk with the last bag if he were anxious to get away at the end of his shift but that did not apply in the present case. On this occasion the workers had been waiting about 10 minutes for paste but any evidence available suggests that they were not unduly concerned about it and there was no inducement to them to use undue haste when the paste did arrive. The arrival of Mullen with the second bag of paste might, however, have occurred while Fulton was still feeding the contents of the first bag into the incorporator and Fulton might have been tempted to sweep the remainder of the paste into the machine so that he could go and take in the second bag. As stated above this would not of itself cause the explosion but, in the presence of any agent capable of producing shock or friction, it would provide a much more sensitive medium. It would seem quite possible that, when Fulton was going to get the second bag of paste, Hill might rest his solvent can on the edge of the incorporator and that it might slip and fall into the incorporator. In the circumstances he probably would not be able to recover it quickly enough and friction sufficient to cause the explosion would result. The injuries to Body C are consistent with such a possibility - particularly the complete disappearance of the arms.

#### 8. Shock or Friction.

##### (a) From Foreign Matter in Paste.

Paste is sieved direct into the bag in which it goes to the incorporating house and hence foreign matter in paste is highly improbable. The method of loading acts as an additional precaution.

##### (b) From Foreign Matter in Waste.

It is realised that there are possibilities of foreign matter getting into waste which comes from the press houses (e.g., a press house knife) and the waste is carefully sorted before use. Normally the waste is added after the paste has gelatinised so that, even if foreign matter came in with the waste, it would only constitute a fire risk. In the addition of waste to the incorporator before the paste, as was the practice at the time of the explosion, the presence of foreign matter would be a definite detonation risk. It does not seem that the full significance of this difference was realised and the possibility of foreign matter having got in with the waste cannot be excluded.

##### (c) From Breakage of Incorporator Blades.

Normally the strain on the blades at the beginning of loading is negligible but, where waste is added first, the position is rather different and the strain might be just sufficient to fracture a blade that was just at the end of its life. On the other hand it is not absolutely certain that waste was used, though it is probable, but even so, the quantity would only be 30 lb instead of the normal 60 lb.

This/

This cause can be regarded as possible but not, in the circumstances, very probable.

(d) From Rubbing of the Shaft on the Body of the Incorporator.

To this cause was attributed a fire in an incorporator and, with dry paste, it could, of course, cause a detonation. The rubbing could only be caused by the shaft being forced out of alignment and this could hardly have been caused by the loading operation as far as it had gone. If it had occurred during the previous incorporation it would doubtless have set the charge on fire.

This cause can be regarded as very improbable.

Conclusion.

The most probable cause of the explosion was either

- (1) Fault of the workers as dealt with in 7 above,
- or
- (2) Foreign matter introduced in waste (85).

Recommendations.

The recommendations made by the chairman of the Court of Enquiry cover the ground fairly adequately. In view, however, of the fact that the addition of waste before paste would be a detonation risk if the former contained foreign matter, I would recommend that the addition of waste before the paste has gelatinised should be prohibited for all types of cordite to which the incorporation process applies.

I would also recommend that the method of mounting lighting bulbs recommended by H.M. Senior Electrical Inspector of Factories (Appendix VI) should be adopted wherever applicable.

APPENDIX I.

List of Killed and Injured

Killed

William Fulton,	aged 52, married,	Process Worker	(Incorporating)	.
Thomas Hill,	" 53, " , "	" "	" "	.
Donald Mitchell,	" 40, " , "	" "	" "	.
Thomas Mullen,	" 43, single,	Trucker	(Paste).	.

Injured

<u>Worker</u>	<u>Nature of Injuries</u>
James Bryce, aged 39 Process Worker (Acids).	Shock and effect of fumes: resumed work after treatment.
James Horn, aged 54, Process Worker, (Incorporating Leading Hand)	Fracture of right humerus, fracture of right malar bone, severe lacerations on left side and back of head and multiple abrasions on almost all parts of body: extremely shocked.
Thomas Whitson, aged 45, Assistant Foreman (Incorporating).	Severe lacerations and punctured wounds of the back, in the regions of the left scapula and of the left elbow: punctured wound in right elbow: shock.

---

APPENDIX II

Damage caused by the Explosion.

1. To Incorporating House 28/304E.

Bay 1.

All walls racked or damaged.

Bay 2.

Wall between Bays 1 and 2 racked and damaged; back wall 50% demolished; wall between Bays 2 and 3 completely demolished. Roof down to floor level on Bay 3 side. Machines damaged by debris and fire but not irreparable.

Bay 3.

All walls demolished. Roof resting on floor. One machine demolished; other machine badly damaged but parts may be recoverable.

Bay 4.

Back wall 50% demolished; wall between Bays 4 and 5 partly demolished. Roof down to floor level on Bay 3 side. One machine badly damaged -- possibly irreparable; other machine suffered only minor damage.

Bay 5.

Back wall racked.  
Machines damaged but not seriously.

Motor Corridor.

Roof and walls collapsed.

Traverse in front of building.

Damaged at point nearest position of waste truck.

Blast Wall opposite entrance between Bays 3 and 4.

Completely demolished.

2. To Adjacent Buildings.

Guncotton Office and Laboratory (25/327)

Some windows broken.

Cordite Stoves (27/302A & B)

Damage to doors and minor damage to ceiling.

Cloth Washing House (27/308)

Timber walls badly shattered; ceiling damaged.

Incorporating Houses (28/304 F & G)

Windows, ceiling and blackout damaged.

Burnings House (28/309)

Sieve Cleaning House (28/310)

Sieve Burning House (28/311)

Doors damaged.

Ambulance Hut (28/325A)

Doors destroyed.

Lavatory (28/337E).

Timber surround of water tank shattered.

D.B.V. Office (28/357)

Some windows damaged.

Recommendations of the Chairman of the Court of Enquiry.

Points Recommended for Consideration	Action Taken.
<p>The question of the addition of re-work cordite at the beginning of an incorporation when cordite of the type of W.M. is being manufactured.</p>	<p>Rework is not to be added to the incorporator at the beginning of the incorporation of any type of cordite.</p>
<p>The question of the advisability of turning empty paste bags inside out before loading with paste, and cleaning the exterior of the bags.</p>	<p>This bag inspection has been done in some cases hitherto and it has been agreed that it shall be general practice in future.</p>
<p>The desirability of the alteration of the design of the incorporating house. It is fairly clear that the 14 inch blast walls outside the entrance to No. 3 Bay directed the flame or hot gases directly on to paste loaded on the bogie. There was no protection from blast from the paste bogie for the main narrow gauge line which was less than 20 yards away, and this line is also used as a normal route between canteens and process buildings. Details of the construction of the building are given in Appendix 5. There is no doubt that the collapse of this heavy building did a lot of damage and the design could be considerably improved.</p> <p>(Note - The mention above of "Appendix 5" refers to the Chairman's report).</p>	<p>It is agreed that the present design is not satisfactory and the working out of an improved design is in the hands of a special committee.</p>

APPENDIX IV

SPECIAL RULES

Incorporating Houses

1. Friction and blows are to be avoided and care is to be taken to exclude all grit or other extraneous matter. Boxes and bags are not to be dragged over the floor but are to be lifted into position.
2. Before commencing work, the chargeman is to ascertain that the machinery is in good working order and that everything is correct. He is to make immediate report to the foreman if anything is not in order.
3. In very cold weather when there would be danger of the water freezing, the fire buckets are to be kept inside the working bays.
4. Doors are to be left open during loading or unloading incorporating machines, except when black-out restrictions, or very cold weather necessitates their being closed.
5. Bags, full or empty are to be conveyed to and from the Incorporating House in covered trucks.
6. Bags containing explosives are to be carried one at a time held in the arms in front of the operative and are not to be carried on the back or the shoulders. The bag is to be carried with the mouth uppermost.
7. If paste is spilt in the porch or on the truck lines no attempt is to be made to clear it up or to move any truck in the vicinity. Immediate report of any such occurrence is to be made to superior authority whose instructions are to be followed.
8. If paste is spilt in the house, it is to be swept up with a flannel and placed in the empty bag provided. A report is to be made to the foreman whose instructions for the loading of the remainder of the spilt bag are to be followed.
9. Empty bags and boxes for explosives are not to be exposed to direct sunlight.
10. Motors are to be started by the Chargeman. The gear control of the machine is to be put in the "off" position before the motor is started.
11. An incorporating machine is to be stopped by turning both the power and gear control handles to the "off" position. Workmen are not to put their hands into the machine until both control handles are in the "off" position and the blades are at rest.
12. Only two bags of paste are allowed in a bay, and no paste is to be taken into a bay until the machine to be charged has been emptied of its previous incorporator load and the dough from it removed from the bay.
13. Solvent is to be added to an incorporator only through the Spraying can. The spraying cans are to be placed on the floor when being filled with solvent.
14. Mineral jelly, carbomite and solvent containers are to be placed within the white lines on the floor when they are not in use.
15. Only one machine in a bay is to be uncovered at a time, except when all machines in the bay are empty.



## INSTRUCTIONS FOR INCORPORATORS

### CORDITE W.M. PASTE

1. The leather cover is to be placed on the incorporating machine with the straight edge of the cover to the front. The loading table is to be placed between the arms of the machine and the lip of the table in position over the straight edge of the leather cover.
2. The blades are to be set in motion in the "forward" direction and half a can of solvent is to be sprayed evenly over the blades, using the spray can.
3. One bag of paste is to be placed carefully on the table with the mouth of the bag at least six inches from the lid (i.e. not beyond the red line.) The mouth of the bag is to be untied and the tapes tucked under the bag.
4. One operator is to stand by the side of the table and load the paste into the machine raising as little dust as possible, while the other operator is to stand at the back of the machine and sprinkle the remainder of the can of solvent through the rose whilst the paste is being loaded.
5. In order to completely empty the bag, paste may be removed by holding the bottom of the bag and allowing the paste to fall out on to the table whence it is to be loaded by hand into the machine. When the bag is empty, the mouth is to be tied securely and the bag folded with the mouth inwards.
6. Operations 3, 4 and 5 are to be repeated with the remaining bags of paste except that the whole of a can of solvent is to be sprinkled over each charge whilst it is being loaded.
7. The machine is then to be stopped, the carbamite and chalk to be added and the addition checked.
8. The loading table is to be removed and the leather cover to be wiped with a sponge cloth and removed from the machine. The top of the machine is to be wiped, the inside of the lid to be cleaned and then slightly screwed down.
9. The blades are then to be restarted in the forward direction. The outside of the machine is to be wiped and the floor cleaned.
10. At least one hour must elapse after the loading of one machine and the loading with paste of the other machine in the same bay.
11. After running half an hour, the blades of the machine are to be run in the "reverse" for about ten minutes, then run in the forward direction.
12. After incorporation has proceeded for 2 hours, the machine is to be stopped, with both motor and gear switches in the "OFF" position and the mineral jelly added. The lid is to be cleaned, tightly screwed down and the blades restarted in the "forward" direction.
13. After incorporation has proceeded for 3 hours, the machine is to be stopped again with both motor and gear switches in the "OFF" position and soft waste is to be added, the amount depending on current instructions. The waste is to be emptied on to the table, the leather cover put on the machine and the waste loaded in to the machine. During loading the waste is to be examined carefully for foreign matter. When loading is completed the lid is to be replaced and the blades restarted in the forward direction.

14. The temperature of the machine is to be raised to 35°C and kept as near as possible to that temperature until the end of incorporation. The temperature should never exceed 40°C.
15. Incorporation is to be continued for at least 5 hours, if a machine is stopped for any reason it must be run for at least half an hour and the temperature raised to 35°C before being unloaded. The time of restarting a machine is to be noted on the blackboard.
16. Before unloading the machine, the blades are to be run in "reverse" for at least ten minutes. The machine is to be stopped with both motor and gear switches in "OFF" position.
17. The hopper is to be placed in position in front of the machine and a dough bag tied on. The machine is then raised to a convenient height and the lid removed. The machine may be further raised during the process of unloading as required.
18. The machine is then to be emptied into ten to twelve bags. All but the last two are to be filled by hand. The last two may be filled by the motion of the blades or by hand as required. Workers must wait till the blades stop before putting their hands into the machine.
19. No dough bag is to be used which has not previously been turned inside out.
20. Two workers are always to be present when the machine is unloaded.
21. When the machine is completely emptied the pit under the machine is to be cleaned from all spillage. The trough of the machine is then to be lowered on to the rubber stops.
22. If not required for immediate use, the top of the machine is to be wiped with a sponge cloth and the inside cleaned out. The lid is to be replaced and the floor swept.
23. The type of cordite, time of loading paste, time of addition of carbamite and time due off are to be recorded on the blackboard above machine. Any interruption in incorporation is to be noted on the blackboard.

USE LIST.

INCORPORATING HOUSES.

Tables, loading, aluminium covered .....	2
Boxes, leather, loading .....	2
Boxes, sweepings, .....	2
Buckets, cleaning .....	2
Buckets, fire (water) .....	6 (1 per bay)
Cans, spraying, leather covered .....	4
Covers, leather, loading .....	2
Cuffs, leather .....	2 pairs
Desk, wood ....	2
Flannels .....	6
Hoppers, leather, unloading .....	2
Indiarubber .....	2
Mops .....	2
Overboots .....	4 pairs
Pencil .....	2
Spatulas, wood .....	4
Whistle, (Roof spotters) .....	1
Stool, loading, wood .....	4

Articles only to be taken into the house for cleaning and lubricating purposes at the end of each week and to be removed before work is recommenced.

Brooms, hair .....	2
Covers, waterproof (or blankets) .....	4
Greasegun .....	1
Ladders .....	1

LIMITS

INCORPORATION HOUSES.

Total per house .....	7,000 lbs.
Per Bay	
(a) in machines .....	900 lbs.
(b) waste or rework .....	150 lbs.
(c) paste, at paste and picrite, in houses on flashless compositions ..	130 <sup>*</sup> lbs.
Workers .....	7 (3 per bay)
Truckers .....	2
C.I.A. Examiners .....	1
Greaser .....	1 (when loading is not in progress).

\* The total quantity of paste (or paste and picrite)  
in the house is not to exceed 650 lbs.

(Jan. 1945).

Summary of Relevant Evidence.

1. By Witnesses at the Court of Enquiry.

Samuel Hendry, Incorporator Chargeman.

The men who started shift with him that day were Horne, Mitchell, Fulton and Hill: all seemed to be in normal health. The work of the house proceeded normally until the first meal break except that there was a shortage of paste. Bay No. 1 was not in use, but the remaining 10 machines were all in action. At about 10.0 a.m., the four men went for their meal, leaving him in the house. While they were away incorporation was completed in machine 53 (Bay 3) and machine 57 (Bay 5) and he wound the machines up into the position for unloading. Horne returned at about 10.45 a.m., Hendry told him about the position of machines 53 and 57 and that mineral jelly was to be added to the other machines at 11.30 a.m. Hendry then left for his own meal and was in the canteen when the explosion occurred.

The other three men would return very soon after he left and would proceed to unload machines 53 and 57, more or less simultaneously, Hill and Fulton taking one machine and Horne and Mitchell the other. He would expect each pair to complete unloading in about 10 minutes, after which they would wind down the machine into the normal mixing position and, if paste were available, would immediately start to reload. He estimated that the men should have been ready to start loading between 11.05 a.m. and 11.10 a.m. When loading it was customary for each man to do the same operations: thus, in the case of Fulton and Hill, it would normally be Fulton who loaded the paste into the incorporators and Hill who handled the solvent can.

He had never observed any electrical sparking or flashing in the building.

He had never seen any foreign matter in paste. On one occasion a load of unsieved paste had arrived at incorporating house: this was the only unusual occurrence he could recall in his 4 years experience.

He was satisfied that all the men involved were good reliable workers.

In delivering paste to an incorporating house, the trucker would not put the bag down but would carry it in his arms until it was taken direct into the arms of the incorporator processman.

The loading tables were too heavy for one man to transport. They were of wood and the bottoms of the legs were felt covered. The felt had worn off one leg of a table in this house. Tables would not be dragged along the floor.

David Fisher, Dough Trucker.

At about 11.00 a.m., he left the canteen and proceeded to incorporating house 28/304E where he collected the dough unloaded from two machines (presumably 53 and 57) and took it to an adjacent press house. As he was leaving the incorporating house, he observed Assistant Foreman Whitson approaching. Horne had asked him to bring some empty bags; he was on his way back with them and had reached a point about 50 yards from the house when the explosion occurred. He estimated that the time since he had left the incorporating house with the dough would be less than 15 minutes.

When he was collecting the dough from Fulton at Bay 3 and Horne at Bay 5, he did not converse with them and did not know what work was going on in the house, as he was new to the job and had not been inside an incorporating house./

house. All 4 processmen were in the house at that time.

When he left with the dough the paste truck had not arrived.

James Horne, Incorporator Leading Hand.

Horne was interviewed in hospital, by the factory police, two days after the explosions and, by members of the Court of Enquiry, just over 2 weeks later.

He appeared to be suffering from the after effects of the explosion and, on neither occasion, was he able to give any useful information; actually he appeared to recollect even less on the second occasion than on the first.

Thomas Whitson, Acting Assistant Foreman.

Whitson was interviewed on the same two occasions as Horne but, contrary to the latter, was very specific in his statements on both occasions although they did not tally on one or two points.

He entered the house just before 11.00 a.m., (Note - originally he said 11.10 a.m., but the earlier time is obviously more consistent with the time of the explosion), that being his first visit to the house that day. His purpose was to adjust the clock and he gave no attention to what was going on in the house. He spoke casually to Fulton and Hill and implied that he also spoke to Horne and Mitchell (Note - originally he said he had not seen the latter two).

When he arrived at the house there was no paste truck outside. After he had completed his work on the clock, he left the house by the entrance between Bays 5 and 6 and at the entry met the paste trucker, Mullen, coming in with a bag of paste in his arms. He stopped and spoke to Mullen mentioning that there had been a shortage of paste supplied to which Mullen had replied that he was doing his best.

Whitson walked along outside the house and passed Mullen's truck standing outside the entrance between Bays 3 and 4. As he passed he counted the bags of paste remaining on the truck and found there were 8 instead of the normal load of 10, so that the bag he had seen Mullen carrying was the second. He assumed it was for Horne and Mitchell and that the first bag had gone to Fulton and Hill. He had only got about 30 yards beyond the truck when the explosion occurred.

It was pointed out to him that, even if taking a bag of paste to Bay 5, it would have been normal for Mullen to enter the house by the entry beside his truck (i.e. the entry between Bays 3 and 4). Whitson agreed but was definite that his statement as to the entrance actually used by Mullen was correct.

James Malcolm, Shift Foreman, Cordite.

He agreed that, if workers were in a hurry, they might be tempted to tip the full contents of a bag of paste into an incorporator at once instead of adding it gradually along with solvent in accordance with the rules. He was quite clear, however, that, in the conditions existing at the time, there was no need for hurry.

If there were waste available, it would be added at the beginning of incorporation in accordance with instructions.

The men involved were all reliable workers.

James/

James McDonald, Grow Chemist.

He gave a detailed description of the method of carrying out incorporation which was in accordance with the Special Rules and Operating Instructions (See Appendix IV) except that the waste was added at the beginning of incorporation instead of after 2 hours. Normally the charge of waste was 60 lb but, as they were short of waste, only 30 lb per incorporation was being added at that time. After starting the blades of the incorporator, a little solvent (about 3 or 4 lb) was added followed by the waste: loading was then completed in the normal manner. The normal time for 2 men to load a bag of paste into the incorporator was 5 minutes. The total weight of the material in an incorporation was about 450 lb, including the solvent, and this would normally be unloaded into 8 or 10 bags.

In the case of Cordito N the addition of the waste at the beginning of incorporation had materially reduced the time required for the paste to "dough up" in the incorporator. Permission had been requested for this procedure to be authorised for Cordito W.M. also and he had understood that the necessary approval had been secured.

About a fortnight before the explosion a blue flash was reported to have been seen in Bay 1 of this house. No work was proceeding at the time. No defect could be found which would explain the occurrence. Requirements permitted the bay to be put off production and it had not been operated again up to the time of the accident.

John Wolstenholme, Chemist-in-Charge.

He only knew of two unusual features in regard to this house which might be worth mentioning.

The first was that for a short period during 1944 this house had been used for the incorporation of an incendiary composition containing, in addition to gun-cotton and carbanite, dibutyl phthalate, sodium nitrate and aluminium. When the work was completed all the machines were thoroughly cleaned but not stripped.

The second point was the occurrence of blue flashes. These have been reported on a few occasions but the only such incident in house 28/304E was the one about 2 weeks previous to the explosion and referred to in the evidence of the previous witness. The incident occurred on a Sunday morning when the house was free of explosive and none of the machines was running. Three men came on duty to start loading and when one was lifting the lid of an empty machine a blue flash was seen. It was described as running from the top of the machine to the black-out screen in the roof which would make it 12 to 14 feet long. The following morning he interviewed all three men and their evidence was unsatisfactory. It was noted that a light bulb in the corridor had failed and he was of the opinion that the apparent flash had been caused by the sudden failure of the lamp.

In regard to the addition of waste at the beginning of incorporation, he said he had put forward a memo on the subject in January but unfortunately it appeared to have been mislaid.

The quality of the paste in use was normal.

There had been cases of bags being tipped straight into the machine. It was generally possible to tell from the condition of the bag afterwards. There was a possibility that a bag had been tipped on this occasion but he considered it a very small one. He did not know of any worker having been infringe<sup>d</sup> for this offence at Bishton.

In/

In regard to a suggestion that press house heels might be included in the waste, he said that by far the greatest part of the waste was odd lengths of cord. The normal method of dealing with heels was to remove any material containing grit or foreign matter with a knife and cut up the remainder for re-incorporation; the defective material cut off was burnt; occasionally the whole heel was burnt.

He knew of a case of a solvent can being dropped into an incorporator; the workers promptly stopped the machine and, although the can was considerably deformed, nothing more serious resulted.

If there were waste available he would expect it to be used.

Albert Edge, Assistant Managing Engineer, Cordite.

The incorporators are all earthed, the earth being a copper plate buried in the soil and to which the machine and the load apron on which it stands are separately connected. The earthing is checked over before restarting after a prolonged stoppage. When this house was to be reopened it was found that there was a leakage at machine 54, the other machine in the same bay as the one in which the explosion occurred. The bay was, therefore, put out of commission till the defect, which was found to be due to faulty lead burning, had been rectified. Thereafter, no further trouble was experienced up to the time of the explosion.

Morris Arnold, Assistant Managing Engineer, Electrical.

When the blue flash was reported to have occurred in incorporating house 28/304E in April, he had a thorough electrical examination of the house carried out and found everything in order. In the course of the examination, the electrician reported that two of the lights in the corridor outside the bay had burnt out. The bulbs were examined and it was found that one of them had short circuited internally when burning; this would undoubtedly cause a flash and was a possible explanation of the effect reported by the workers as a blue flash from the incorporator. The last previous report of a blue flash was in November, 1943, and, on this occasion also, it was found that a light bulb had short circuited internally when burning out. There had been blue flashes reported on 4 previous occasions but attention had not then been directed to the possibility of a bulb short circuiting internally when burning out and it was not possible to say whether this explanation applied to all or any of these previous cases. These earlier flashes had occurred during the hours of daylight and it had been suggested that a possible cause in these cases was the reflection from metal surfaces of the sunlight coming through crevices in the verandah roof. In all cases tests were made for static but in no case was any found.

2. From the Medical Officer's Report.

The factory medical officer made a careful examination of the bodies and remains which were recovered and the relevant portions of his report are given in the following paragraphs. The letters used to designate the different items correspond to those marked in red on Plan No. 2.

Body A.

Intact except for the face region. Body and limbs severely charred and numerous lacerations. The large toe of the right foot had at some time been amputated and the second toe was deformed.

Note -- The defects of the right foot identified this as the body of Donald Mitchell).

Body B./



Body B.

Face destroyed: small stump of left arm attached to body but right arm missing; thoracic and abdominal wall destroyed; right thigh showed gross injuries and left thigh missing. (Note - The hair, which was not destroyed, was dark brown and reference to the record of the physical characteristics of the workers, recorded at the time of engagement, showed that this could only be the body of Thomas Mullen).

Body C.

No head identifiable; thoracic and abdominal wall destroyed except lowermost part of latter; both arms missing but left shoulder joint present.

(Note - No personal feature was present which gave any clue to the identity of this body.)

Remains D.D.

In the main these were small portions which could not be identified as belonging to any one of the three bodies referred to in the preceding paragraphs. There were, however, two right shoulder blades. One of these was found to fit Body B. The other was compared with the left shoulder blade of Body C and was found to be definitely dissimilar; it, therefore, is a part of the fourth body.

The Medical Officer says in his report:-

"among the remains examined were numerous portions of chest wall. The ribs in the three bodies originally examined were more or less intact except on the right side of body No.3." (Note - 3 = C.).

"I am again of the opinion that these portions of chest wall must have belonged to a fourth body."

APPENDIX VI.

Blue Flashes in Incorporating Houses.

Copy of Letter from H.M. Senior Electrical Inspector of Factories to  
H.M. Inspector of Explosives.

FACTORY DEPARTMENT.

MINISTRY OF LABOUR AND NATIONAL SERVICE.

Gov. Acc. 29/1945.

Exp. 43.

Electrical Branch,  
Grosvenor Gardens House,  
Grosvenor Gardens,  
LONDON, S.W.1.

10th July, 1945.

Dear Watts,

Bishopton R.O.F. - Blue Flashes

On the 23rd May you sent me a note of an accident which occurred in the cordite incorporating house 28/304.C5, at Bishopton. Four workpeople were killed and three injured, and during your enquiry witnesses referred to flashes.

This is not the only R.O.F. where either blue or green flashes have been observed and a good deal of time was expended in investigating the same phenomenon at Ruddington in 1943. Fordham Cooper could draw only negative conclusions, but I believe the flashes were fairly common, because I once met a lady Welfare Supervisor who had worked at Ruddington and who spoke of these green flashes as an almost everyday occurrence.

I wrote a rather carefully concocted letter to Jones after receiving yours of the 23rd May, because I wanted him to get away from the accepted lines of investigation and approach the problem de novo with a clear eye. In my letter I suggested that some importance might attach to the fact that both at Ruddington and Bishopton, lamp failures were reported. I suggested that he should try in some way to relate these to the green and blue flashes, because in at least two other rather inexplicable explosions, we have found that lamp failures immediately beforehand did point to a state of affairs which might lead us step by step to the right solution. A case in point was the British Oxygen acetylene explosion near Newcastle.

Jones pursued this suggestion, and has submitted a very simple explanation of the blue and green flashes, based on the fact that the lamps are installed in a hollophane bulkhead type fitting in such a manner (see diagram (a)) that should the filament fail, it will collapse on the supporting wires, causing a flash of considerable brilliancy, sometimes persisting for a few seconds. At Bishopton, the incorporator house is a long building which due to the flat concrete roof and the earth filled traverses at the entrances, is rather dark. If to this fact we add the natural sensitiveness of workpeople in an explosives factory, we get factors which would lead to the more importance being attached to a lamp failure than would normally be the case.

Jones says that as late as 10th April, 1945, a blue flash was reported in the same incorporator house where the explosion occurred on the 20th April. Immediate inspection of the nearest light in the corridor, clean and dirty ways, revealed the fact that it had failed. Jones inspected this bulb and found that most of the filament had burned away, one or two small pieces remaining free inside. There was severe concentrated blackening at two spots opposite the

ends of the two filament supporting stems. This blackening was not like the ordinary blackening due to age, which is more uniformly spread, and moreover there was a heavy bead of fused material on the end of each leading-in stem which shows that comparatively severe arcing had occurred. The normal stem length in this size of bulb is  $1\frac{1}{2}$ " and in the bulb that Jones examined the stem had been burned down to 1".

It may seem a little extraordinary to you to think that arcing of sufficient severity to burn away a quarter of an inch of a lamp bulb leading-in stem could persist, but the fact remains that it obviously did, and does, and also without blowing even a 5 ampere fuse. This is because the bit of filament which has collapsed across the leading-in wire does not create a dead short-circuit, but acts as a limiting resistance, passing, however, very much more than its rated current. It will in fact become its own circuit fuse, and volatilises after reaching extreme brilliancy, which at the moment of finality would probably represent an output in lumens many times that of the original candle-power of the lamp.

We have had something like this where little  $2\frac{1}{2}$ v. lamps are used by surgeons for lighting nose and throat operations. They have found that by over-running them to the verge of failure the amount of light emitted increases enormously, which is, of course, a fact. They omitted, however, to appreciate that just before the point of failure of the filament, the little glass bulbs reached a temperature sufficient to ignite ether/oxygen mixtures.

We are not suggesting ignition in the Bishopton case, but merely that the mounting of the lamps in a vertical plane does lead to a very brilliant flash when collapse of the filament occurs, either due to old age, vibration or any other natural cause. I think the flash would really be more white than either blue or green, but electric flashes are usually considered to be blue, and this might be the pre-conceived notion in the minds of those who suddenly become aware of a flash only in time to realise that it has gone.

We next come to recommendations, which can be very simply expressed by suggesting that the lamp should be mounted the other way up, as in diagram (b)

Yours sincerely,

(Sgd.) H. W. Swann.

(a)



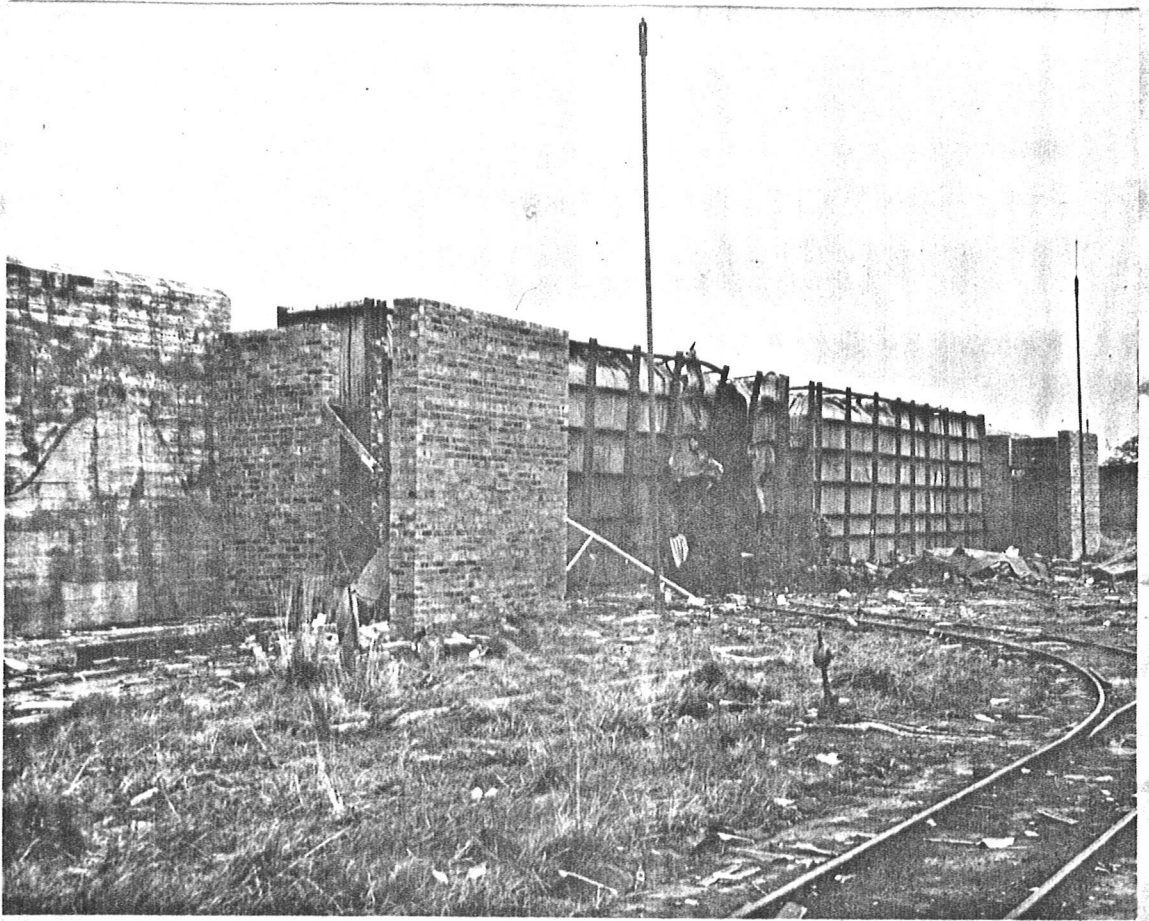
Filament above  
supporting stems.

(b)



Filament  
suspended.

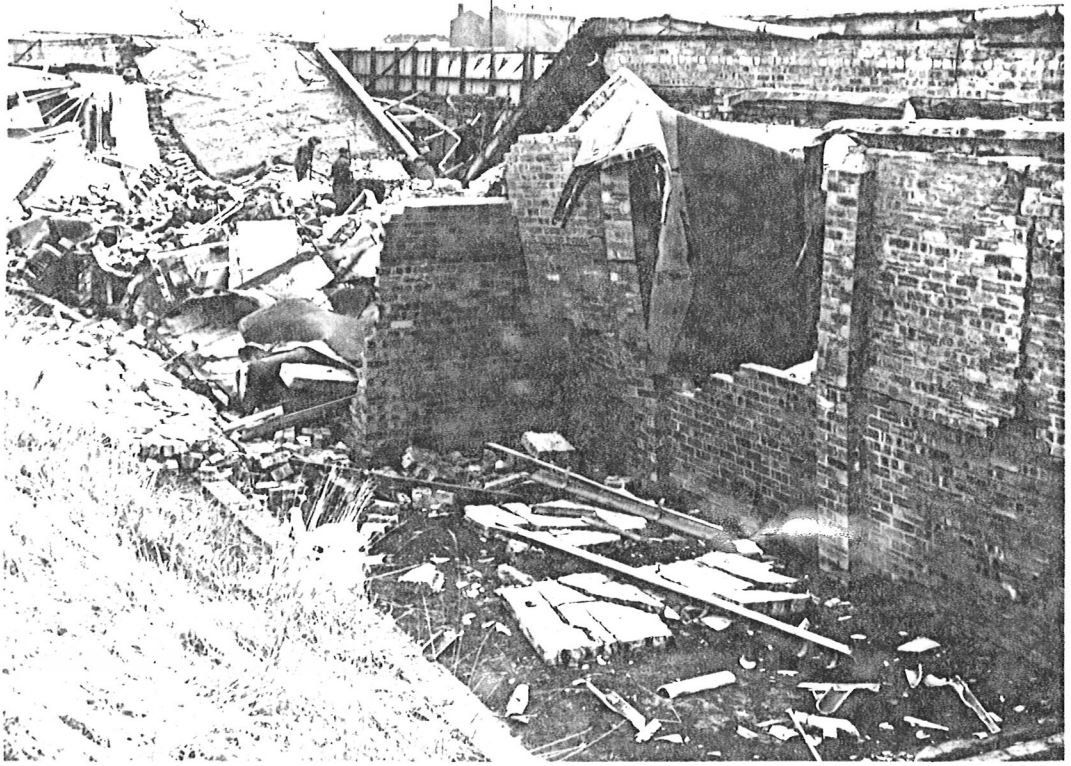
H. E. Watts, Esq.,  
Explosives Dept.  
Windyridge,  
21 Harryat Road,  
Wimbledon, S.W.19.



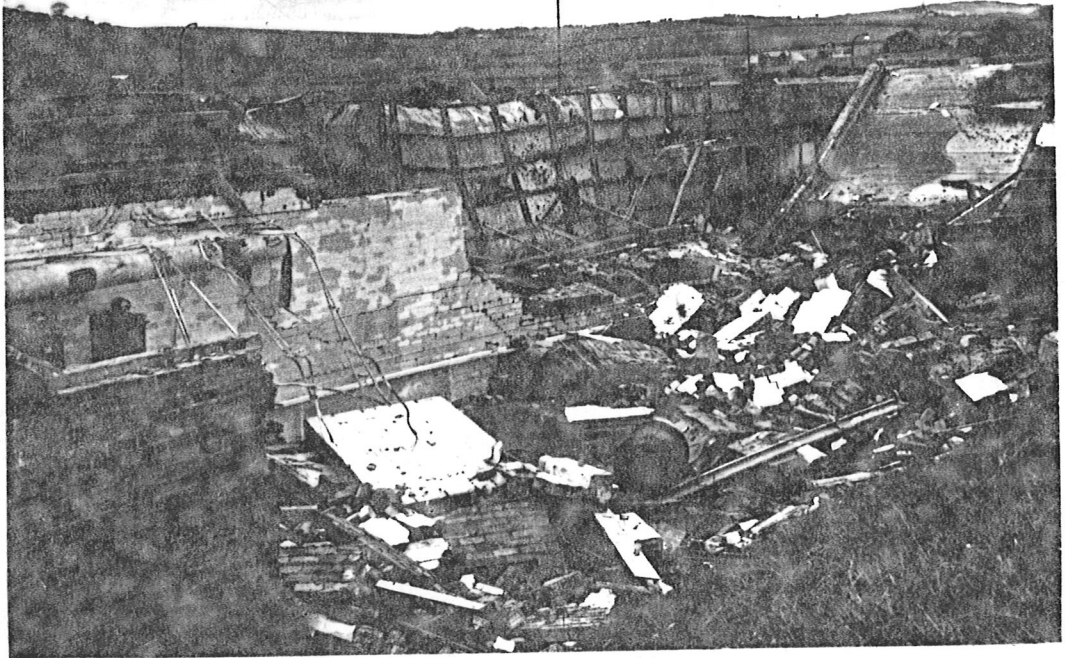
Traverses outside front of house showing  
damage due to explosion of trucks of paste.



View showing roof collapsed on floor of  
bay 3.

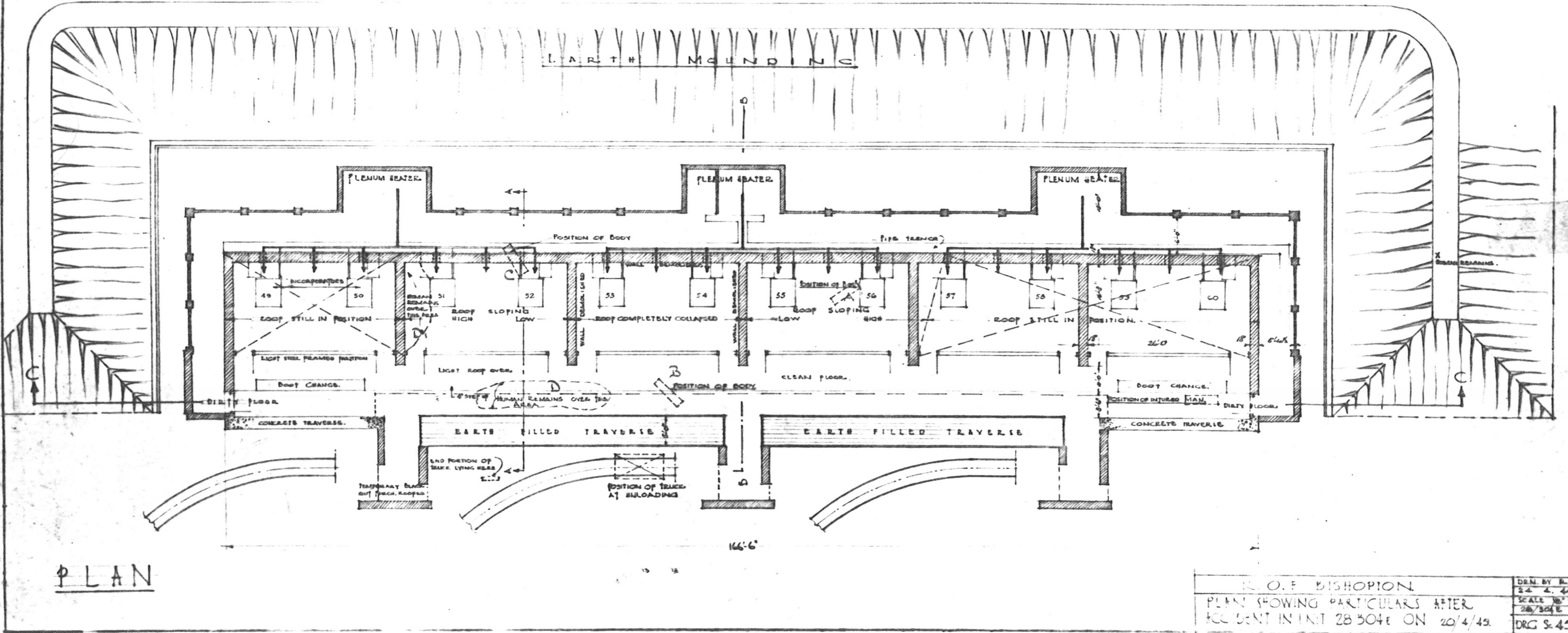


VIEW FROM BACK OF HOUSE LOOKING N. W.



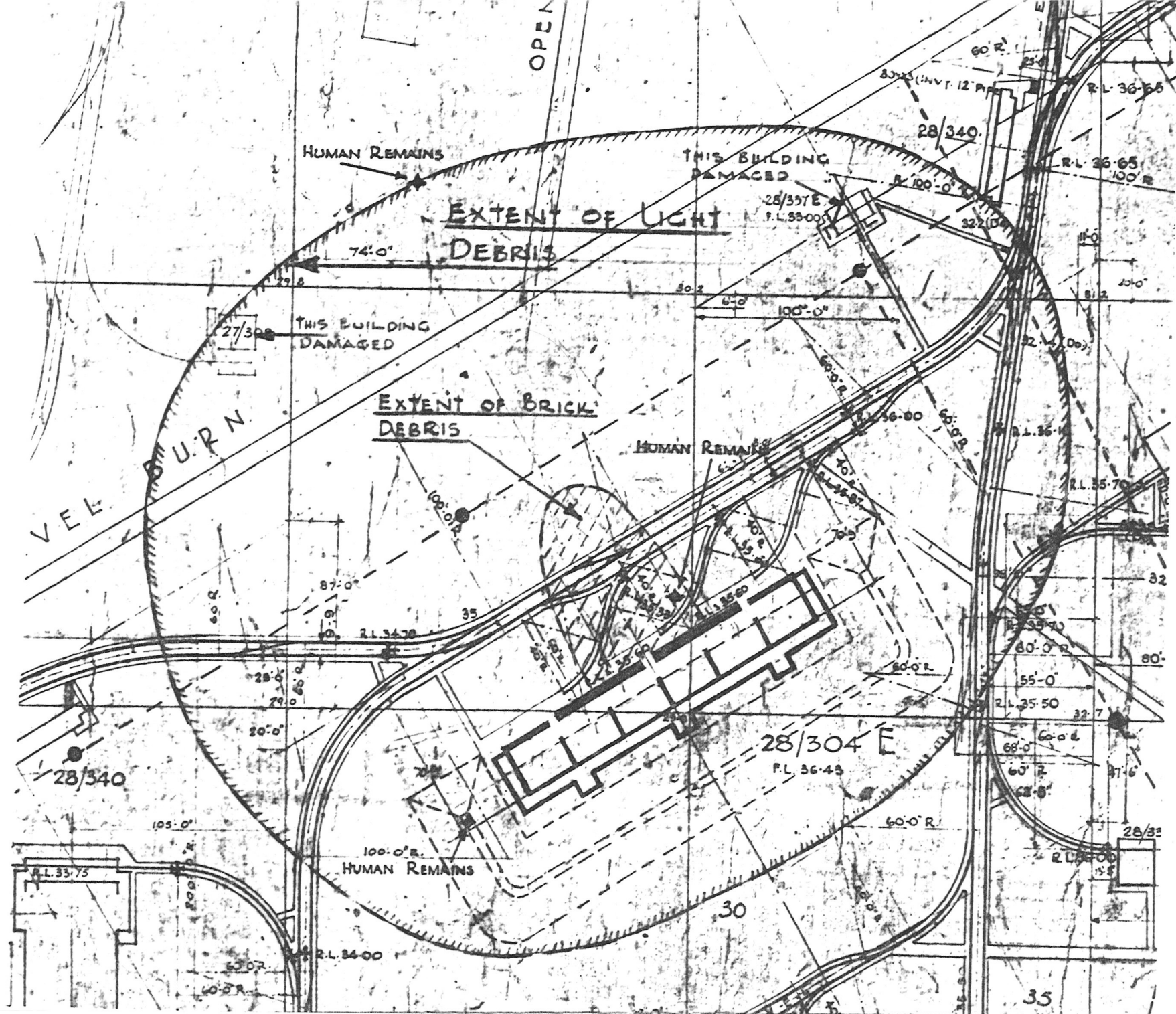
VIEW FROM BACK OF HOUSE LOOKING S.

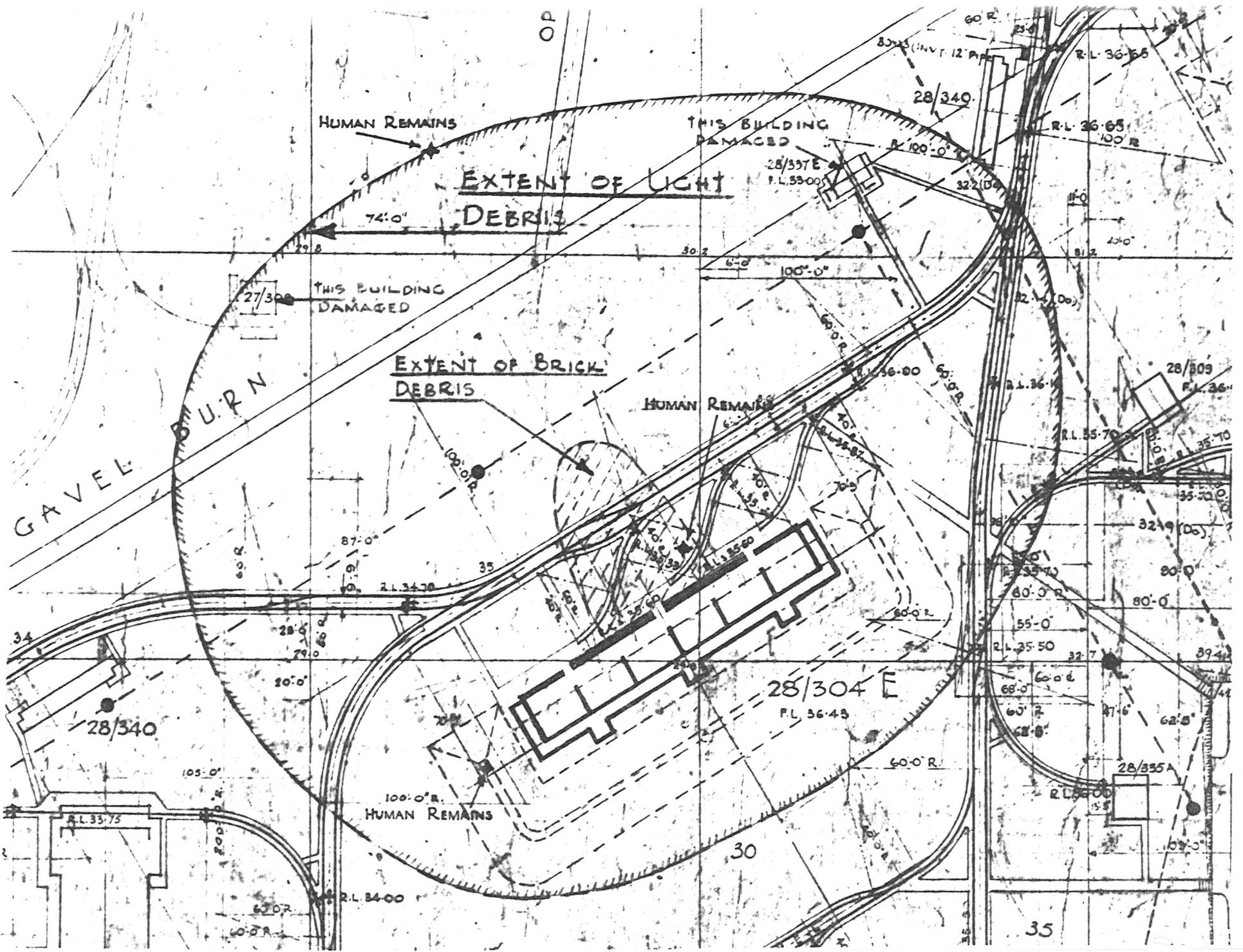
SECTION C.C.



PLAN

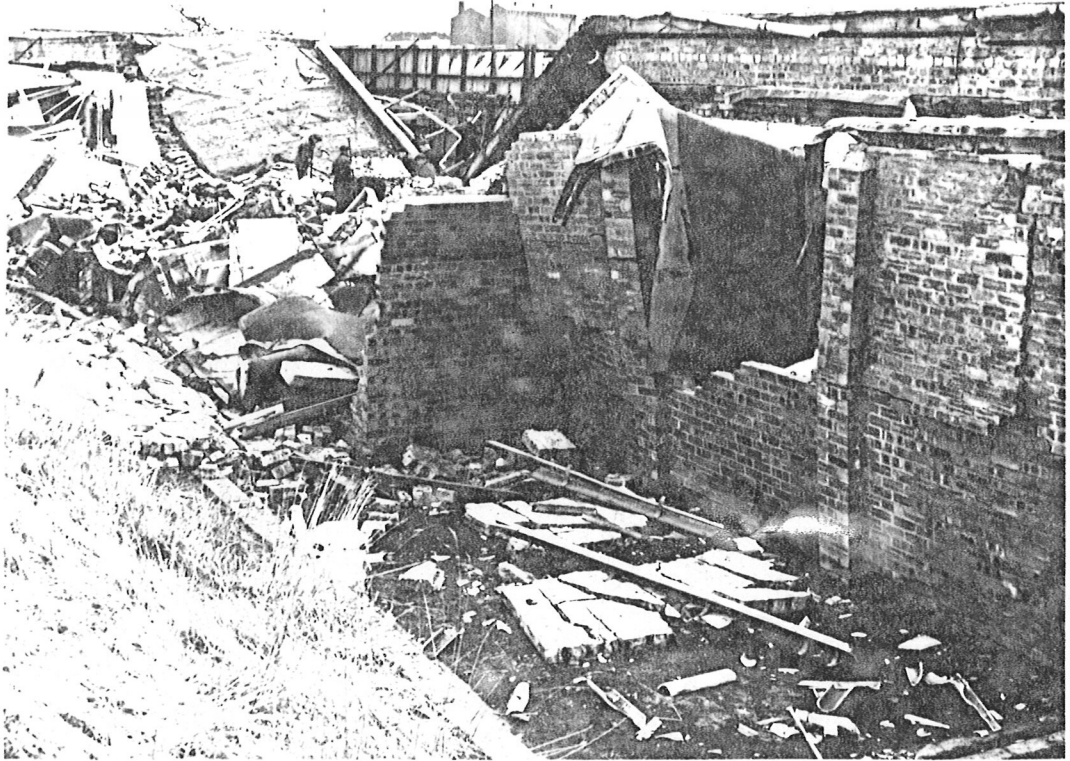
H.O.F. BISHOPTON		DRN BY B.S.
PLAN SHOWING PARTICULARS AFTER		24-4-45
ACCIDENT IN UNIT 28 304E ON 20/4/45.		SCALE 1/8" = 1'-0"
		28/304E
		DRG S-452











VIEW FROM BACK OF HOUSE LOOKING N. W.



View showing roof collapsed on floor of  
bay 3.  
VIEW FROM BACK OF HOUSE LOOKING S.