WASC 2253

List of
TNA Supps
Documents with
Comment
relevant to
South Site

Waltham Abbey Royal Gunpowder Factory, South Site (relevant Supp 5 documents):

G403	Steam boiler house (1905): 865
G431	Pulping & Moulding (dipping) room of the Gun Cotton Factory (1888): 865
M351	Drying Stove of the Gun Cotton Factory (1892): 369
M349	Cordite box & tray Store (1892): ?842
486	Store or Mixing House of the Nitroglycerine Factory on Quinton Hill (1894): 710
SS113	WW2 Gas Shelter/Passive Air Defence (1940s): 984

RDX explosive: 1129, 1130, 1132, 1134, 1153
Cordite Mark I propellant (1890-1900) - how was it made, what happened in the buildings?: 368, 369, 710, 803, 842, 843, 844, 845, 862
Project 3 (propellant)
Ballistic assessment (firing and missile behaviour): ?782, ?803, ?843

List of Supply 5 documents that have been accessed: (highlighted documents to go back to?)

327 1893-1898 Cordite accidents - of no use.
328 c1903-1911 Cordite accidents - of no use.
368 1889-1892 Cordite manufacture - notes taken.
369 1892-1894 Cordite manufacture - useful, notes taken by MAC, more taken.
456 1930-1936 TNT - new method of purification (report W.500/6) - of no use.
597 1881 Stores - barrels, bags, etc. - notes taken by SC.
601 1892-1895 Stores - cotton waste - notes taken by SC.
697 1898-1921 Factory notices and awards - of no use.
710 1902-1914 Annual reports on gunpowder, cordite, nitroglycerine, etc - notes taken.
720 1945 Correspondence and history - photo copied.
749 1843-1940 "Explosions and fires at Waltham Abbey" - of no use.
782 1871-1874 Guncotton - of no use.
803 1894 Cordite Mark I: "Explosives and their modern development" - notes taken
841 c1890-1891 Nitroglycerine and cordite branch - personnel and pay - of no use.
842 c1893-1906 "Experiments - cordite" - take notes?
843 1893-1894 "Analysis - cordite" (including ballistics) - take notes?
844 c1896-1920 Cordite "Experiments etc No. 1" - take notes?
845 1896-1898 Cordite manufacture - "Standard lots and batches" - notes taken.
860 1861-1904 Photo album Vol 1 of explosions and the plant.
861 1903-1938 Photo album of explosions Vol 2, the plant and women war workers.
862 1905-1931 Photo album of experiments and explosions Vol 3.
863 1940-1941 Photo album of damage done by enemy action.
864 1940 Photo album of explosions.
865 nd. Index of photos Vols 1-3 - copied.
984 1937-1938 Principles and practice of passive air defence for explosives factories: reports S - SS113, notes taken.
1129 1942 RDX Bridgewater - notes taken from technical report.
1130 1943 RDX Bridgewater - notes taken from technical report.
1132 1943 RDX Bridgewater - notes taken from technical report.
1134 1943 RDX Bridgewater - notes taken from technical report.
1153 1942 RDX Bridgewater - notes taken from technical report.
1215 1944 Drying granulated tetryl in a quinan stove (report W16) - notes taken by SC.

<u>List of possible documents to access:</u>

77 1866 Woolwich gun factory notes on processes carried out.
153 1903-1904 Woolwich removal of guncotton drying houses to Waltham Abbey.
188-210 1787-1841 Waltham Abbey: In letters (210 Gunpowder manufactory).
211-255 1787-1868 Waltham Abbey: Out letters (244 Inspector of gunpowder).
256-293 1840-1856 Waltham Abbey: Original correspondence - letters.
309 1906-1909 Waltham Abbey: Correspondence - houses and land.
370-381 1894-1903 Cordite manufacture.
382-383 1894-1900 Cordite machinery.
384 1890-1894 Cordite materials - stores, etc.
386-387 1890-1900 Cordite cases.
406-408 1891-1903 Cordite general.
411 1891-1892 Cordite machinery.
451 1943 Brief history of factory.
460-465 1876-1903 Guncotton.
477 c1900-1909 Files - machinery and plant - managers papers.
480 1889-1891 Misc. general.
487 1889-1902 Nitroglycerine - misc. stores.
490 1895-1896 Nitroglycerine - machinery.
491 1892-1902 Nitroglycerine - general.
602 1900 Files - stores - miscellaneous.
618-619 1889, 1892-1895 Superintendent's correspondence misc.
637-638 1889-1890, 1894-1898 Proceedings of the committee to consider questions relating to nitro-glycerine plant and cordite manufacture.
770 1862 "Velocities of rifle bullets" by Rev. Samuel Haughton MA FRS.
797 1888 "Handbook of gunpowder and guncotton" by Maj. General Waldell.
798 1888 "A dictionary of explosives" by Maj. J.P. Cundill.
839 1910 Ballistics tables.
858 nd. Diagrams of gunpowder manufacture.
975 1886 Plan of factory.
983 1923 Plan of factory.
997 1888 Explosives: "Testing and proving of gunpowder gun cotton" - war office booklet describing methods and specifications.
1003 1944 Chemical defence factories: History of factory and plant construction by Imperial Chemical Industries on behalf of Ministry of Supply and Ministry of Aircraft Production: Randle, Springields, Valley and Forward Filling Depots.
1012 1945 Chemical defence factories: D x G Dept.: History of propellant production, 1939-1945.
1022 1872 Woolwich: Papers relating to govt. manufacturing establishments at Woolwich, Enfield and Waltham Abbey.
1050 1915 Notes on design and construction of ordnance factories.
1061 1913-1920 Research Dept. Woolwich: Report No. 23 Proposed stabilisers for propellant powders; Report No. 39 Principles of internal ballistics.
1063 nd. Research Dept. Woolwich: Report No. 36 Shrinkage of cordite during drying.
1064 1919-1922 Research Dept. Woolwich: Report No. 38 Calculation of internal ballistics and its application to gun design; 1907-1919 Report No. 42 Climatic trials of service propellants.
1065 1922-1926 Research Dept. Woolwich: Report No. 63 Description and discussion of air disturbance around bullets in free flight.

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1061 1913-1920 Research Dept. Woolwich: Report No. 23 Proposed stabilisers for propellant powders; Report No. 39 Principles of internal ballistics.
1063 nd. Research Dept. Woolwich: Report No. 36 Shrinkage of cordite during drying.
1064 1919-1922 Research Dept. Woolwich: Report No. 38 Calculation of internal ballistics and its application to gun design; 1907-1919 Report No. 42 Climatic trials of service propellants.
1065 1922-1926 Research Dept. Woolwich: Report No. 63 Description and discussion of air disturbance around bullets in free flight.

1131 1941 ROF Bridgewater: RDX diluter at spent acid strengths Report G.52.
1144 1956 ROF Bridgewater: RDX nitration Report G.240.
1199 1918 Manufacture of TNT.
1201 1918 Manufacture of ordinance ballistite.

Non essential research:

855 1936 Use of Non Actinic Glass in Cordite Buildings.
857 nd. Tracings, photostats, etc. of misc. maps of Waltham Abbey 1713-1904.
874 c1868-1896 Record book of encroachments and copies of relative authorities in respect of land at Woolwich, Birmingham, Purflee, Shoeburyness, and Waltham Abbey.
996 1872-1906 Charcoal, guncotton and nitroglycerine experiments: Reports, correspondence and other papers
998 1889 New method of moulding and pressing gun cotton: Illustrated booklet of the new Explosives Co. Ltd.
1060 1908-1913 Research Dept. Woolwich: Report No. 1 Deterioration of cordite.

Photocopy charges:

	A4	**A3**	**A2**
monochrome	not done	40p	62p
colour	£2.10	£4.20	£19.80
bromide	£7.50	£9.70	£12.90

Supp 5 327

This document is of little use. It is about cordite explosions that occurred from 30.3.94-31.8.98. It consists of accident reports that provide the following topics of information:

1. Date of accident.
2. Time of accident.
3. Nature of accident.
4. Cause of accident.
5. Person in charge at the time.
6. Repairs to be made.
7. People injured.

The document also contains actual artefacts thought to be involved in the accident eg. a marble, a nail.

Supp 5 328

Also of little use. It contains the following items:

1. Contents page listing cordite accidents that have occurred around the turn of the century.
2. Individual reports on each of these accidents.
3. Annual Report on Accidents (information on salaries, etc).
4. Notification of fire inspections.
5. Instructions for what to do in the event of a fire.

Supp 5 368

A useful document containing information and correspondence (many letters and memos that are quite difficult to read as the ink has faded) regarding cordite manufacture. Contains:

1. Pamphlet "Nobel's dynamite and blasting gelatine" 8 pages with ink drawings of things being blown up - photocopy?

2. Pamphlet "Settle's Patent Gelatine -Water-Cartridge for safety-blasting in coal, &c." 20 pages with lithograph reproductions showing sections of cartridges - photocopy?

3. A paper entitled 'Outline of the process of manufacturing 'cordite' at Waltham Abbey' (1890/1892?): "It is assumed that the nitro-glycerine is made and stored in the tank in the nitro-glycerine store, that the dry guncotton pulp is stored in the dry guncotton store and that the acetone and tannin are available in their store, which would also contain a supply of empty 'subcharge' vessels.

"The process of making cordite will then be briefly as follows:-

"1. Preparation of nitro-glycerine subcharge. The proportion of tannin (1.3 lbs) for a subcharge is first placed in the subcharge vessel, and then the measured proportion of acetone (2.6 lbs) is run in. These, and subsequent proportions, are those for a 13 lb incorporation machine, making No: 92 Cordite. The tannin dissolves readily in the acetone, and the vessels, carefully covered over, to prevent the escape of the very volatile solvent, are conveyed at once in light covered trucks, to the nitro-glycerine store. Here a charge of nitro-glycerine (7.15 lbs) is run into the tannin solution, from a suitable measuring reservoir in immediate connection with the main tank. The nitro-glycerine subcharge is now complete, and is taken at once carefully covered over to the incorporation house, in covered trucks which act as small expense stores.

"2. Preparation of the guncotton subcharge. The guncotton subcharge (4.55 lbs) is weighed out in suitable hoppers as constructed that when placed on the incorporating Machine, they cover one half of the open top of the latter. The guncotton subcharges are taken direct to the incorporation house, in trucks similar to those used for the nitro-glycerine subcharges.

"3. Incorporating. A hopper, containing a guncotton subcharge is placed on the incorporation machine, and the machine set in motion. The nitro-glycerine subcharge is slowly run in from its vessel on to the knives of the incorporating machine, and the guncotton hopper started. Care is taken to begin with the nitro-glycerine subcharge to avoid friction between the dry knives and the dry guncotton pulp. The charging of the incorporation is so regulated, that the two subcharges are expended simultaneously. As soon as the incorporator is charged, the hopper and vessel are removed at once, and sent to their respective stores, and the machine immediately hermetically closed. Incorporation is complete in 6 hours.

"4. Removal and disposal of incorporated charge. When the incorporating is completed, the machine is stopped, the cover removed, and the charge taken out at once by hand, and transferred to earthenware guncotton pots. This is done as quickly as possible to prevent the charge drying. In these pots, which are provided with closely fitting covers, it is sent to the pressing house.

"5. Pressing. In the pressing house, the material is fed into a pug mill which delivers it into the press cylinders. When charged these cylinders are fixed in position in the pressing machine, which squirts the material into cord of the required thickness. From the commencement of the incorporating until the material comes from the pressing machine as cord, every possible care is taken to prevent its exposure to the air.

"6. Cutting Cannon Cordite. The thicker natures of cord, used for cannon cartridges, is, as it leaves the pressing machine, delivered into an endless band provided with knives. The distance between the knives is regulated so as to cut the cord into lengths suitable for the particular cartridge for which it is intended. The pieces of cord as they are cut are removed from the band by hand, and collected in shallow trays.

"7. Reeling Cordite for Small Arm Cartridges. The fine cordite for small arm cartridges is wound, as it leaves the press, on large drums, having circumferential partitions, so that the number of turns in each partition when cut right through forms one long bundle giving the requisite number of pieces for cutting up into charges.

"8. Drying. Both the trays containing the large cannon cartridge Cordite, and the bundles of fine small arm cartridge cordite, are removed to the drying house, which must be well ventilated and gradually dried at a temperature not exceeding 80° Fah.

"9. Packing. When the solvent has all been driven off, the finished cordite is packed into suitable wooden cases for transport to Woolwich."

4. Queries, memos, supply requests and suggestions for manufacturing. Examples include:

i. A list of materials required for the manufacture of Cordite Mark I for the 4"7? gun consists of: Dry Guncotton 340 lbs, Blasting Gelatine 400 lbs, Acetone 22 falls/galls?, Vaseline 55 lbs, to produce about 1050 lbs of cordite per week (according to Capt. Nathan in a letter to the Supt. R.G.P.F. Waltham Abbey, 19.8.1890.

ii. Specifications for a box to hold 100 lbs of cordite (drawn up by Capt. Nathan, 18.8.1890): "Sides, ends and bottom made of yellow deal, top of Teak with Beech Clamps, and hard wood cleats for rope handles; top secured with eight brass screws and nuts, and strip of fearnought on lid to make close joint, painted inside with black, and outside with red [crossed out and replaced by stone? colour] shellac paint". Dimensions: (length/width/depth in feet and inches) interior = 2.3, 1.2 1/2, 7 1/2, exterior = 2.7, 1.5, 10 1/4.

iii. Cordite store - what they already contain and what they need to order - outlined in a letter from the Director General of Ordinance Factories at Woolwich to the Superintendent R.G.P.F. Waltham Abbey, dated 10.7.1891. It states that cordite manufacture has already begun at WA and outlines what the Supt must do to keep up his large, regular output. The letter also lists the equipment at WA including 2 big presses and 2 small ones, with 2 more small ones being ordered and plans to make another big one and 3 or 4 small ones on site. The Director mentions that WA already has plenty of incorporators and a supply of reels for first winding. He urges the Supt. to work the presses day and night to keep up with the demand and to keep the incorporators charged so that they are ready with incorporated material as it is required by the presses. Finally, the Director requests that records of the details of manufacture must be maintained.

iv. Sketch on a memo of cordite lots.

v. Requests to test buildings to see what would happen if an accident occurred.
5. Certificates of trade proficiency;.

Supp 5 369

A document containing information on cordite manufacture from June 1892-April 1894. Consists of a large folder of handwritten memos that are often difficult to read as the writing has faded. Topics mentioned include reporting of sweating cordite, requests for experiments to be performed on cordite (such as firing and proofing), chemists results (figures tablified under the following headings: lot no., maker, size, length, weight, loss at 150° F, % NG and jelly, % GC, % Nitrogen, heat test, remarks), notice of visits/inspections to be made, supply requests, notices of climatic trials for the manufacture of cordite, notice of rejection of lots (for reasons such as low velocity and pressure, high pressure), condemned cordite (notice that it must be destroyed, but not told how). There is little, if any, detailed information contained in these memos. The documents contained in 369 provided a little extra information:

1. Description of box pattern for storing guncotton (page bookmarked, copied out in full as follows:) - 'Box A made to pattern except that a recess is made at each end for lifting off the lid. Box B in this box the ledges are put inside the lids instead of outside. This secures the lid without the brass pins. The cords could be added if you think them necessary. Estimated cost as under Box A £18.8.10 per 100 Box B £16.11.1 per 100 WRB' W.R.B. Feb? 1892. Cordite boxes are stencilled and labelled (including lot number). All old labels should be pulled off rather than superimposing new ones over the top. Brown shellac varnish was used to attach the labels, but a paste and glue mixture was found to be better, the label coated with white hard varnish afterwards (noted in a memorandum from the Director General of Ordinance Factories at Woolwich to Supt. R.G.P.F. Waltham Abbey, 19.2.1892).

2. Letter from D.G.O.F to Supt. W.A. asking production capabilities of cordite in small and large presses (dated 3 March 1892) - page bookmarked - notes that 8 small presses are at work at WA including the old Woolwich horizontal press. This can produce about 1250 lbs of 5/11 cordite per week in the small presses, and one of the large presses can supply 2500 lbs of 5/11 or 3300 lbs of 20/14 or 6300 lbs of 30/14 per week. This is equivalent approx. to an output (5 days/50 weeks) per year of: small arm cordite 55 tons, 5/11 cordite small press 28 tons/1 large press 56 tons, 20/14 cordite 1 large press 74 tons, 30/14 cordite 1 large press 140 tons. Total with existing plant 353 tons. Following table also in letter:

Cordite out-turn						
description	presses		daily	weekly	yearly	remarks
	no.	at work	3 shifts	5 days	50 weeks	
SA 0.0375	8	6	600	3000	10000	
0.05-5	1	1	115	575	?28700	large press with ? ?
0.05-5	1	1	600	3000	150000	}only
0.075-7.5	1	1	600	3000	150000	}the
0.10-10	1	1	600	3000	150000	}large
0.20-20	1	1	650	3250	?152000	}press
0.20-20	1	1	1140	5700	285000 (2 ?dies)	}available
0.30-30	1	1	1250	6250	312000	}as
0.40-40	1	1	1250	6250	312000	}?
0.45-45	1	1	1250	6250	312000	}therefore
0.50-50	1	1	1250	6250	312000	}??????????

(document difficult to read).

2b. Memo 23.3.92 noting that there is great variation between different reels of the same batch - described as an unsatisfactory irregularity.

3. Item No. 91 Notice (extract bookmarked, entire document typed out as follows:)

'Guncotton Drying Stove

'1. This stove is not to be heated above 100° F.

'2. All operations, movements of Trays etc must be carried out with the greatest care, and each tray when being moved should be lifted clear from place to place and must not be allowed to slide on the racks, or elsewhere.

'3. The floor and woodwork must be frequently swept, and kept as free from Guncotton dust as possible.

'4. India rubber shoes must always be worn inside the barrier.

'5. The door and landing outside the Barrier must be frequently mopped with a damp cloth and on no account is any Guncotton pulp or dust to be left about.

'By order Sc J.W.J. Barker Lt. Col. R.A. for Supt.'

3b. 'Instructions for blending cordite sizes 20 & 30 - length 14". 1. The cases to be blended should be arranged in a convenient manner for blending. 2. Each man blending must take a small portion from each case, that is to be blended (taking the cases in rotation) and place it in a case (previously weighed). This operation is to be repeated until the case is filled. 3. When finally blending from blends into lots one case of each blend is to be blended together in the same manner.' 'Instructions for blending cordite size 5 - length 11". 1. as above. 2. Each man...[as above except]...place it in one partition of a case. This is to be repeated until the partition is filled, when another partition can be commenced and the operation continued till the case is filled. 3. as above plus: a small portion is to be taken from the four partitions of the case of each blend and placed in trays for bundling. The bundles must be tied up nearby and the ends of the strands kept even. Each bundle is to weigh about 2.5 lbs. Sc J.W.J. Barker Lt. Col. R.A. for Supt. R.G.P.F.'). 1892.

4. Extract p. 108, 761 20 August 1892 'The composition of cordite are as follows:

Cordite Mark I	Blank
Nitro Glycerine 58%	61.053%
Guncotton 37%	38.947%
Mineral Jelly 5%	Nil

S.A. Cordite differs from the other sizes in being made with mineral jelly of a lighter colour and of a purer quality. Its chemical composition is practically identical with that of the larger sizes. Director.'

5. Belgian smokeless powder: 2.5g, small cubes of powder, 1.5mm^2. Black, smelling strongly of Ethyl Acetate. Microscopic examination shows that they are made for dough rolled out and cut. Moisture (loss over Sulphuric Acid) 0.89%, NG 29.70%, Charcoal (black) 9.48%, Soluble in water 1.82%, Nitro Cotton (soluble nitrocellulose containing about 10% insoluble) 58.11% (analysis by ?W. Kellnes, Chemist, 21.6.1893).

6. Cordite and ballistics: GC as made at WA gives an almost constant per cent of 12.8 to 12.85 of nitrogen, 'so that as far as the GC is concerned there should be no variation in the ballistics of the cordite into which it is made here. It is possible that a GC containing a higher percentage of nitrogen could be made here on a manufacturing scale , but to do so would undoubtedly increase the cost and would also probably necessitate variations in our present process of alterations to our plant which would take time and experience to elaborate. Would not the point raised by Dr Dupre be met by inserting a high as well as a low limit for the percentage of nitrogen in the specification.' W. Anderson D.G.O.F, 6.11.1893.

7. Letter (E. Bainbridge Col Supt RL to D.G.O.F., 14.2.1894) suggesting how to minimise the effect of a fire in the cordite filling houses where the reels are exposed, by making 3 screens of wood covered in asbestos cloth, to prevent the spread of fire from one reel to another. A request was made to try their efficiency (and that of the improved protective clothing). Results of the subsequent experiment showed that unprotected reels posed more of a danger.

Supp 5 597

1. Bookmarked - Patent for Haermetic Gunpowder barrel design and drawing from E. Kraftmeier & Co., United Rheinish Westphalian Gunpowder Mills, Cologne, 16 March 1881.
2. Cases specially for Prismatic Powders.
3. Prismatic Powder for Ajax Agammemnon and Sattelite c1882.

Supp 5 601

Cotton Waste suppliers: Adams & Co. Manchester, excellent quality, lack of oily matter and very absorbent.

Supp 5 697

Of little use, containing notices of royal birthdays, public holidays, etc and lists of awards given to employees for their suggestions regarding the running of the factory.

Supp 5 710

Contains annual reports with separate folders on Gunpowder section (1903-08), Machinery Section (1903-1910), Acetone Recovery (1903-1910), Nitroglycerine factory (1902-1910), Cordite Section 1903-1910 and 1904-1905 to 1913-1914.

NG 1902-10

QH 1 April 1902-31 March 1903: No accidents occurred during this period. Skimmers abolished from washing tanks because they were a possible cause for explosion at Nobels' factory. Air pipes were fixed in the wash tanks for the same reason. Thermometer supports were fitted in the wash tanks. Measuring vessels (burettes) for weighing out NG which are safer, quicker and more accurate have replaced scales jugs and weights. Brass lined boxes and barrels replaced by India rubber covered canvas bags. Preparations for earthing of plant being made. From 1903, hand mixing of all material preparatory to incorporating to be reverted to as it is safer. Mixing houses are lined with zinc to reduce projections for GC to settle on, and to allow for washing down of the house. The lead covered mixing tables with fixed lead sieves are ?burned to the floors. The ventilating windows are swung on brass pivots, the ?bearing surfaces of which run under vaseline. No tools of any description whatever are allowed in the house, the only moveable articles other than the soft rubber bags, being soft flannels. The men wear socks only, on their feet and are being supplied with flannels, shirts and clothes, without buttons. The GC is brought to the mixing house already weighed out in soft rubber bags. The NG is measured out in the burette and poured direct into the bags. The NG and GC are then emptied into the trough of the mixing table where they are roughly mixed before being rubbed through the half inch mesh lead sieve which is solidly burned into one end of the table. After passing the sieve the paste is collected in the bags again and is ready to be tied up and sent away to the incorporating house. In case any electricity should be generated at any stage of the mixing the whole of the plant is in metallic contact with the lead floor and this, in turn, is earthed in the usual manner. The old wooden GC storing racks with moveable gauze trays have been replaced, in stove nos 16-18 by new racks with straight brass wires two inches apart running across the shelves. There are no moveable parts in the new racks and all metal parts are connected to earth through the lead flooring. These points render the new racks very much safer than the old ones, and besides this the GC is dried much quicker as the old gauze trays had a blanketing effect on the air currents in the stove. Nitrating house almost complete. No. of charges nitrated for Mark I - 191, for Cordite MD - 246; NG made with cordite - 73 tons, NG made with MD - 96 tons; total NG m/factured - 170 tons; yield on glycerine nitrated - 218.28%.

QH 1 April 1903-31 March 1904: QH NG factory closed Aug 27 1903 because enough could be produced at Edmondsey. Improvements include: 1. New nitrating apparatus (nitrating and separating in the same vessel obviating the passage of NG through cocks of any description and allowing of the removal of the NG as it separates, used for the first time 5 May 1903). 2. New method of breaking NG waste acids (by adding from 1.5-2% of water to the waste acids produced, so as to prevent the separation of NG form waste acid after the separation proper has been completed). 3. Filtration of the charge after pre-washing (by passing the charge through a muslin or flannel filter immediately after it had been pre-washed). 4. Extended use of labyrinth (in the nitrating house through which wash waters from the prewashing tank were passed in order to reduce the amount of NG sent to the wash water settling house). 5. The replacement of lead lined wooden tanks by tanks entirely made of lead (in the nitrating and mixing houses to avoid wood saturated with unpurified NG and copper tacks falling loose). 6. The use of a weaker and colder soda solution and softened water in the washing house (preparing soda solution so it can be added to NG without dilution and therefore avoiding NG temperature getting above 37°C and the formation of lime scale). Refrigerator in use from 19 May - 27 August 1903 and enabled the nitration of the double charges to be carried out without undue loss of lime.

QH 1 April 1904 - 31 March 1905: No improvements this year as Edmondsea is being converted to a NG plant and QH is in temporary use in the meantime. 1. The original nitrator-separator of no. 2 Nitrating House still in use. 2. After separating plant not used for waste acids. 3. Four washings increased to five (as fourth still had impurities). 4. Hydrometer used to weigh dry GC instead of phosphor bronze scales which is no good in a house where much dry guncotton dust is always present. 5. Refrigerator still in use.

QH 1907-8: Remodeling on the lines of Edmondsey. No. 3 Nitrating house, the ?A/S house, charge house and ?mead washing house were pulled down and the materials used to build a new and larger charge house, capable of housing all acid soda and purified water tanks. No. 2 nitrating house was dismantled, the floor has been relaid and strengthened, and a commencement made with the replacing of the remodeled plant.

QH 1908-9: New office and lab built. Water tower into disuse.

QH 1909-10: Work has again been started in the nitrating house, both nitrators and a pre-wash being already built and set in position. A commencement has also been made with the fitting up of air and steam services. No. 1 mixing tank was repaired early in the year, and a new cover of heavier material fitted. A tower has been erected for the condensation of fumes from the mixing operations. An iron cock has been ?tried for mixed acid and has been in use for six months.

<u>Cordite m/facture 1903-10, 1904-5 to 1913-14</u>

Very detailed and long reports, hand writing quite difficult to read. It is not always clear if they are for QH or another plant. Folder 2 (1904-5 to 1913-14 contains duplicates of folder one 1903-10, many in pencil note form and impossible to read). Topics include: mineral jelly, acetone, paste (all technical details), incorporation, pressing, drying, cutting, blending (very detailed on every occurrence during the year), building inspection, experiments.

1903-4: QH? Output restricted due to insufficient machinery, particularly drying accommodation for larger sizes of MD. 3 new high pressure hydraulic presses obtained. New large incorporating machines have worked satisfactorily. 12 new drying stoves have been completed. No 2 blending house and magazine ?up. works no longer in use. A box house of lower stores taken into use.

1904-5: Stoving: the method of taking cordite form stores during 3 shifts has been discontinued the work being done my a day work gang. Packing as a distinct operation has to a large extent been done away with . Packing and blending in one operation is now carried out in Blending Houses. Boxes have been introduced for collecting strands of 20-10/7 and 11/15 in lotting resulting in a saving of 5% of the time for this operation. All of the new buildings with the exception of 3 magazines have been taken into use. The old packing house has been converted into a testing room and office and taken into use. The loading stages of cordite and ?lauding stage for boxes, both in black ditch were taken in use but owing to a subsidence of the banks, work has been discontinued.

1905-6: All packing and blending of small sizes of cordite and 20/sc done at QH.

1906-7: Experimental cordite MD and MkI has been made with GC made with cotton received form the Cellulose Pulp Co. and from cotton rag received from the New Explosive Co. and has been issued for Proof at Woolwich. ?Dowe has also been made from ?Ramie fibre. There has been no alteration or improvements in the methods of stoving , packing, blending, and ?lotting cordite during the year.

1907-8: QH. Again, no alteration or improvements. Reel stove and no. 3 stove have been converted to acetone stores. Estimates for a cordite factory for the Australian Govt. have been made.

1908-9: QH. No alteration in methods. Heavy rains caused landslides in the cuttings and round magazines.

1909-10: No improvements or alterations. Lightning conductors being adjusted.

1910-11: Tarring of the walls inside the houses to keep out damp carried out. Suggestion to coat outside wood platforms to prevent people slipping.

1911-12: Deal sided cordite trays deteriorate too rapidly thus they were replaced by oak sides and ended trays.

1912-13: Manufacture of Chilworth Smokeless Blank and C.M.J. carried out.

1913-14: M/facture of Nitrocellulose Smokeless Blank and C.M.J.

Acetone recovery 1903-10

1903-4: Acetone recovery plant at no. 4 tray stove. Only new feature introduced in connection with the recovery has been the trial of a modified Rayleigh Still for the secondary distillation of the acetone, with favourable results. Total cordite Mk I dried - 681 lbs.

1904-5: No alteration in methods. Redistillation report: no manufacture of acetone from acetate of lime has taken place during year. Picrate of Ammonia manufactured during this time. During the year, acetone has been recovered from 18 stovings of cordite. Solvent for stencilling cordite boxes changed from turpentine (which can cause fire) to a solvent made of higher boiling ketones and acetone condensation products (which are acetone m/facture by-products).

1905-6: The re-erection, in connection with no. 1 and 2 reel stoves (Great Hoppit), of the small acetone recovery plant removed from no. 4 and 5 tray stoves (QH) was completed in the beginning of June 1905 and on June 5th the recovery from No. 2 reel stove was started. At first the yield of acetone was small, owing mainly to the loss of vapour through the roof of the stove which was not gas tight. To reduce the loss, the roofs were lines with canvas and painted. This increased yield, though the unsuitable plan of the stoves still means recovery is not as high as possible. This is also due to the fact that much of the acetone used in the manufacture of the smaller sizes of cordite is lost before reaching the stoves. The general system of recovery proved satisfactory and no alterations were mede int he methods employed. No acetone made from acetate of lime.

1906-7: Difficult to read. Concerned with Cob Mead.

1907-8: Plant altered considerably during the year resulting in increased yield of acetone and less loss of material. Alterations include: intermediate pullys fitted to vapour pumps, sealing rings fitted to small flash traps, solution pumps replaced by eggs (??), delivery pipes altered from secondary pump to large tank inside building, caustic soda tanks fixed over primary distillate tanks, main with ?cracks fitted form still watchers to primary tanks (??), water supply to ? and tanks altered so as to do away with hose and flexible ?cruppings, fittings provided and connections made to ?vers for blowing acetone vapour from drums after emptying, trough with cooling pipe fitted to residual banks, the air compressor from Hoppit plant has been removed and fixed in pump room, the removal of sulphur burner to verandah so as to do away with cocks and the frequent repair of piping, is in hand.

1908-9: The set of vapour pumps to which has been fitted intermediate gearing have been worked almost continuously since the alteration was made in May 1907. They are now in a bad state of repair and the values in particular require immediate attention. This is in hand. The sulphur burners were removed to verandah early in the year and have worked very satisfactorily since. A single lead coil for boiling the solution in primary stills was fitted in May and proved to be more suitable than any system tried previously, all three stills have now been fitted in this way. The rubber slip joints have been replaced on towers by earthenware cocks. The solution pumps and rotary pump with gearing and motor have been removed from the west end of the building and replaced by eggs.

Foundations and platforms have been erected to receive the refinning still and condensors brought from Woolwich. The automatic centrifugal water pump has not yet been made satisfactory and is still in hands of contractor.

1909-10: c163 tons acetone recovered over the year (up on last year). The second set of vapour pumps have been altered to work at a slower speed and can now be used alternately with the set previously altered. The ?Rif [paper ripped] still recovered from Woolwich last uear has been erected and is ready for work when required. The automatic centrifugal pump has been completed but beyond trial runs has not been used. The glass covers on top of towers have been removed from one set and replaced with wooden covers.

Supp 5 720

Of little use. Small file concerning correspondence and history, was closed until 1972. Contains 3 letters from 1945, to W.H. Simmons from C.J. Haslar, requesting information on the commencement of cordite manufacture at the Waltham Abbey factory where Mr Haslar worked. Also contains a photo: "Pioneer of cordite manufacture at Waltham Abbey 1891" (picture of factory workers including Mr Haslar, a 'wee boy' of 16 in a 'red serge suit next to the old boy with his watch chain exposed to view' - doesn't say right or left, but looks like boy on the left is younger).

A4 colour photocopy ordered of photograph, cost £2.10.

Supp 5 749

Of little use. Large book containing press cuttings of accidents from 1843-1940: "Explosions and fires at Waltham Abbey". None of the accidents are in the relevant buildings and the clippings focus on compensation given to widows and medals for bravery.

Supp 5 782

Of little use. Smallish book on guncotton from the period of 1871-1874: "Report of the select committee on guncotton etc".

Contents: 1. Report on manufacture, storage and use of guncotton including an addenda of experiments and plans, 2. Evidence (court transcripts) from people who have worked with guncotton, 3. Court transcripts relating to the explosion at Stowmarket (11.8.1871).

This document also contains a description of an experiment at Woolwich to ascertain the behaviour of various explosive substances when subjected to the shock caused by the impact of a bullet fired from a rifled small-arm.

Supp 5 803

Useful little book on cordite Mark I: "Explosives and their modern development" V.B. Lewes, 1894. **Photocopies taken pp. 12-28, 9pp x 40p = £3.60.**

Contains 4 lectures:

1. "Explosives and explosions" - gunpowder - history - methods rendered necessary by the growth and changes in the character of the guns employed - modern powers and the methods by which the desired results are obtained pp. 1-11.
2. "Gun cotton" - The improvements which have taken place in its manufacture since its discovery by Schönbein - *English service gun-cotton and its manufacture* (partic. pp. 12-16) - nitroglycerine - dynamite pp. 11-19.
3. "Smokeless powders" - the early attempts to utilise gun-cotton, and the causes of their failure - *the smokeless powders of today* (includes notes on how cordite is made pp. 25, 27-8 with tables including ballistics, and a paragraph on gun cotton at Waltham Abbey) pp. 19-28.
4. "Blasting explosives" - requirements -fiery mines- a good safety explosive as great a safeguard as the safety-lamp - explosives employed - the safety explosives now in use - Roburite, etc. pp. 28-37.

Supp 5 841

Of no use - largish, loose-leafed folder - "Cordite (wages)", c1890-1891, about workers, their pay and transferals (at the WA gunpowder factory, nitroglycerine and cordite branch).

Supp 5 842

Useful large folder on "Experiments - cordite", c1893-1906. Consists of handwritten notes on experiments - very technical.

Trays:

ordinary trays)
↓)moisture -
large wooden trays)increase
↓)
sheet brass trays)

Details on the *manufacture* of cordite made with amyl-acetate around 1897 (1 page).

Also contains: cordite registers (with info. on size, nature, batch no., length, diameter, weight, volume, heat, percentage, remarks), notes on modified cordite, foreign material in cordite, guncotton registers, moisture experiments, cordite gravity, samples of cordite made from G/C pulp moulded and not PM, cordite constituent experiments, cordite drying experiments, die experiments, the analysis of cordite from Waltham Abbey, cordite exposed in oven, climatic and keeping trials, flash point experiments, cotton waste, cordite measurements and calculations, ballistics, weighing experiments, acetone experiments.

Supp 5 843

Useful, largish folder similar to Supp 5 842 in its handwritten technicality, "Analysis - cordite - ", 1893-1898, 1894-1895.

Contains info. on cordite constituents, tables (lot no., batch no., size, heat tests, charge, paste, nitric acid for nitroglycerine, signature of worker), results of analyses (constituent percentages), analysis of rifle cordite, *ballistics* of rifle cordite.

Supp 5 844

Useful, handwritten, technical experiments regarding cordite: "Experiments etc No. 1", c1896-1920.

Contents: manufacture of "5/11" cordite, tables of measurements, sleeping experiment, reworking experiment (effect of ballistics), mixtures and ballistics tables (size, lot no, gun fired in, est. wt/100", ?VM^V(%), velocity, pressure) and drying experiments, weights and diameters, reports on mineral jelly, nitroglycerine purification experiments and effects on stability of size of 3 3/4 cordite, drying equipment - trays and stoves, acetone vapour inflammability experiments, loading up stoves and locality trials, dipping process of painting gun cotton and cordite case, cordite keeping trials, particulars of manufacture of standard cordite (including stoving - no date), experiments ?with hydraulic press, heat tests, memos, ballistic reports, Lydditye Shell experiments.

Supp 5 845

Useful, largish, unbound book of technical, hand-written notes entitled: "Statistics lots and batches", 1896-1898.

Contents:

1. Memo to guide the preparation of a standard lot of 30/14 (1 page with topics including: selection and drying of gun cotton, selection of nitroglycerine, incorporation, pressing).

2a. Standard lot of cordite size 30/14 analysis of ingredients and materials.

2b. **Drying of gun cotton for standard 30/14** Drying: The G/C dried in no. 1 and 3 G/C stoves at a mean temp. at windows of no. 1 - 90.02°F, No. 3 - 87.9°F the actual time taken to dry it being 146.5 and 136 respectively. Acetone: 9 drums of W.A. acetone Cru 45 and 46 were blended thoroughly together into a tank and weighed into bottles for use in incorporating house. Mineral jelly: 6 barrels of mineral jelly - Stem Bers. Cru 30 were blended together and heated sufficiently to run through a metal funnel with a fine copper gauze soldered over hole in the funnel with the object of removing any foreign matter that might be in the mineral jelly. The jelly was then weighed into dishes and allowed to cool before use in incorporating house. Incorporation: The paste was incorporated in no. 2 incorporating house in the 150 machines, each N/G charge being kept separate, with the acetone of mineral jelly described above. After 7 hours incorporation, the cordite was taken direct from machines to no. 2 press house in closed brass-lined boxes. Pressing: The cordite was pressed in no. 3 large press-8" cylinder. The die used having 3 holes, the parallel part of which was .306" diameter and 1.5" long. The die was gauged every 8 hours with plug gauges. After the whole of the cordite was pressed the die was found to have worn about .0005 of an inch. 3 strands taken from cutting band at the beginning, middle and end of each pressing were weighed. The 3 weightings were given consecutive nos and recorded in books [text very difficult to decipher]. The 14 lengths from each pressing were packed in a separate tray and [unreadable]...the cordite from each charge of N/G being kept separate. The weight of the 3 strands when pressed varied fro 681 grains to 757 the mean weight being 719.729 grains. The material was sent to no. 3 tray stove as soon as pressed in closed trucks. Stoving: The pressed material was dried on the trays in no. 3 tray stove for 1 week, at a mean temp. of 98°F and removed to blending house for blending. The 10" lengths being sent to the sorting house (?) for weighing. Weighing: The 10" weighed lengths from each pressing were again weighed after drying and weights recorded in the books under the corresponding weights when pressed. The dry weights varied from 571-649 the mean weight of the 3 strands being 610.0375 grains. Blending: All trays whose corresponding 10" lengths weighed less than 590 and more than 640 grains were picked out and blended together for preliminary rounds for proof purposes, the cases in which they were packed being stenciled in red paint and marked 'preliminary' but having the same lot no. as the standard ? 245. All trays whose corresponding 10" lengths weighed not less than 590 and not more than 640 grains were first blended together from material made from each N/G charge and then the material from the different charges also thoroughly blended together into cases and stenciled in black marked 'standard' and lot no 245. The pressing ? 3 shifts will take a fortnight. Drying: Drying to be done in stoves 4 and 5 and to proceed continuously so that all may be in the ?store for the same length of time. This will necessitate withdrawing on Saturday and Sunday (?). Blending: Each charge of N/G will give about 12 cases of 100 lb each. These 12 cases to be first blended into 22 ?fluids of 12 cases each, then one case to be taken from each of the 22 ?fluids and the ?fluids blended up in this way until the lot is complete [very difficult to read].

3. **Drying of gun cotton for standard 4.5/11**: drying G/C same method. Nitroglycerine charge used (but not in above). All other stages - same method as above.

4. **Drying of gun cotton for standard 10/14, 15/14, 10/14 batch 8, 7.5/11 batch 2, 15/14 batch 11, 20/14, 40/25 lot 294, 50/16 lot 308, 20/14 lot 313, 20/17 lot 389, 20/17 lot 389, 30/24 lot 444, 30/24 lot 445, 30/24 lot 448, 30/24 lot 453, 50/17 lot 654, 30/24 lot 460**: Same method as 3 above plus some sizes have an analysis of ingredients and materials. STEVE - these are all on drying G/C too and follow the same method, they just have different figures in the standard pre-printed text because they are different sizes, lots and/or batches - I just confused you (because I was confused myself) by originally describing them as if they were different reports/formats than 2/2b/3 above. Sorry!

5. Report on the manufacture of standard batches sizes 7.5/11, 10/14, 15/14: Same method as 3 above plus analysis of ingredients and materials for each size.

Supp 5 860

Excellent for photos of explosions around the 1890's including photos of a steam boiler and a pulping and moulding room. **No. 40-2 photocopied @ £6.30.**

Supp 5 861

Photo album of explosions Vol 2, the plant and women war workers, 1903-1938. **No. 247-8 & 253 photocopied @ £6.30.**

Supp 5 862

Photo album including marked pages of cordite explosions, cordite analysis apparatus, plant models and mark of ignition.

Supp 5 863

Photos 1940-1941 (closed until 1992). Only 1/8 of the book filled. Includes cordite tray store after damage by enemy action in 1940 (negs 304-301) and the new nitroglycerine factory viewed from the tower, 26.8.1941 (negs 340-42).

Supp 5 864

2 small folders with **photos**:

1. Explosion at Edmondsey 18.1.1940 including mixing houses and GC stoves (small photos).
2. WA explosion of 19 & 20 January 1940 including mixing house and stove (large B&W photos - much better for reproduction).

Supp 5 865 (Index to photos)

Photo No.	**Album No.**	**Description**	**Year**
223	2	Acetone refinery - retort	1904
224	2	Acet. ref. - condenser & watcher	1904
270	2	Acet. bisulphite stills	
272	2	Acet. recovery plant	
346, 347	2	Air raid shelters	1918
148, 150-1, 153	1	Boilers - range of mG/C boiler house	1904
149, 152	1	Boiler house G/C exterior	1904
210	2	Beater blade sharpener - Williamsons patent	1904
230	2	Boiler house G/C - Hotchkins circulators	1906
M.1-4	3	Bomb, Calorimetric, and gas measuring app: at main lab	1905
		Cordite and composition exploding	
49	1	No. 2 large screw press	1891
81	1	Large vertical screw press, No. 2 press house: G.H.	1893
79, 80	1	Manlets around hydraulic press, No. 2 press house: G.H.	1898
131-138	1	Cordite blank cutting house explosion	1902
139-147	1	Cordite incorp. house	1902

		group G explosion	
213-4	2	Hydraulic press lift with cylinder - group H	1904
215-6	2	Group H front & back view	1904
217	2	Group E showing traverse	1904
218	2	Group H landing stage	1904
219-22	2	Erection of stoves Cob Mead	1904
238-43	2	Hydraulic press plunger head & gauge explosion	1907
260	2	Incorporating machines	
261	2	Hydraulic press	
264	2	Small (rifle) presses	
265-9, 271	2	Hydraulic press group H explosion	
284-5	2	Drum winding & reeling machines	
294-5	2	C.E. stove - fire at	1916
296-302	2	C.E. plant	
303-4	2	C.E. purification house - fire at	1917
305-8	2	C.E. nitrating house - fire at	1916
309-10	2	Cordite hydraulic press ignition, No. 2 press house	1916
332-4	2	Cordite tray stoves 25 & 32 - fire at	1912
337-9	2	C.E. purification house (Acetone) - fire	1918
340	2	Cordite tray stove boat (R.D.B.) fire	1918
343-4	2	Cordite MD. ignition at JW5 press house	1918
348	2	Cordite hydraulic press at JW5 press house	1918
345	2	C.E. purification house (N.A. process)	1918
349	2	C.E. water purif house	1919
350-1	2	C.E. sieving house	1919
352-3	2	Cordite coming house	1919
244	2	Dining room near main office - (demolished)	1908
126	1	Drilling machine - guncotton	1902
284-5	2	Drum winding	

		machines, cordite	
355	2	Densimeter for CSRD - made at R.G.P.F.	1928
			Explosions and fires
1-3	1	Gunpowder - No. 10 mill (LI)	1861
4-5	1	Gunpowder - No. 6 mill Millhead	1877
6	1	Gunpowder - group A mills	1861
18-9	1	Guncotton - G/C factory; water oven	1884
20-31	1	Guncotton - No. 1 breaking Dn. house	1890
332-6	1	Guncotton - group C mills	1890
37-9	1	Guncotton - group G mills	1892
40-2	1	Guncotton - G/C stove, Qn. Hill	1893
43-7	1	Gunpowder - Cam house, L. Island	1893
51-2	1	Guncotton - G/C dipping house	1894
53, 60-1	1	Nitroglycerine - settling pond Qn. Hill	1894
62-74	1	Nitroglycerine - washing house & store Qn. Hill	1894
75-8	1	Gunpowder - group C mills	1895
82-4	1	Gunpowder - group B mills	1895
107-8	1	Gunpowder - group B mills	1897
111-8	1	Picric powder - No. 5 mill	1897
119-20	1	Gunpowder - group B mills	1898
122-5	1	Gunpowder - group B mills	1899
127-30	1	Guncotton - G/C press house	1900
131-8	1	Cordite - blank cutting house	1902
139-47	1	Cordite - incorp house group G	1902
238-43	2	Cordite - hydraulic press group H plunger head, gauze, etc	1907

265-9, 271	2	Cordite - hydraulic press group H	
286-7	2	Guncotton yarn - fire at No. 25 G/C stove	1916
288-91	2	Cordite M.O.T. 20-10 No. 5 press house	1916
292	2	Guncotton, 9-oz primer in G/C press	1916
293	2	Nitroglycerine pond after explosion	1916
294-5	2	C.E. stove - fire	1916
303-4	2	C.E. purification house	1917
305-8	2	C.E. nitrating house	1916
309-10	2	Cordite MD 37 - No. 2 press house	1916
332-4	2	Cordite tray stoves 25 & 32	1917
335-6	2	Guncotton yarn waterproofing house	1917
337-9	2	C.E. purification house (acetone) - fire	1918
340	3	Cordite tray stove boat (RDB) - fire	1918
343-4	3	Cordite M.D. ignition - No. 5 press house	1918
M43-8	3	Magazines at Research Dept. Woolwich	1907
M80-1	3	Fishing - pike choked while swallowing 8” roach	---
			Gunpowder and guncotton
1	1	No. 10 mill, Lower Island - explosion	1861
2	1	No. 10 mill, Lower Island - explosion	1861
3	1	No. 10 mill, Lower Island - explosion	1861
4	1	No. 6 mill, Millhead - explosion	1877
5	1	No. 6 mill, Millhead - explosion	1877
6	1	Group A mills - explosion	1861
11	1	No. 3 stove	1879
12	1	No. 3 steam stove	1879
13	1	No. 2 grand magazine	1888
14	1	No. 4 dusting house	1879
15	1	Mill head stream	1878
16	1	Cylinder house cut	1878

17	1	Group E mills	1879
18-9	1	Guncotton water oven - explosion	1884
20-31	1	No. 1 breaking down house - explosion	1890
32-6	1	Group C incorp. mills - explosion	1890
37-9	1	Group G incorp. mills - explosion	1892
40-2	1	Guncotton stove No. 1 - explosion	1893
43-7	1	Cam house explosion	1893
48	1	No. 1 cam machine	1893
51-2	1	Guncotton dripping room - explosion	1894
75-8	1	Group C incorp mills - explosion	1895
82-4	1	Group B incorp mills (LI) - explosion	1895
59	1	Guncotton factory from Qn. Hill	1896
98, 109-10	1	Guncotton - broken wheel of compound engine and showing guard attached	1897
99, 105-6	1	Gunpowder buildings conversion to cordite: removal of mill runners	1898
107-8	1	Group B mills - explosion	1897
111-18	1	No. 5 mill (picric powder) - explosion	1897
119-20	1	Group B mills - explosion	1898
122-5	1	Group B mills - explosion	1899
126	1	Guncotton drilling machine	1902
127-30	1	Guncotton - explosion in hydraulic press	1900
231-2	2	Guncotton displacement apparatus	1906
254	2	Guncotton displacement apparatus	1909
255	2	Guncotton nitrating house (Abel Process)	
253	2	Guncotton - cotton waste drying oven	
252	2	Gunpowder - incorporating mill	

256	2	Guncotton vat house	
257	2	Gungotton mixed acid tanks	
258	2	Guncotton acid cooling and heating coils	
259	2	Guncotton beaters & potchers	
262	2	Guncotton hydraulic press	
263	2	Guncotton moulding machine	
275	2	Guncotton press	
277	2	Guncotton moulding machines	
282	2	Guncotton press No. 2 - broken columns	1915
335-6	2	Guncotton yarn waterproofing house - fire	1917
354	2	Guncotton pulping machine for India	1921
230	2	Hotchkiss circulators in G/C boiler house	1906
211-2	2	Kessler apparatus - Edmondsey	1903
			Miscellaneous
7-10	1	Sydney Herbert Memorial, Pall Mall	---
104	1	Sandhurst hospital	1895
15	1	Mill Head Stream	1878
16	1	Clylinder house cut	1878
252	2	Mill - gunpowder	
279-81	2	Main office & lab, photo house & fume cupboard	1912
283	2	Long walk from main labs	
M.1-4	3	Calorimetric bomb and gas measuring app	1905
M.25	3	Spontaneous combustion of oils - app. for	?
		Birds nest	
			Nitroglycerine section
53, 60-1	1	Nitroglycerine settling pond - explosion	1894
54-5	1	No. 2 nitrating house Qn. Hill	1891
56	1	After separating house	1891

		Qn. Hill	
57-8	1	Washing house Qn. Hill	1891
62-74	1	Washing house and store - explosion	1894
85	1	Boiler house and shaft Edmondsey	1897
86	1	Water tower Edmondsey	1897
87	1	After separating and egg house Edmondsey	1897
88	1	G/C stove No. 4 Edmondsey	1897
89	1	W/W/settling house Edmondsey	1897
90-1, 95	1	Nitrating house Edmondsey	1897
92	1	Site of G/C stoves and new cut Edmondsey	1901
93	1	Mixing house Edmondsey	1897
94	1	Washing house No. 3 Edmondsey	1897
96, 100	1	Washing house No. 2 Edmondsey	1897
97	1	Nitrating and Washing house Edmondsey	1897
101-3	1	Newtons pool Edmondsey	1897
211-2	2	Kessler apparatus Edmondsey	1903
154-81	2	Nitroglycerine plant Qn. Hill	1903
182-209	2	Nitroglycerine plant Edmondsey	1903
225	2	Nitrating apparatus Qn. Hill	1904
226-8	2	Nitrating app Edmondsey	1905
229	2	Washing house Edmondsey	1905
233-4	2	Nitroglycerine house Edmondsey	1908
249-51	2	Nitroglycerine plant Edmondsey	1909
273	2	Nitric acid condensing coils	
274	2	Washing house	
276	2	Nitrating house Edmondsey (pipes of	

		platform)	
293	2	Nitroglycerine pond after explosion	1916
M.25	3	Oils - apparatus for spontaneous combustion of	---
111-18	1	Picric powder explosion No. 5 mill	1897
121	1	Picrate of Ammonia plant	1900
235-7	2	Power house Qn. Hill	?
356-7	2	Petrolite factory Edmondsey	1928
326-31	2	Ruston Proctor Locomotives	1918
M.5	3	Rubber boots from Victoria Rubber Co	1905
M.10-11	3	Rifle ? maxim gun bands - erosion of	1900 & 1903
M.43-8	3	Research Dept. Woolwich - explosion at magazines	1907
245-6	2	Silvered vessel hut - after explosion	1908
M.9	3	Steelyard in reeling house	1905
M.37	3	Steaming apparatus for cordite analysis	---
M.25	3	Spontaneous combustion of oils - apparatus for	---
M.12-16	3	Smokeless blank experiments	1905
802	3	Sun, eclipse of 8.4.1921	1921
247-8	2	Teasing machine - G/C factory	?
M.71	3	Trees blown down in Long Walk	---
M.83-4	3	Tree (Chestnut) Mill Head Stream	1930
210	2	Williamsons Patent Beater Sharpener	1904
311-25	2	Women workers during the war	1917
341-2	2	Women fire brigades	1918

<u>**Supp 5 984**</u>

Excellent. Date 1937-1938. 9m = c27ft. Take notes/photocopy:

1. Headquarters (Directing Staff) Refuge (SS113) Map 2, also map of North Site Refuge and Decontamination centres and map of North and South Site fire and hose house locations - photocopy these??. Take notes from text (don't be too exact) making general points on passive air defence at Waltham Abbey and also more details on 'Refuges' (more for psychological reasons than for physical protection: "The moral effect of refuges, however slight the protection, cannot be too highly stressed." p. iv of Appendix I).

2. 1213, 886 workers on the plant - get more information?

A3 B&W photocopy taken of 33' refuge, cost 40p.

Air defence. The principles and practice of passive air defence for explosives factories.

Contents.

(B) Summary of report.

"It is considered that defence has to be provided against:-

"HE bombs [entered in pencil]

"Gas bombs

"Gas Sprays

"Incendiary bombs and

"Machine Gun Fire.

"Direct hits by high explosives bombs cannot be provided against, but provision can be made against splinters, and the effects of internal explosions caused thereby. It has been assumed that no better protection need be provided in a Factory than is to be provided for civilians in normal domestic life, bearing in mind the extra risks associated with an Explosives Factory.

"Refuges to be erected for complete personnel of sufficient capacity to enable occupants to remain enclosed for 12 hours - no provision will be made to give a supply of purified air, therefore 200 cu. ft. per person to be allowed.

"Construction to be strong enough to withstand light incendiary and gas bombs and high explosives splinters and internal factory explosions. A heavy construction is considered essential owing to the number of persons congregated at one spot.

"Erection to be on sites as close as possible to the work-place of the persons allocated to them to allow for very little warning being given.

"Sites also to be chosen so that the minimum possible distance has to be certified as free from gas before evacuation of personnel can be undertaken, i.e. all refuges to be arranged as far as possible on one main path.

"Maximum number of persons per refuge - 50.

"Refuges to be "clean" buildings in which persons wearing Danger Building clothes can congregate and return immediately to work after raid.

"Warning:- An audible siren in conjunction with telephone messages to all Departments to me organised.

"Decontamination:- Before personnel can be discharged from Refuges, the surrounding areas to be freed from persistent vesicant gas, or such parts freed as are essential for evacuation to a freed area.

"Trained Squads of men to be provided with protective clothing and gas masks and organised for this work. They will work under the supervision of Officers picked from supervisory staff, and use the standard methods of decontamination. These Squads to be divided into units and for control purposes to be accommodated at "Gas Defence Stations."

"The secondary parts of the Organisation deal with casualties, building demolition work and fire fighting.

"Provision to be made for:- (a) Casualties by high explosives splinters, falling masonry, shock, fire etc. at First Aid Stations. (b) Casualties due to (a) above combined with gas, possibly also contaminated with persistent visitant at First Aid Stations. (c) Casualties due to gas at Decontamination Stations. (d) Contaminated cases otherwise uninjured at Decontamination Stations.

"The sites for these stations are chosen as for Refuges.

"In this connection provision to be made for complete reclothing of all contaminated personnel, and for transport of all Hospital cases to Local Hospitals.

"Fire Fighting and Demolition Work will be provided for by trained squads of men provided with protective clothing attached to the Gas Defence Stations.

"Finally provision is to be made for Decontamination of all stores used during the decontamination work, and all clothing of contaminated personnel etc. For this work a Decontamination Laundry with boiling and baking facilities is required.

"The Organisation proposed for this Defence Scheme is divided into two parts, first: the staff to supervise training of personnel in special duties and supervision of stores and equipment etc. during peace or pre-raid periods, and secondly: the active raid organisation which comes into action on receipt of a raid warning. A permanent staff appointed for this work form the backbone of this organisation, supplemented by the squads etc. Trained in special duties and supervisory staff seconded for this work from manufacture.

"For control purposes, the Factory is divided into Areas, and the Areas sub-divided into Sectors, each Sector having its own Gas Defence Station, Decontamination Station, First Aid Station, and Refuges.

"Decontamination Laundries which only operate after a raid can be allocated one to each Area.

"Essential Services may have to be continued during raid periods, and the personnel so engaged will be provided with protective clothing and will remain at their posts protected as far as the nature of the work allows." (3 Charts of staff hierarchies and the relationship of different areas on the plant follow this summary.)

(From p. 18) Section III Details of units, A. Headquarters (directing staff):

Accommodation to consist of refuge for staff, office for control purposes, 1 latrine, store for protective clothing etc., decontamination arrangements for staff.

Services required include hot and cold water, emergency supply type light, telephone, steam heating, decontamination laundry plant, motor ambulances, boats and trucks, tractors, fire fighting appliances, hand pumps and air filtration units.

Stores of protective clothing, respirators, stores for clothing repairs and for Superintendent's area and sector headquarters (various requirements such as food stuffs, etc).

Layout sketch 1 p. 68 section and plan of Supt. and area H.Q. and Section H.Q. - photocopy?

Construction - Nissen patent construction, concrete and earth covered, special doors, non-ventilated.

Staff

	O.C. H.Q.	Area H.Q.	Sector H.Q.
supervisory staff	2	1	1
gas defence supervisory staff	1	1	-
messengers)			
telephone operator)	7	7	5
	10	9	6

p.9 Figure: "Tabular layout raid conditions" - photocopy?

Notes already taken:

Lab 59/7 Explosives Inspectorate Annual Reports 1906-1910

Contain information on ? government and ? accidents

1909 - Bridgewater

1910 -

Supply 5 984 Passive Air Defence for Explosives Factories

RGPF (WA) 1937

Part I (A) Preliminary statement:

1. Measures to prevent detection from the air.
2. Preparations to prevent whole factory being put out of action by a chance hit on a vital spot, which is largely a matter of duplication of essential plant.
3. Defence measures when the factory is detected and attacked.

Threats - HE bombs [added to the document in pencil], gas bombs, gas sprays, incendiary bombs and machine gun fire.

Refuges - up to 50 people max per refuge - refuges to be in clean buildings - need for decontamination personnel and stations, decontamination laundry for clothing, first aid squads - threat from internal ? explosions.

Factory divided into areas and sectors, audible warning and telephone contact ? services to be maintained throughout the raid.

Refuges - Nissen patent construction concrete and earth covered, special doors, non-ventilated. Casualties ? to local hospitals.

Observation posts (p. 25) ? - manned to observe the progress of a raid on a factory (n.b. distinction between active and passive defence).

p. 31 list of personnel employed in each different process area including NG, GC, CE, Picrite, R.D. 202.

No mention of gunpowder, RDX or TNT - South Site not included on list.

Lists of equipment required for passive defence.

'Nissen' type structure - reasonably gas-tight - resisting splinters, internal factory explosions and direct hits by small type of bombs. Corrugated sheet steel lining supported by I & T section girder work of small dimensions covered with a layer of concrete (not reinforced) and a layer of earth. Special joints are used for the end sections which are also protected by sand bags.

n.b. South Site 10 refuges built

fig. - photocopy?

Refuge - 25 persons: length 33', 50 persons: 56'

Sketch 6 - D/C laundry with boiling coppers

Sketch 10 - W.D.C. Observation posts, dimensions: overall = 12' x 8' x 8',

under cover = 6' x 6' x 8'. There are observation slits on all sides

Due to early removal of R.G.P.F. to a new site, it is not proposed that the passive air defence scheme as laid down in Part II be implemented at Waltham Abbey. It is recommended instead that a certain minimum amount of preparation should be made to meet emergencies that may arise before removal is completed. Preparation considered essential includes: darkening (of windows to avoid detection from the air), camouflage (of roofs where possible), avoidance of panic at R.G.P.F. in the event of a sudden emergency. A system of trenches as refuges is impracticable, owing to the low-lying level of the terrain, water is struck 1'6" to 2ft. below ground level in most cases.

n.b. maps at rear of document.

Supp 5 1129 (RDX Bridgewater)

Thin manila folder marked secret. A short, very technical report (with tables, graphs and equations).

Title of enclosed document: "R.D.X nitration and dilution (programmes B.P. 3 & 5) Part I: Factors affecting nitrator design" P.M. Garwood, K.G. Denbigh et al. 31.8.1942

Contents: Introduction p. 1, Rate of solution of Hexmine Crystal p. 1, Rate of temperature rise in nitration p. 2, Heat of nitration p. 3, Rate of nitration reaction p. 3, Time of passage in plant nitrator p. 4, General discussion of the nitration reactions p. 6, Summary p. 7, Recommendations p. 7, Appendix 1: Rate of nitration of Hexamine p. 8, Appendix 2: Theory of probability bypassing in a tank p. 10, Appendix 3: Experiments on the reactions leading up to the fume off pp. 12-13.

Introduction: "The nitration of hexamine is a rapid and highly exothermic reaction. As much as 600 calories are evolved for every gram of hexamine nitrated and, as shown below, about 50% of this heat is evolved within the first thirty seconds after the moment of mixing. It is therefore essential to have very good cooling in the nitrator, especially in that part of the vessel where the first stages of the process occur. One of the objects of the present report has been to measure the rate of evolution of heat in the reaction in order to determine how the cooling surface should be distributed between the different sections of the nitration vessel.

"Other important matters in nitrator design concern such questions as the time required for the hexamine to dissolve and the time of passage in the nitrator which is necessary for the hexamine to be completely concerted to R.D.X. Another important question is whether the incoming hexamine and acid should be allowed to mix with the products of reaction, as is the case in the existing tank type of nitrator, or whether the various stages of the process should be segregated from each other, as would occur if the nitration was carried out in a flowing tube.

"The present report is the first of a series and is mainly a compilation of various measurements on reaction rate which have been made at [word cut from text] towards determining the best design of nitrator. The operation of the nitrator and such matters as the best working temperature, acid:hexamine ratio, etc, are dealt with in subsequent parts.

"The results quoted in the present report are obtained by batch methods in which 10 parts of hexamine were added to 114 parts of acid in a stirred beaker or Thermos flask. In many of the experiments a closer approximation to plant conditions was obtained by studying the effect of adding a small quantity of hexamine to a volume of acid in which a fairly large quantity of hexamine had already been nitrated. This method, spoken of below as the 'last 10% method' was carried out by slowly adding 9 parts of hexamine to 114 parts of 98-99% acid, with cooling and stirring, and then studying the effect (on yield or heat evolution, etc. as the case might be) of adding a further one part of hexamine. Certain information was also obtained by the 'first 10% method' in which the effects were studied after only 1 part of hexamine had been added to 114 parts of acid."

Summary: "Various measurements concerning the rate of formation of R.D.X. and the rate of evolution of heat have been made, especially in relation to factors concerned in the design of continuous nitrators.

"The formation of the R.D.X. is very rapid and at 30-35° C is 90% complete in two minutes. The degree of bypassing in the plant nitrator has also been measured and it has been found that the loss due to incomplete nitration of the hexamine is only 1% or less, on account of the high speed of this reaction. Heat is also liberated very rapidly and the total heat to be abstracted in a continuous nitrator amounts to 600 calories per gram of hexamine. About 60% of this heat is eliminated with the first minute and about 90% within the first five minutes. About 90% of the total cooling surface should therefore be placed in the first compartment of the nitrator.

"The rate of evolution of the heat has been found to be dependent mainly on the size of the hexamine crystals, the heat being evolved more slowly the coarser the material . For this reason the hexamine used in the plant should be fairly coarse, to reduce overheating at the moment when the hexamine falls into the acid. This overheating, when it occurs has been found to cause considerable reduction in yield. The hexamine can be as coarse as will pass a 14 mesh sieve without there being any loss of yield due to hexamine crystals passing through the nitrator undissolved.

"Following the formation of the R.D.X. it has been shown that slow secondary processes continue to occur, with further evolution of heat and the evolution of a colourless gas. This is probably nitrogen or nitrous oxide. The fume-off occurs when these secondary processes have reached a definite stage and provided the conditions of temperature, etc. are sufficiently closely defined it is possible to state with fair accuracy how long the nitration system can be held before the fume-off occurs."

<u>Supp 5 1130</u> (RDX Bridgewater)

Thin manila folder marked secret. A short, very technical report (with tables and equations).

Title of enclosed document: Report G.51. R.O.F., [words cut from text] (The laboratory). "R.D.X. nitration and dilution Part IIA: The nitric acid balance and the absorption efficiency" (Addendum to Part II. Report L.39) by R.A. Gotts 4.3.1943.

Contents: Summary p. 1, Introduction p. 2, Measurement of fume passing through the absorption system p. 2, Experimental method p. 3, Calculation of quantity of R.D.X. fume and absorption efficiency from gas analyses p. 3, Additional data obtained p. 4, Calculations p. 4, Hexamine /fume ratio p. 4, Results of the determination of overall efficiency and quantity of R.D.X. fume p. 5, Discussion of results, pp. 5-6.

Summary: "Analyses for nitrous oxides, oxygen, carbon dioxide and nitrogen, have been carried out on the gases entering and leaving the common absorption system. These are the R.D.X. fume, the gas from the ammonia converters and the exhaust gas. From each set of simultaneous gas analyses two algebraic equations are set up in which the quantities of carbon dioxide and nitrogen in the ingoing gases are equated to the quantities in the exhaust gas. From these equation two unknowns can be calculated, which are the quantity of nitrous gas from R.D.X and the absorption efficiency. The quantity of nitrous gas from the oxidation of the ammonia is taken as a known quantity. Expressed more simply the quantity of R.D.X. fume and the fraction of the total nitrous fume which is absorbed are calculated by reference to the carbon dioxide and nitrogen which pass through the absorption system unchanged.

"It is thus found that the absorption efficiency, when all circulation pumps are operating, is 96% and the quantity of fume evolved in the R.D.X. dilutor is equivalent to 4.3 parts of nitric acid per part of hexamine nitrated.

"The tentative nitric acid balance in R.D.X. nitration and dilution as given in Part II can now be stated more closely as follows:-

HNO_3 as spent acid	5.7	)	
HNO_3 as fume	4.3	)	Parts per part of
HNO_3 as R.D.X.	1.0	)	hexamine nitrated.
HNO_3 dead loss	1.3	)	

	12.3		

"The above applies accurately only when the R.D.X. yield is 1.09 parts per part of hexamine. Probably at least half of the dead loss is in the form of nitrogen and nitrous oxide, formed in side reaction."

Discussion of results: "The absorption efficiency of the W.N.A. plant with all pumps in circulation and a normal intake of fume in 95-96%.

"The R.D.X. fume/Hexamine feed ratio is very consistent allowing for variations in conditions at the Nitration Houses which is shown by daily variation in the concentration of the nitrous fume in the fume main. For example the low figure (17.1%) obtained on January 9th is known to be due to the fact that the C. Nitration House shut down during the period of sampling. The average figure for this ratio is 4.3 parts of nitric acid per part of hexamine nitrated.

"Some indication of the amount of fume condensed in the fume lines on the plant may be deduced from these figures. The average NO_2/CO_2 ratio from the results shown above is 2.7. At the dilutors this ratio is 3.0-3.2 according to the [word scratched out] reports. So that the amount of fume converted nitric acid in the fume lines is about 14%. This gives the quantity of fume evolved at the dilutors a 4.9 parts of nitric acid per part of hexamine nitrated.

"These figures confirm the results obtained with the laboratory continuous nitrator and dilutor as given in Part II.

"With regard to the nitric acid balance in R.D.X. nitration, the total usage of concentrated nitric acid and the return of spent acid are known from stock tank measurements, Over a period of four months the figures were as follows (from the earlier report L.39):-

Total usage of C.N.A. as HNO_3		12.3 pts. per part of hexamine
Spent acid as HNO_3		5.7 pts per part of hexamine

	Balance	6.6

"Of the balance of 6.6 parts, 1.0 parts go into the R.D.X. and 4.3 parts are evolved as fume, as shown in the present report. The remaining 1.3 parts therefore appear as dead loss, and at least half of this is in the form of nitrogen and nitrous oxide, which are known to be formed in side reactions in the nitrator and dilutor. This will be discussed more thoroughly in a later section of this series of reports on R.D.X. Nitration and Dilution.

"On the basis of the present report the nitric acid balance in nitration and dilution can now be stated much more closely as follows:-

HNO_3 as spent acid	5.7	)	
HNO_3 as fume	4.3	)	parts per part
HNO_3 as R.D.X.	1.0	)	of hexamine
HNO_3 dead loss	1.3	)	

	12.3		

"The above applies accurately only under such conditions of nitration which give 1.09 parts of R.D.X. per part of hexamine. Higher nitration efficiency gives lower evolution of fume and lower loss as nitrous oxide."

<u>Supp 5 1132</u> (RDX Bridgewater)

Thin manila folder. A slightly longer, very technical report (with tables, graphs and equations).

Title of enclosed document: Report No.G.53. R.O.F. 37. (The laboratory). "R.D.X. nitration and dilution Part IV: The fume-off phenomena" A.W. Pond & J.D. Johnson 5.3.1943.

"Programme 32. Objects.: To determine the conditions which give rise to a fume-off in the system hexamine:nitric acid and the system R.D.X.:nitric acid. Reasons: The study of the fume-off is of importance for three practical reasons, apart from the light which the study may throw on the nature of the nitration processes. These reasons are:- (a) The conditions governing safety in nitration are of great importance. (b) The safe conditions of recovering waste R.D.X. by solution in nitric acid require to be laid down in view of recent fume offs. (c) It is necessary to determine the best conditions for the initiation of the fume-off in the start up of the diluter. Procedure: Study the ease of initiation of the fume-off under various conditions of acid strength and temperature, using both nitration mixture and solutions of R.D.X. in nitric acid. Also to study the effect of various added substances. The technique is the measurement of the induction period under isothermal conditions or the rate of temperature rise under adiabatic conditions."

Contents: Summary p. 3, Introduction p. 5, Section I The fume off of nitration mixtures p. 5, Effect of nitrous acid p. 5, Effect of glass and stainless steel surface p. 8 , Effect of ammonium nitrate p. 9, Effect of acid strength p. 10, Effect of metallic salts p. 10, Effect of sulphuric acid and hydrochloric acid p. 11, Effect of temperature p. 12, Section II The decomposition and fume off of R.D.X. dissolved in nitric acid p. 13, Section III The initiation of the fume off in the diluter p. 14, Effect of acid strength p. 14, Effect of temperature p. 15, Effect of nitrous acid p. 15, Section IV Theoretical discussion of the fume of phenomena p. 16.

Conclusions: "1) It is not necessary for the concentrated nitric acid used in nitration to have as low a nitrous acid content as 0.01%, which was the plant operating condition prior to this research. The figure of 0.2% given in the specification is perfectly satisfactory as regards safety, although it will be necessary to carry out further research to determine whether the reactions of nitrous acid with hexamine caused loss of R.D.X. yield. 2) The recovery of waste R.D.X. can be carried out most safely by the use of cold concentrated nitric acid as a solvent. 3) The violent fume-offs which have sometimes occurred at the start up of the plant dilutors can probably be avoided by the use of a rather weaker acid (45-50) for the initiation of the reaction."

Supp 5 1134 (RDX Bridgewater)

Thin manila folder marked secret. A short, very technical report (with tables, graphs and equations).

Title of enclosed document: Report No.G.56. R.O.F. 37 (The laboratory). "R.D.X nitration and dilution Part V: The yield of R.D.X. by continuous nitration of hexamine (Programme No. 3)" J.D. Johnson 7.5.1943.

"R.O.F. 37 Investigation department programme B.P. (C) 3 Investigation on the most economic conditions in the R.D.X. nitration process. Objects.: A reduction in the cost of R.D.X. production might possibly be achieved in two directions:- (1) In the nitrator, by discovering those conditions of temperature, acid concentration and acid hexamine ratio which result in least loss. In laboratory experiments the American workers have claimed that a reduction in temperature and an increase in nitric acid concentration both have a more pronounced effect in raising the yield than has been found by R.D. This requires investigation. (2) In the diluter. See Programme B.P. (C) 5. Procedure: (1) To carry out in the laboratory small batch nitrations in which the effect of temperature will be studied, between the limits 5° c and 30° C, together with the effect of acid concentration and the effect of acid-hexamine ratio. The object of this is to detemine the most economic values of these variables. (2) To construct a continuous laboratory nitrator and dilutor, made either in glass or stainless steel, and to check the result obtained in (1) above."

Contents: Summary p. 1, Recommendation p. 2, Introduction p. 2, Experimental p. 2, Relationship between continuous and batch yields p. 5, Dual feed nitration p. 7, Choice of most suitable ratios for operation p. 9, Consequences of operating at an overall ratio of 10:1 on a dual feed nitrator p. 10, Triple or multiple feeds, p. 11, Conclusions p. 12, References R.D. [word cut out] Report No. 10.

Introduction: "The object of this investigation was to study the yield obtained by the nitration of hexamine under conditions approximating as closely as possible to those obtaining on the plant. A considerable amount of literature is available on the subject of batch nitration but so far there has been very little recorded work on continuous nitration. For the present purpose a small continuous nitrator has been used and the effect of two variables has been investigated. These were the nitric acid strength and the acid:hexamine ratio. A constant temperature of 25° ± 1° C has been used throughout the work, as the information available indicated that this may be the temperature of optimum yield This has still to be confirmed."

Conclusions: "The important result is that continuous nitration gives as high a yield of R.D.X. as is obtained in batch nitration, but that a higher usage of acid is required to obtain this yield. The reason for this is that in the normal continuous nitration the hexamine is added to an acid in the nitrator which is weakened by the products of the reaction. The nitrating medium, in fact is identical with liquid flowing out of the vessel and is thus a 'spent' acid. In batch nitration, on the other hand, the hexamine is added to an acid which is initially fresh and it is only towards the end of the hexamine addition that the acid becomes weakened to the point where poor yield of R.D.X. is obtained. It is therefore necessary to use a larger acid:hexamine ratio in continuous nitration than in batch nitration in order to maintain the same average acid strength in the reaction system.

"Continuous nitration could probably be made to operate at the same low usage of acid as for batch if the hexamine were added directly to the precooled incoming nitric acid instead of to the weaker acid in the body of the vessel. This might be achieved in tubular nitrators if the problem of the rapid heat evolution were not so difficult. However an approximation to the ideal conditions can be obtained in the existing type of nitrator by introducing separate streams of hexamine to the acid in a number of compartments. In this case the acid only becomes 'spent' after the greater part of the hexamine has already reacted under the most favourable conditions. The experimental results on a simple dual feed nitrator give complete confirmation to these ideas."

Supp 5 1153 (RDX Bridgewater)

Thin manila folder marked secret. A short, very technical report (with tables, figures, graphs and equations).

Title of enclosed document: [word cut from text] laboratory. Report No. L 39. "R.D.X. nitration and dilution Part II: The nitric acid balance" W. Eno & K. G. Denbigh 16.12.1942.

Contents: Summary p. 1, Recommendation p. 2, Introduction p. 3, Experimental method p. 3, Experimental details (acid collected in flask B, acid contained in the R.D.X., fume absorption, fume evolved from the spent acid) p. 4, Experimental results p. 4, Discussion p. 4, Appendix I: Determination of the quantity of R.D.X. fume by measurement of acid absorbed in the plant absorption towers p. 8, Appendix II: Application of the results to the [word cut from text] plant p. 10.

Summary: "Experimental determinations have been made of the nitric acid balance in nitration and dilution. The apparatus was the small scale laboratory continuous nitrator and dilutor and the fume evolved from the dilutor was absorbed in its entirely in strong sulphuric acid and subsequently determined. The quantity of nitric acid appearing in the spent acid was also measured.

"It is shown that the quantity of nitrous gas evolved in the dilutor is dependent to some extent on the R.D.X. yield, the quantity of fume being greater the larger is the amount of hexamine which is degraded to carbon dioxide.

"Under plant conditions of nitration at 30° C and with an acid:hexamine ratio of 12:1, the nitric acid balance was found to be as follows:

Nitric acid converted to R.D.X.	1.0	)	2.0 consumed
Nitric acid completely lost	1.0	)	nitric acid
Nitric acid as fume	4.8	)	10.0 recovered
Nitric acid as spent acid	5.2	)	nitric acid.

	12.0		

"The figures are expressed as weight parts of nitric acid per part of hexamine. The R.D.X. yield under these conditions is about 1.17 parts per part of hexamine.

"These figures agree quite well with those obtained by Roberts at [word cut from text] & by Bawn & Briscoe at {word cut from text]. There is some uncertainty, however, whether the figures are exactly applicable to the [word cut from text] plant. The uncertainty lies in the fact that water is evolved from the dilutor both as vapour and as acid spray. This water can then react with nitrous gas in the fume lines leading away from the dilutor according to the reaction

$3\ NO_2 + H_20 = 2\ HNO_3 + NO$.

"The extent to which this reaction occurs will be dependent on the amount of water available for the reaction and this in turn will be dependent on the temperature and strength of the acid in the dilutor and on the extent of air leakage. The greater the air leakage into the dilutor, the greater will be the vaporisation of water.

"The reaction will probably occur mainly in the fume duct and gas cooler immediately outside the nitration house and the liquid nitric acid formed by the reaction will be returned to the classifier. It will thus appear in the plant nitric acid balance as spent acid. The greater the extent to which the reaction occurs the greater the spent acid will be inflated, with corresponding decrease in the quantity of fume passing to the absorption towers.

"The experimental work described in this report was carried out under conditions similar to those in the plant and all nitric acid which could be condensed from the fume has been included in the acid balance as 'spent acid', as would be the case in the plant. Nevertheless it is not certain that the conversion of nitrous gas to liquid nitric acid was quite as great as may be the case in the plant.

"Direct determinations of the quantity of fume received in the plant absorption towers have been carried out during two short periods (38-48 hours) when the ammonia converters were shut down. These gave results within 5% of the determinations in the laboratory. Nevertheless it is best to regard the plant nitric acid balance as slightly indefinite for the time being. The probability is that it lies between the following limits:-

Nitric acid converted to R.D.X.	1.0
Nitric acid completely lost	0.5-1.0
Nitric acid as fume	5.0-4.0
Nitric acid as spent acid	5.5-6.0

	12.0-12.5"

Supp 5 1215

Contains a document entitled 'Drying granulated Tetryl in a Quinan Stove' by R.A. Wallace (c 1944), a Quinan Stove at ROF31. Successful - better than cupboard stove method. Also contains a plan of pan arrangement in Quinan Stove, details of air supply and heat exchanges at Fan House, and a cross-section over navigable waterway.