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Nitro-glycerine washing house, South Site, Waltham Abbey Royal Gunpowder Factory, Essex

Stuart Foreman

This article presents the results of an archaeological survey of the late 19th-century Quinton Hill nitro-glycerine washing house at Waltham Abbey Royal Gunpowder Factory, carried out in 1996 in advance of the redevelopment of RGPF South Site. The building is remarkably well-preserved, retaining many internal fixtures and fittings from the turn of the century. As part of the first government cordite factory, and as the only standing example of its type in the country, the washing house is a monument of national importance.

Introduction

Waltham Abbey Royal Gunpowder Factory (RGPF) comprises three separate sites beside the River Lea: North Site, Lower Island Works and South Site (NGR: TQ 38319960, Figure 1). Latterly used as a government research establishment, the complex was finally closed on 30 June 1991. An intensive survey of North Site by the Royal Commission on the Historical Monuments of England (RCHME),[1] in association with English Heritage, culminated in the scheduling of a large part of the former works as an ancient monument and the listing of 21 buildings. The Ministry of Defence (MoD) set up a Steering Committee to examine a suitable re-use for North Site. These efforts resulted in the announcement of a major grant from the Heritage Lottery Fund in October 1996, intended to allow the development of the site as an interpreted landscape.

During the intensive survey of North Site, the RCHME also compiled low level records for 12 of the more significant buildings on South Site.[2] Among these are three circular, timber buildings dating from the 1890s, including the nitro-glycerine washing house, a mixing house and guncotton stove, which are thought to be unique survivals in Britain. Similar structures formerly stood on North Site, but these are no longer extant. Essex County Council Archaeology Section had grave concerns over the long-term survival for the buildings on South Site, in particular the exceptionally well-preserved washing house. A recording project was therefore initiated by the Field Archaeology Group of Essex County Council. The results presented below will assist in any future reconstruction of the washing house on North Site.

Survey Method

The washing house was surveyed in plan and section using a Zeiss Rec Elta 15 total station theodolite. Detail points were plotted and drawn at a scale of 1:50. Cross-sections of the entrance tunnel and each conduit tunnel were drawn at a scale of 1:10. Professional photographic coverage of the interior and exterior of the building, including video footage, was commissioned to complement the existing RCHME photographic archive.[3] All archive drawings, digital data and photographic material will be held in the Essex Record Office (ERO), with copies provided to the Essex Sites and Monuments Record (ESMR) and the National Monuments Record, Swindon (NMR).

History of the Site

The Royal Gunpowder Factory at Waltham Abbey (Figure 1) was a major centre of gunpowder production, and latterly chemical-based explosives manufacture, for more than 300 years. There is documentary evidence that gunpowder was being produced at North Site by the mid-1660s. The mills were acquired by the government in 1787, and expanded greatly as a result of the demand for powder generated by the Napoleonic wars. After a period of retrenchment from the 1820s, the RGPF returned to prominence in the second half of the 19th century, playing a leading role in technical innovation, meeting demand for cannon powders for guns of ever-increasing size, and manufacturing moulded powders in large quantities.[4]

In the later 19th century, experiments with chemical-based explosives revolutionised military propellants. Guncotton, and later cordite, which was a blend of guncotton with nitro-glycerine, were particularly important in the development of British service explosives. The greatly increased power of guns using cordite led to gunpowder being largely displaced by the end of the century as the principal military propellant. Waltham Abbey RGPF in the late 19th and early 20th centuries was a centre of innovation. Senior

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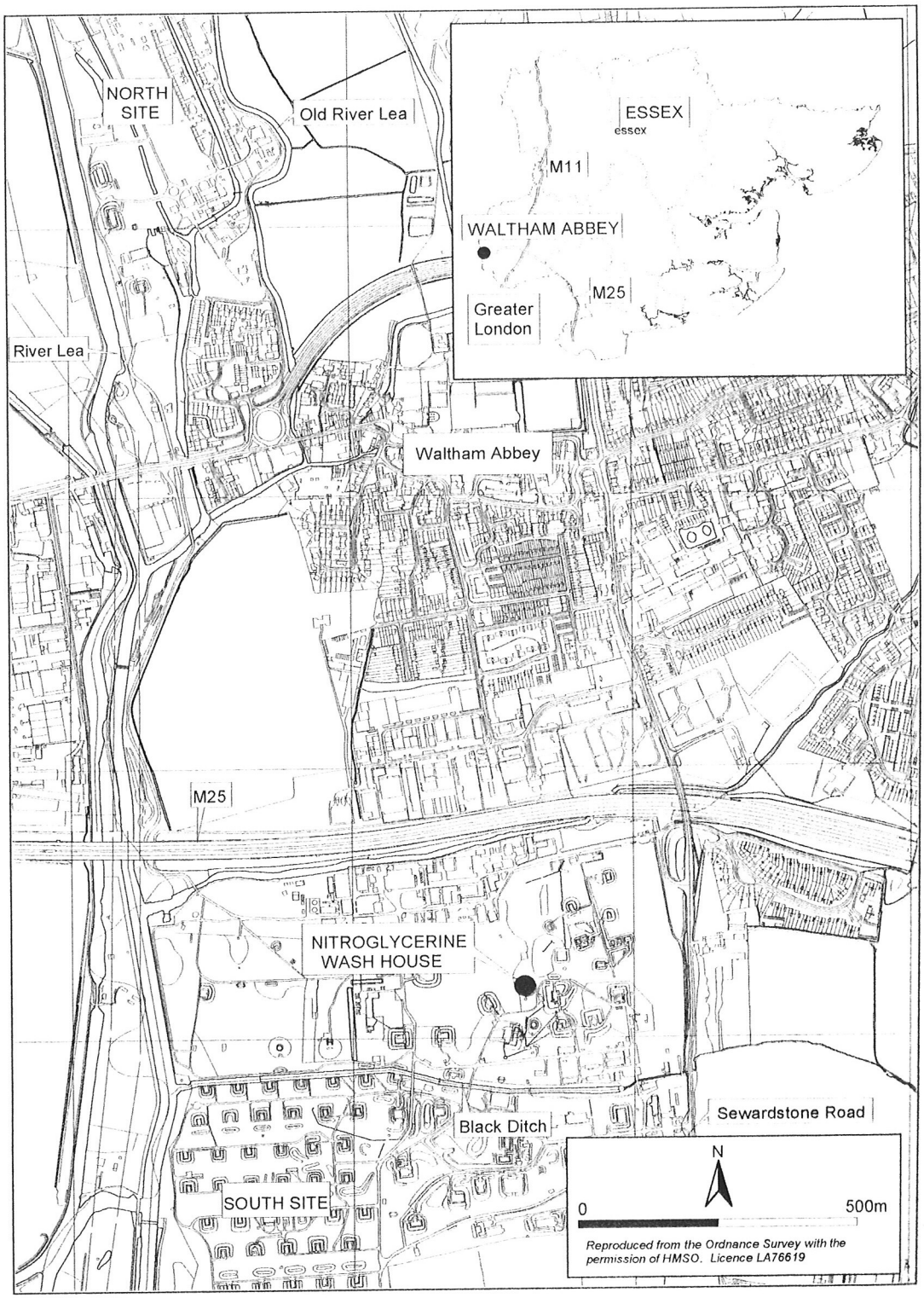


Figure 1. Nitro-glycerine washing house, South Site, Waltham Abbey Royal Gunpowder Factory (RGPF), Essex. Site location. Drawn by Ellen Heppell (ECC FAU).

staff at the factory produced a number of technical papers and official manuals at this time which had a world-wide influence on explosives manufacture.[5]

Background to the adoption of guncotton, nitro-glycerine and cordite

Guncotton, which is created by the action of a mixture of nitric and sulphuric acid on cotton[6] was discovered by Professor Schobein of Basle University in 1846. It was investigated by Sir Frederick Abel as a potential British service explosive from 1863, and was first manufactured on a large scale at Waltham Abbey from 1872. By the 1880s, the military demand for guncotton could no longer be met by the original facilities on North Site. In order to increase production capacity, a new, purpose-built

factory was established on land purchased on Quinton Hill in 1885, known as South Site. The factory was complete by 1889, and began production in 1890.[7]

The explosive properties of nitro-glycerine were first discovered in 1847 by the Italian chemist Professor Ascanio Sobrero, who called it piro-glycerine. In 1863, Alfred Nobel introduced it to Norway as a blasting agent, but it proved too dangerous in liquid state for practical purposes. After a long series of experiments, Nobel discovered that when blended with a suitable stable absorbent material, nitro-glycerine could be stored and used safely. Nitro-glycerine blended with 'kieselguhr' was patented as 'Dynamite'. Nobel later succeeded in replacing the kieselguhr with an explosive absorbent and in 1875 he patented 'blasting gelatine', the most powerful form of which consisted of 93% by weight of nitro-glycerine and 7% by weight of soluble nitrated cellulose (gelatinised).[8]

In 1889, Abel and Dewar patented a new explosive, 'Cordite', which was a blend consisting of 58% nitro-glycerine, 37% guncotton and 5% mineral jelly.[9] Only two years later, in 1891, Cordite was adopted as the propellant for the .303 cartridge for the British Army's new Lee-Enfield rifle,[10] and rapidly replaced gunpowder in large bore armaments.[11]

Nitro-glycerine manufacture at Waltham Abbey RGPF

The following account briefly summarises the processes of nitro-glycerine manufacture in use at Waltham Abbey RGPF at the turn of the century, covering the washing and filtration processes in more detail. The manufacturing process is usefully summarised by Figure 2, which is a schematic diagram of the Quinton Hill nitro-glycerine plant as rebuilt after the disastrous explosion of 1894 (Figure 3). The only major difference between this plant and the plant built at Edmonsey Mead, on North site, the following year, is that the elevation required to run the nitro-glycerine between the houses by gravity was gained by use of the natural slope of the ground, rather than a lift. More complete accounts can be found in the technical papers and official manuals written at the turn of the century, on which this description is based,[12] and in the recent RCHME report.[13] The descriptive section of this report includes a detailed discussion of the plant surviving in the washing house.

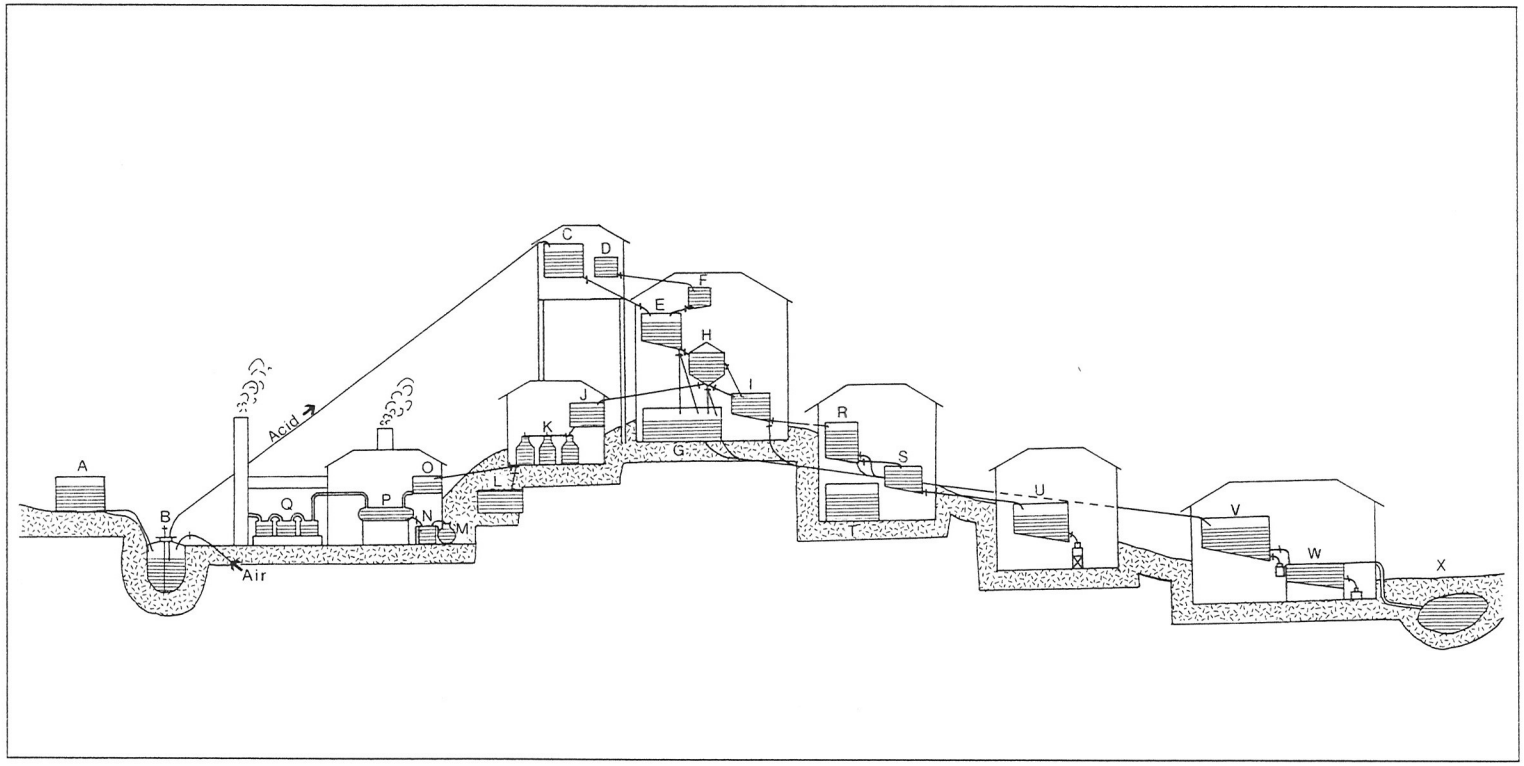
The nitrating process (see Figure 2)

Nitro-glycerine is formed by the nitration of glycerine in a mixture of nitric and sulphuric acid. The acids were initially transported by the site narrow gauge railway system to the acid store tank (A). A mixture of the two acids was moved by compressed air from the 'acid egg' (B) into a tank in the charge house (C) (Figure 4, 477). A second tank in the charge house contained glycerine (D). A charge consisting of 1054lb of nitric and 1785lb of sulphuric acid were run down by gravity into the lead nitrating vessel (E), in the nitrating house (Figure 4, 476, 477), where the acid mixture was cooled to 16°C by passing water or brine through coils in the base of the vessel. The glycerine was run down from the charge house to a storage tank in the nitrating house (F), then sprayed into the base of the nitrating vessel. As there was a danger of explosion if the temperature of the mixture was too high, a 'drowning tank' (G) filled with cold water was placed below the nitrating apparatus, into which the charge could be emptied if the temperature rose above 22°C.[14]

After nitration, the charge was drawn off through an earthenware cock, into a 'separation tank' (H), where the nitro-glycerine was allowed to displace to the surface, forming a layer about 4.5in (0.11m) thick. The nitro-glycerine was run into the pre-wash tank (I) and washed four times in water, the last time using warm soda solution. The pre-wash waters were run off to the 'wash water settling house' (Figure 4, 507) where any residual nitro-glycerine was removed and returned by hand to the pre-wash tank.[15] The waste acids were drawn off from the base of the separator tank through a second earthenware cock, and run down to the 'after separating house' (Figure 4, 475) for recycling (J–Q).

In 1901, a minor explosion occurred in an earthenware cock in No. 2 Nitration House (Figure 4, 476) at the South Site plant. Although little damage was done, the incident encouraged the factory's superintendent, Sir Frederick Nathan, and others, to develop safer manufacturing methods. The resulting 'Nathan-Thomson-Rintoul process' introduced a number of important changes including substantial changes to the nitrating apparatus.

The Nathan-Thomson-Rintoul plant installed in No. 1 Nitration House at Quinton Hill in 1903 was designed with the aim of simplifying the production process and removing the more dangerous operations entirely wherever possible. In particular, it had always been recognised that the use of earthenware cocks for drawing off separated liquids at various stages of the production process was a source of considerable danger 'owing to the possibility of friction being set up between the body of the cock and the key, when the latter was manipulated,



KEY

A	Acid Store Tank		**After Separating House**		**Washing house**
B	Acid Egg	J	Acid Tank	R	Washing Tank
	Charge house	K	Separating Bottles	S	Filter Tank
C	Acid Tank	L	Drowning Tank	T	Drowning Tank
D	Glycerine Tank		**Acid Separating House**		**Weighing House**
	Nitrating House	M	Sulphuric Acid Carboy	U	Store Tank
E	Nitrating Apparatus	N	Syphon Tank and Coil		**Wash Water Settling House**
F	Glycerine Tank	O	Settling Tank	V	Wash Water Settling Tank
G	Drowning Tank	P	Acid Still	W	Labyrinth
H	Separating Tank		**Acid Shed**	X	Ponds
I	Pre-wash Tank	Q	Nitric Acid Receivers		

Figure 2.
***Quinton Hill nitro-glycerine factory**. Schematic diagram of the plant, based on a diagram from the War Office, 'Treatise on Service explosives' of 1895.*

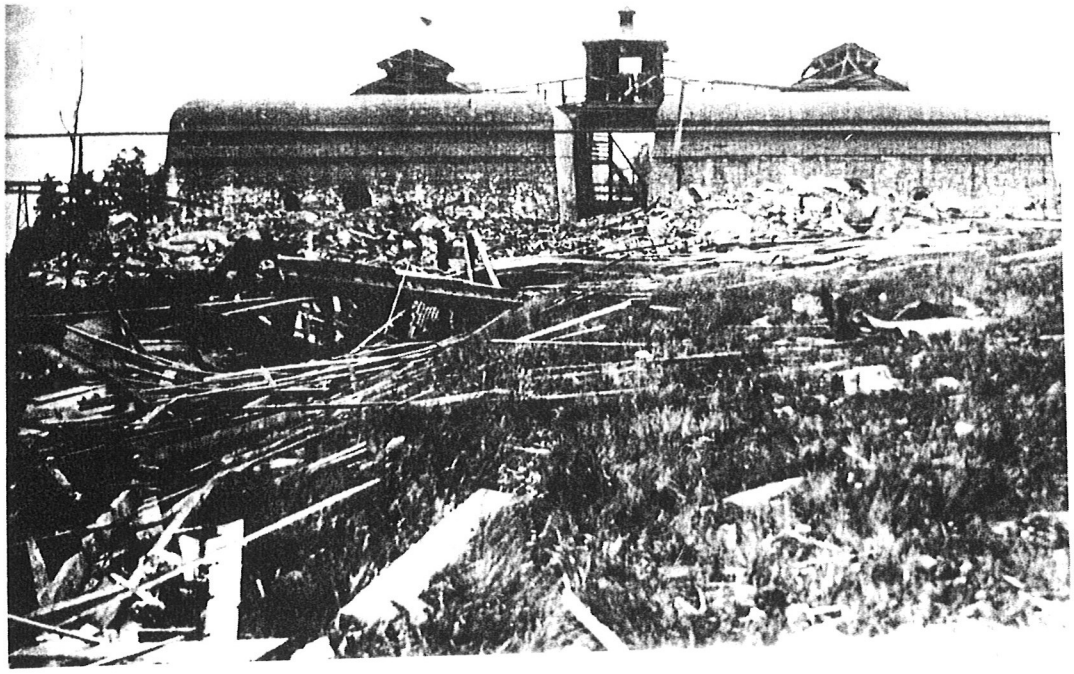


Figure 3.
RGPF South Site. Damage to the original Quinton Hill nitro-glycerine washing house (built in 1891) in the aftermath of the explosion of 7 May 1894 (looking north) (MOD photograph).

should any foreign gritty substance be present'.[16] A new separation technique was devised in which the nitro-glycerine was floated to the top of the separation tank on the surface of an inert, heavier liquid. Waste acid was used for this purpose. The nitro-glycerine was thus pushed over the edge of the tank and into a gutter connecting the 'nitrator-separator' to the pre-wash tank.

The washing and filtering process

The pre-washed nitro-glycerine charge of about 750lb was run, by gravity, down lead-lined gutters to the washing house (Figures 4, 483, and 5), where two batches could be washed at a time. The gutter rested on wooden trestles where it crossed open ground. It consisted of an inner and outer lead jacket, between which warm water could be run when necessary, to prevent the nitro-glycerine from freezing. Early gutters were protected from the weather and dirt by a V-shaped timber cover, but this was later replaced with a canvas cover, permanently attached on one side and laced down the other to allow access for cleaning. The scrupulously observed safety regulations demanded that after a charge had been run down the gutter, its full length should be wiped down with a flannel cloth, in the direction of the washing house, to remove any traces of nitro-glycerine.[17]

The washing was carried out in two lead-lined wooden barrels (R), supported on raised platforms in the washing house. Before the charge was run down, some warm soda solution was sent down the gutter from the nitration house to the washing tanks. This was immediately followed by the nitro-glycerine charge, and then by some more warm soda solution. The nitro-glycerine was washed three times using warm, weak soda solution, and once using water, to remove any remaining traces of acid. The wash water was kept constantly agitated by means of compressed air, injected into the tank through a movable pipe, laid around the bottom. The warm soda solution, and softened and filtered water used in the washing process, were supplied from the main supply tanks in the charge house.[18]

The washing tanks were provided with two cocks; one at the base for drawing off the nitro-glycerine and one at a slightly higher level for draining the wash-water (Figure 6). The wash-water was drained off using a saucer-shaped 'skimmer dish' connected by a rubber pipe to the wash-water drainage cock. The skimmer dish was raised and lowered by hand, using a counterweight pulley system attached to the outside of the building. Earlier types were of lead, but later designs were lighter, being made of brass, covered with rubber cloth.

In the early factory, lead splash screens were fitted around the tops of the washing tanks.[19] By 1903, hoods of rubber cloth were provided instead, each connected to a funnel passing out through a hole in the roof. A compressed air jet could be inserted into the funnel to force the fumes out of the building. A rectangular drowning tank (S), kept filled with cold water, was placed below the washing tanks. If the wash waters exceeded 50°C, the charge could be made safe by releasing it into the tank.[20]

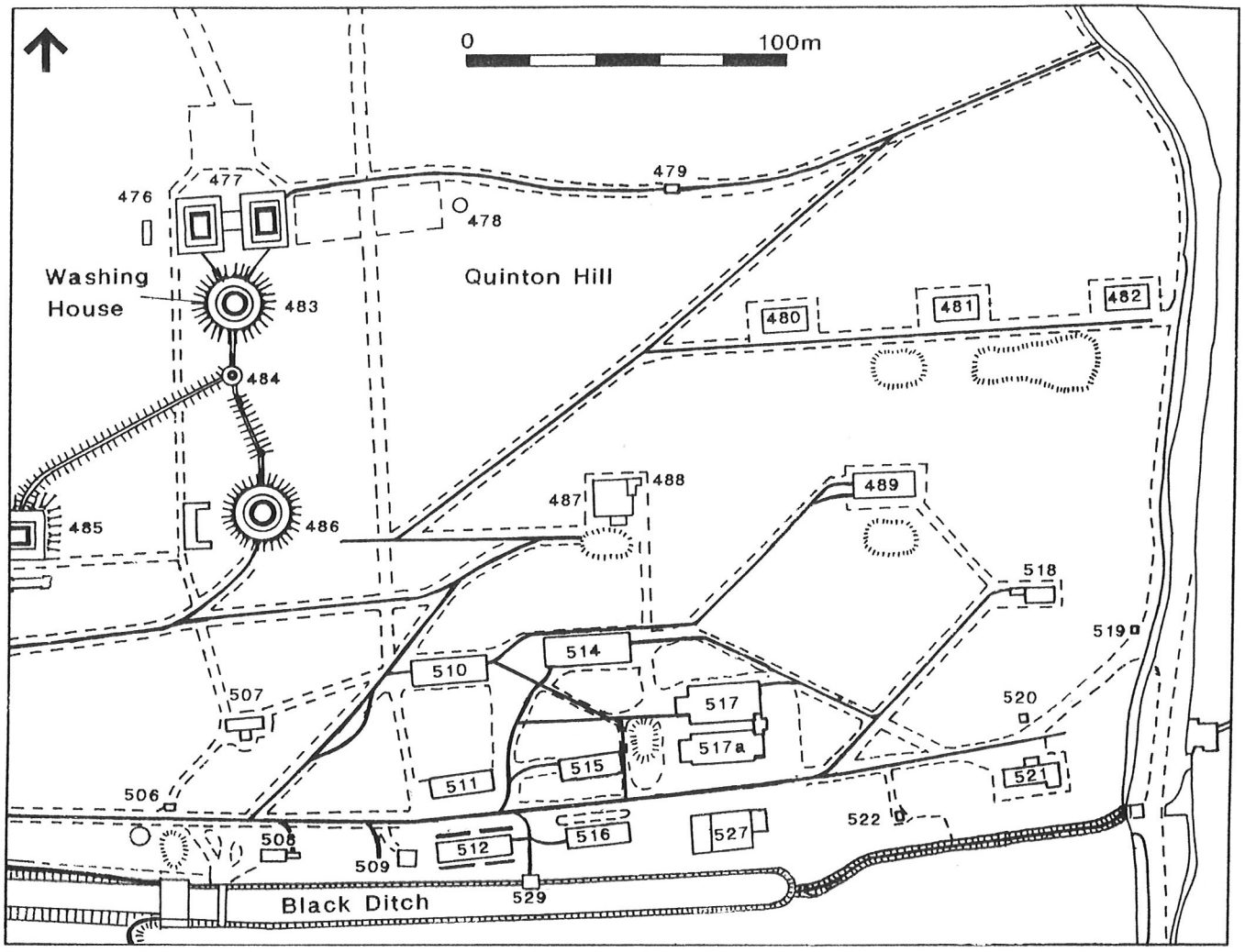


Figure 4. RGPF South Site. Plan of the nitro-glycerine and cordite incorporating plants in 1908.

KEY

475	Site of the After Separating House (demolished 1903–4)
476	Nitrating House No.2 (Air Reservoir adjacent to the W).
477	Nitrating House No.3 (Charge house adjoining to the W)
478	Water Tower
479	Glycerine Store
480	Acetone Store
481	Acetone Store
482	Acetone Store
483	Washing house No.3
484	Junction House/Covered Way
485	Mixing House No.5
486	Mixing House No.6
487	Dry Guncotton Store
488	Latrine
489	Reel Stove
506	Mud Washing Shed
507	Wash Water Settling House
508	Office P.F. Cordite
509	Experimental House No.2
510	Acetone Store
511	Acetone Store
512	Box House
514	Store
515	Acetone Store
516	Box House
517	Sorting House
517a	Press House No.9
518	Cordite Tray Stove
519	Police Hut
520	Searchers Hut
521	Dining and Shifting Room
522	Earth Closet (E.C.)
527	Boiler House and Dynamo House
529	Landing stage

After washing, the nitro-glycerine charge was filtered to remove any remaining water or flocculent matter. This process was usually carried out in the washing house. The nitro-glycerine was run by gravity from the washing tanks, via an earthenware cock and an indiarubber connecting tube, into a lead lined wooden filtration tank (T). The filtration tank was supported on a platform at a lower level than the washing tanks. It had a cover, pierced by a brass tube with the top end open. The bottom end of the tube was sealed with wire gauze attached to a solid metal ring. A flannel bag filled with salt was placed on top of the gauze to act as a filter. The nitro-glycerine was run into the top of the tube and through the salt in order to absorb any moisture, and filter out flocculent matter. It then passed into the body of the tank, from where it could be

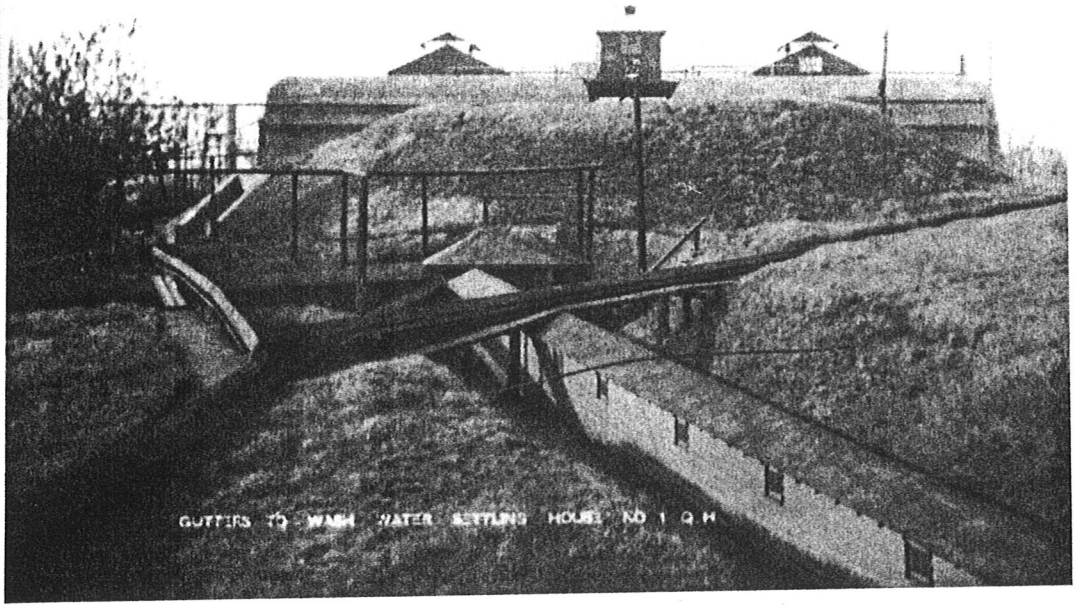


Figure 5.
RGPF South Site. View of the Quinton Hill nitro-glycerine factory in 1903. (Background: nitrating houses and charge house. Centre: washing house. Foreground: junction house, covered ways and wash water gutters) (MOD photograph).

drawn off through an earthenware cock. The salt bag was replaced daily, or more often if necessary.[21]

Procedures for dealing with the nitro-glycerine charge after filtration underwent some change between 1894 and 1904. Before the disastrous explosion of 1894 (see below), the nitro-glycerine was run down a lead-lined gutter from the washing house to the nitro-glycerine store, where it was kept in a tank until required for blending with guncotton. After the explosion, however, the practice at Quinton Hill was changed so that liquid nitro-glycerine would no longer have to be stored. Instead, the charge was run down a gutter to the weighing house (Figure 4, 485, 486), where it was weighed and immediately 'poured-on' a charge of guncotton contained in a tin box.[22] The resulting 'cordite dough' could be stored in relative safety, once it had passed the Abel heat test for stability. By 1900, the nitro-glycerine was drawn directly from the filtration tank into a suitable vessel placed on scales for weighing. The charge was then run down to a tank in the mixing house (formerly the weighing house) (U) (Figure 4, 485, 486) and immediately 'poured-on' guncotton.[23]

Under the new Nathan-Thomson-Rintoul method, adopted in 1903, the filtration process was moved out of the washing house and into the mixing house. A new type of plain lead filtration tank was introduced. It had a perforated, fixed false bottom, and used sponges sewn up in flannel instead of the salt-filled filter bag. The use of a burette to draw off the nitro-glycerine from the filtration tank, in place of the dangerous earthenware cock, allowed the charge to be accurately measured rather than weighed. It also meant that the nitro-glycerine could be poured from the filtration tank directly onto the guncotton charge. By this date, the guncotton was carried to the mixing house in rubber-lined canvas bags rather than tin boxes.[24] Nitration plant of the Nathan-Thomson-Rintoul design was installed in No. 1 Nitration House in 1903,[25] but it is not clear whether the new filtration plant was ever used in the washing house at Quinton Hill. A photograph taken in 1903 shows the Nobel-designed filtration plant still in place (Figure 7).

Contaminated wash waters were drained from the washing tanks into a lead-lined gutter, and run by gravity to a store tank in the wash water settling house (V) (Figure 4, 507). Any residual nitro-glycerine was allowed to settle to the bottom of the settling tank (W). This was then drawn off into rubber buckets and returned to the preliminary washing tank in the nitrating house. The mud from the settling tank was removed each week, washed to remove any remaining nitro-glycerine, then mixed with paraffin and burnt.[26] The wash waters were drained into a large settling pond, which served all of the nitro-glycerine houses, and which was blown up every Saturday with a dynamite charge (X).[27]

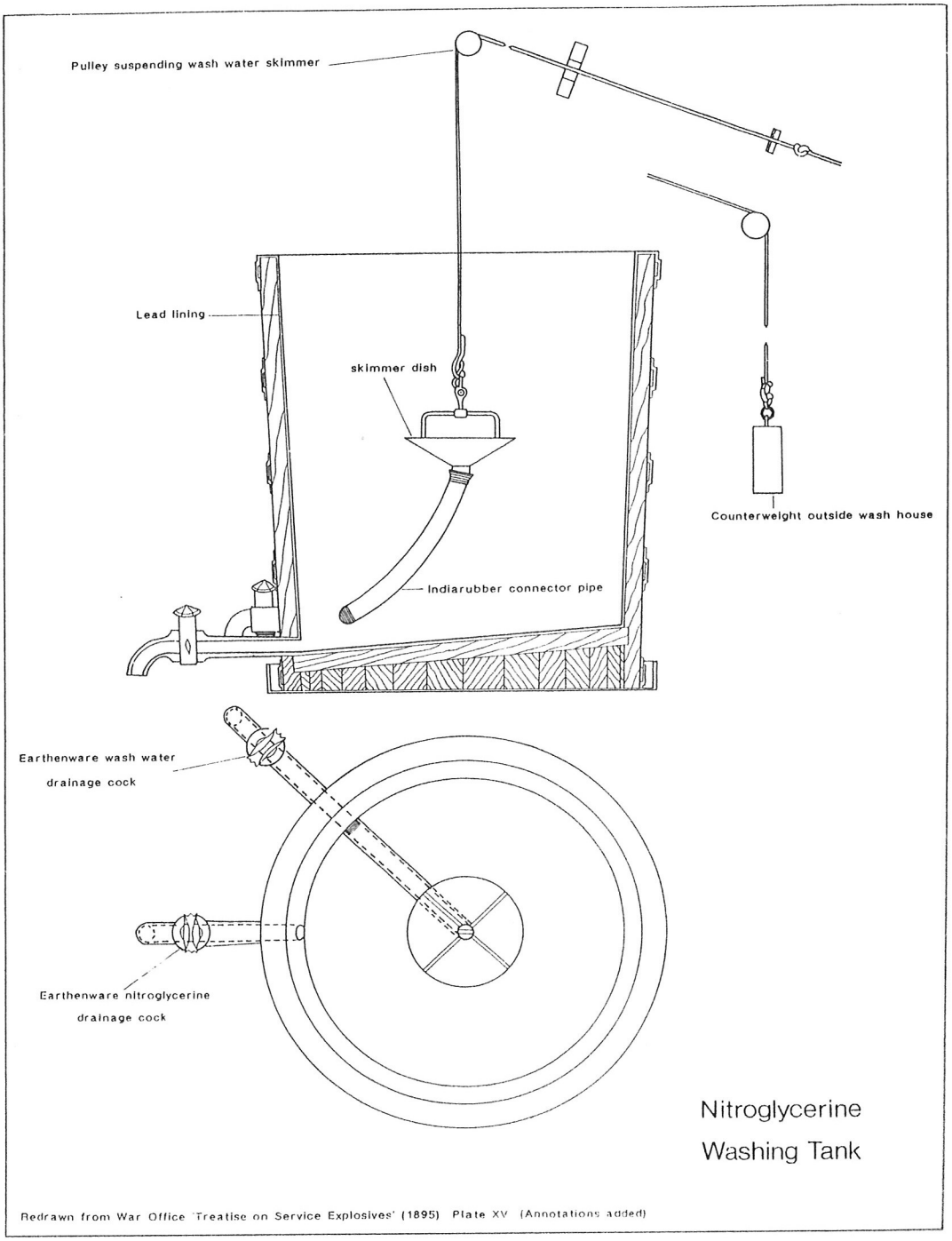


Figure 6.
RGPF South Site.
Nitro-glycerine
washing tank. Drawn
by David William
(ECC FAU).

History of the South Site (Quinton Hill) nitro-glycerine factory

In order to allow large-scale manufacture of cordite, nitro-glycerine production facilities were constructed on Quinton Hill in 1891 to complement the newly built guncotton works (in production from 1890). Waltham Abbey RGPF (South Site) was the earliest cordite factory in the country, though a privately run factory at Hayle, in Cornwall, was producing the explosive under licence from 1894.[28]

The design of the nitro-glycerine plant followed that of the Nobel factory at Oplagen, near Cologne, and the manufacturing plant was also imported from Germany. Some alterations were made to the German plant, based on the experience of the superintendent of the Nobel plant at Ardeer, in Scotland, where nitro-glycerine had been made since 1873.[29]

Two Nitrating Houses (numbered 1 and 2) were built on the summit of Quinton Hill, adjacent to one another, but separated by massive brick traverses (Figure 3). Only one house was to be used at a time, allowing maintenance work to be carried out on the other. The two houses shared a charge

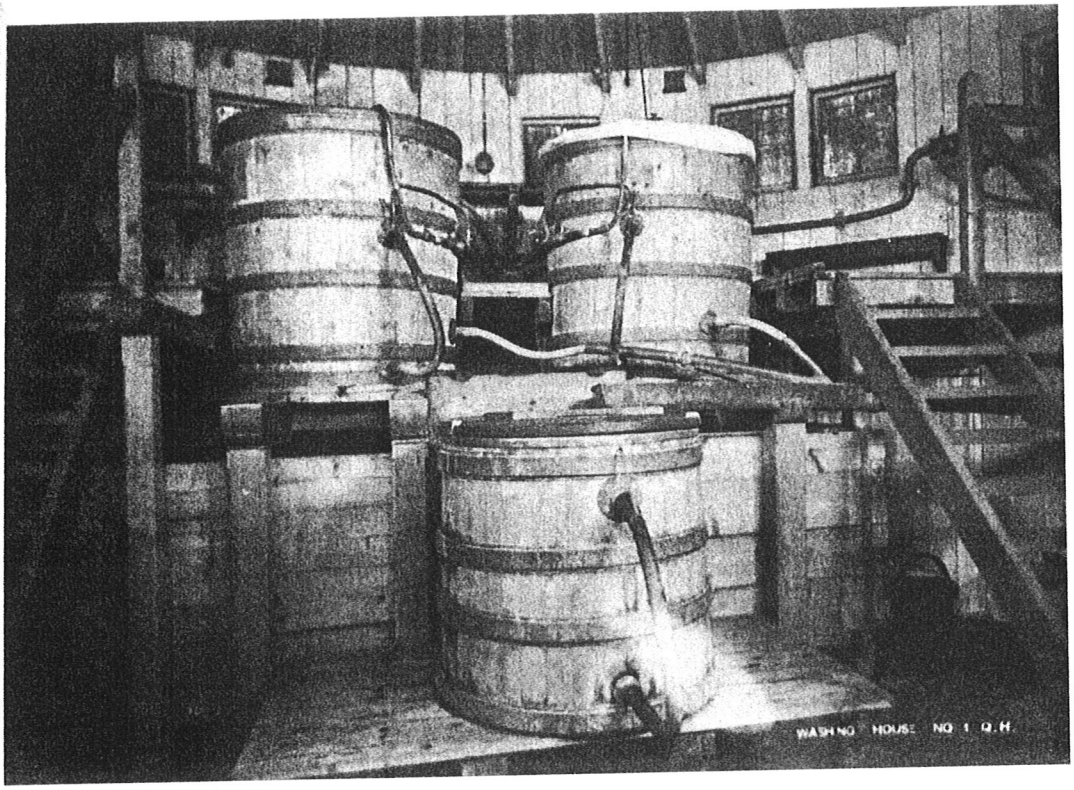


Figure 7.
RGPF South Site. Interior of the Quinton Hill nitro-glycerine washing house in 1903 (looking north). The washing tanks are mounted on the upper platform, the filtration tank on the lower. The drowning tank is below the washing tanks (MOD photograph).

house mounted between them on top of the traverses. The nitrating houses were constructed on top of the hill, so that the nitro-glycerine could be run down to the washing house by gravity. The nitro-glycerine store was adjacent to, but separated from, a building intended to be used as a dry guncotton store. The latter was never used as such however, and was converted into an additional nitro-glycerine store in 1894. All of the nitro-glycerine houses, except for the after separating house and the wash water settling house, were protected by high brick traverses, filled with earth, similar to those used to surround gunpowder buildings.[30]

At eight minutes past four on Monday 7 May 1894, there was a disastrous explosion at the plant, in which both the washing house and the nitro-glycerine store blew up (Figure 3). The process man working in the washing house was killed, together with the chemist-in-charge, the foreman of the nitro-glycerine plant and the foreman plumber, who were apparently approaching the washing house entrance at the time. Other buildings in the area were extensively damaged, particularly No. 2 Nitration House, where a nitration was in process. The chemist-in-charge of the guncotton factory, despite being injured, entered the nitration house and with the two process men working in the building, saw the charge safely drowned before seeking medical attention. A carpenter and boy working on the new guttering between the converted dry guncotton store and the washing house, miraculously escaped serious injury, despite being between the two exploding buildings.

As the nitro-glycerine store was locked and unoccupied at the time of the explosion, the subsequent Court of Enquiry concluded that the washing house had blown up first. Although no definite cause could be found, a number of working practices were immediately changed, and the explosion added impetus to the search for safer production processes.[31]

The destroyed process buildings were quickly rebuilt after the 1894 explosion. The military demand for cordite was such that the factory had to be brought rapidly back into commission.[32] In the interests of speed, the same site was used, overriding the Court of Enquiry recommendation that the nitro-glycerine plant should be placed at a greater distance from the South Site guncotton and cordite works.

The original nitrating plant was retained and the washing house was rebuilt using a new design, including a circular wooden structure, partly sunk into the ground. The nitro-glycerine gutters leading to the mixing houses were housed within sunken, 'covered ways'. A junction house, consisting of a small square, weather-boarded timber hut, sunk within a circular brick-lined pit, was built to the south of the washing house (Figure 5). Inside the junction house, the nitro-glycerine could be transferred from the washing house gutter to either of the

mixing house gutters, by means of a moveable indiarubber pipe.

The brick revetted traverses surrounding the destroyed nitro-glycerine houses, which had proved unsatisfactory for containing the explosions, and had in fact added to the quantity of flying debris, were replaced on the new washing house with an earthwork traverse, revetted with brick on the inside. The Court of Enquiry recommended this change as earthwork traverses had successfully contained nitro-glycerine explosions in the plant at Ardeer. The brick traverses surrounding the nitrating houses remained in use.[33]

The loss of production caused by the explosion highlighted the danger of concentrating cordite manufacture on a single site. On the recommendations of the Court of Enquiry, a new factory was constructed at Edmonsey, on the North Site, in 1898, with much of the cordite incorporating and pressing plant being installed in converted gunpowder buildings. The new factory was supplied with guncotton from the existing South Site plant. Whereas nitric and sulphuric acid, required for the manufacture of both guncotton and nitro-glycerine, had previously been acquired from outside sources, the new North Site cordite factory included a purpose-built acid plant. Glycerine continued to be supplied from commercial sources.[34]

The new Nathan–Thomson–Rintoul designed plant (see above) was installed in No. 1 Nitration House at Quinton Hill in 1903, and the Edmonsey Hill factory in 1904. No. 2 Nitration House continued to use the old Nobel-designed plant.

At around the same time, the proportion of nitro-glycerine used in cordite was reduced from 58% to 30%, as tests had shown that Mark I cordite was causing excessive erosion to gun barrels. The consequent reduction in demand for nitro-glycerine allowed the Quinton Hill plant to be put in reserve in August 1903. At about the same time, the Nitrating House at Edmonsey was designated 'No. 1', while those at Quinton Hill were renumbered '2' and '3' respectively.

Nitrating House No. 2 at Quinton Hill was briefly brought back into service between April and December 1904, while the Edmonsey plant was being converted to the Nathan–Thomson–Rintoul design, but went back into reserve in January 1905. Nitrating House No. 3 was demolished in 1907–8, along with the after separating house, which was not required in the Nathan–Thomson–Rintoul process.[35]

Of the original 1891 factory buildings, Nitrating House No. 2 survived relatively intact until its demolition in 1992. Of the buildings built after the 1894 explosion, the washing house, junction house and mixing house were all present in 1991.[36] At the time of writing, the washing house survives in a good state of preservation and the mixing house is present, but is not so well preserved. The only traces of the junction house and covered ways are the circular, brick-lined pit, within which the junction house was set, and the gullies, now mostly back-filled, within which the covered ways ran.

DESCRIPTION OF THE WASHING HOUSE

Overview (Figures 8, 9 & 10)

The washing house consists of a circular timber roundhouse, surrounded by an earthwork traverse. The traverse, which has an external diameter of *c.* 32m, and an internal diameter of 9.05m, is revetted on the inside by a brick wall, capped with concrete. It is pierced by four brick-vaulted tunnels, including the entrance passage, and three conduit tunnels.

The earthwork traverse and entrance tunnel (Figures 5 & 8)

The building is entered from the south-west along a curving, brick-vaulted passage, passing through the traverse. The sides of the entrance beyond the end of the tunnel are revetted by brick walls, sloping at the same angle as the traverse slope and terminating in low brick plinths.

The passage was formerly closed at the entrance by a wooden, slatted door. This was painted red, following the usual practice in danger buildings.[37] The surviving hinges show that the door opened outwards. The entrance passage is floored with gritless asphalt. Original electric light fittings are attached to the brickwork at either end of the passage, linked by wires encased in small-bore iron pipes which run along the full length of the passage.

The porch (Figures 8 & 9)

Access to the timber roundhouse is via the 'shoe room' or 'porch'. This feature was incorporated into the washing house design after the 1894 explosion, to ensure that workmen changed their footwear or put on overshoes before entering the building, in case grit attached to shoe soles should cause a spark. The shoe room occupied the 1.0m gap between the traverse revetment wall and the roundhouse door. This area is now open to the sky, but was formerly covered by a short length of timber and galvanised metal roofing, extending *c.*

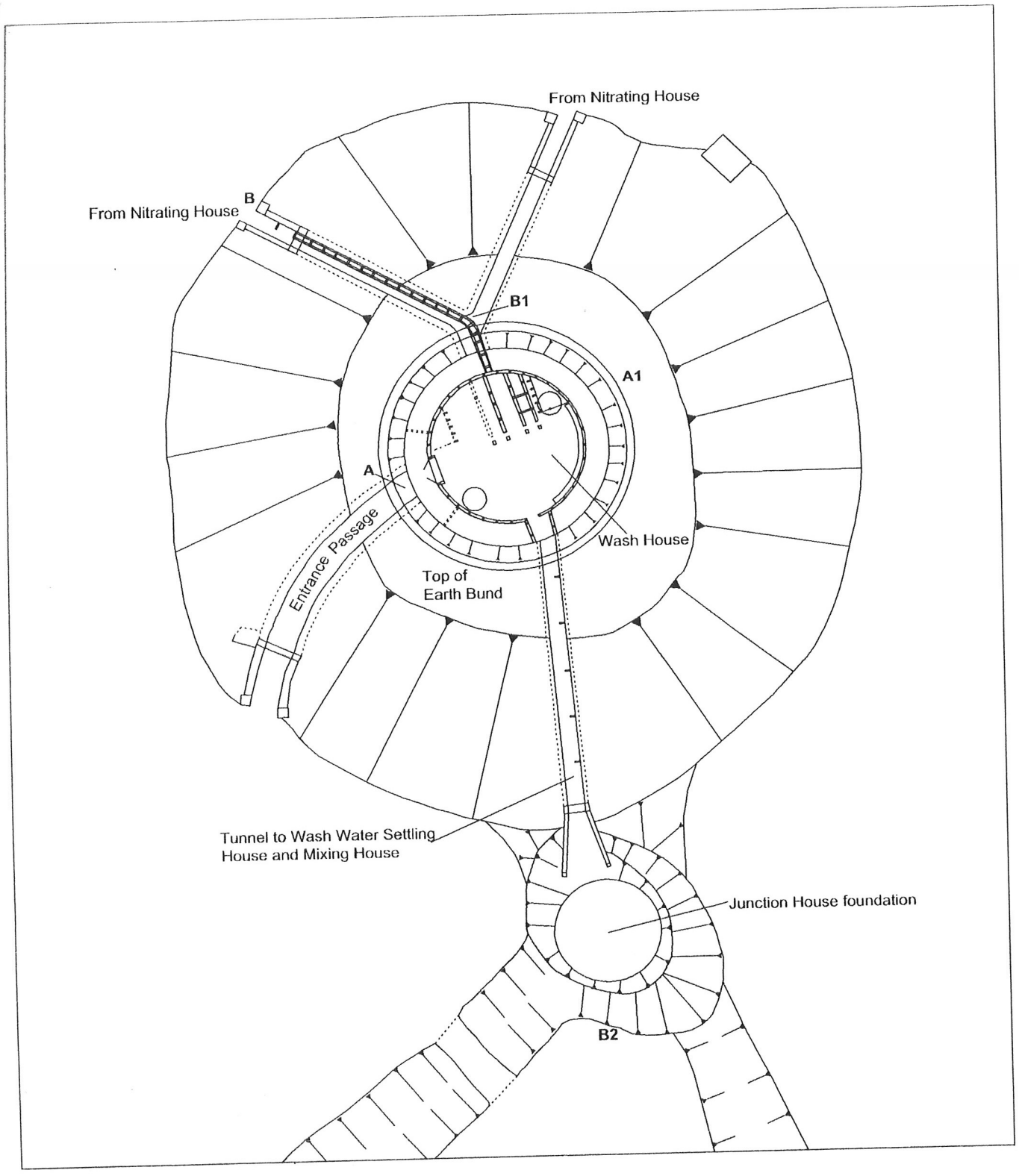


Figure 8.
RGPF South Site.
Nitro-glycerine
washing house.
Building plan. Drawn
by Andrew Lewsey
(ECC FAU).

2.25m on either side of the roundhouse door. The roof was supported on timber framed half-walls, with half-glazed wood-panelled doors on each side of the porch, giving access into the gap between the roundhouse and the revetment wall. Remains of the collapsed roof lie on the floor below its original position.

Three wooden coat hooks are attached to the exterior of the roundhouse wall on the southern side of the door. Below the coat hooks is a small, rectangular, glazed window, providing a view of the round-house interior from the shoe room. Between the roundhouse door jambs at floor level is the remains of a wooden toe-board,

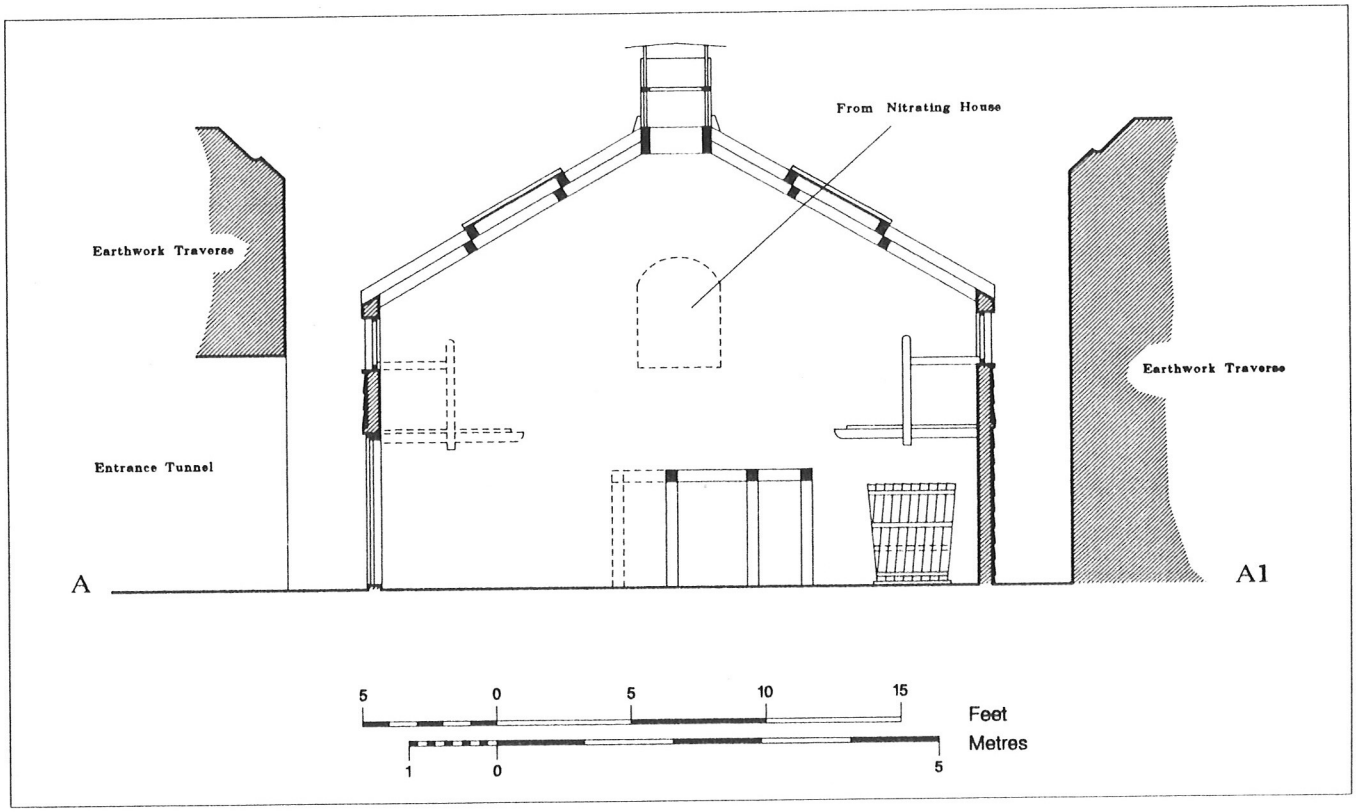


Figure 9. RGPF South Site. Nitro-glycerine washing house. Section A-A1. Drawn by Tony Calladine, RCHME. © *Crown copyright.*

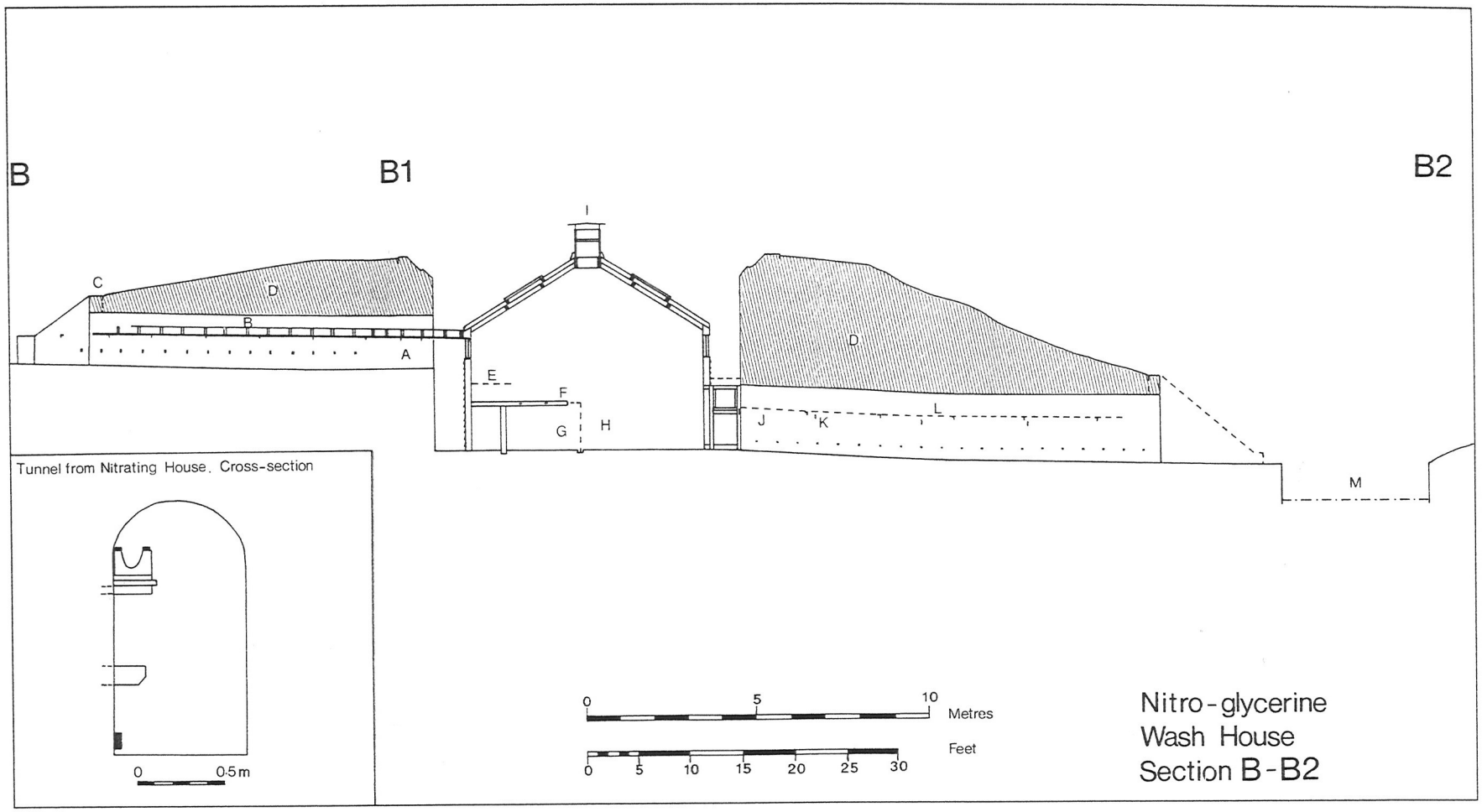
formerly painted red, which served as a physical dividing line between the 'clean' roundhouse interior, and the 'dirty' shoe room floor. The roundhouse is entered from the shoe room through panelled double doors hung on brass butterfly hinges. Brass was used in preference to iron fixtures and fittings wherever possible, to reduce the risk of sparks causing an explosion. This practice even extended to the use of copper barbed wire, a strand of which was found attached to a telegraph pole to the south of the building.

The upper conduit tunnels (Figures 8, 10 & 11)

The washing house was served by a Y-shaped arrangement of conduit tunnels, passing through the traverse on the north side of the building, and forming a right angle at their junction. The western branch led from No. 1 Nitrating House, the eastern branch from No. 2 Nitrating House. Nitro-glycerine and soda water were fed downhill from the active nitrating house along a 54m length of lead gutter. This was supported on wooden trestles across open ground, and on iron brackets set into the brickwork where it passed through the conduit tunnel. The gutter itself no longer survives, but the plank shelf and shaped wooden blocks on which it was carried survive *in situ* in the north-western conduit tunnel (Figure 12). The shelf is attached to the northern wall of the tunnel. The level of the gutter drops 0.37m over a distance of 11.55m (a slope of *c.* 1 in 30).

A short length of canvas cover survives at the junction of the northern conduit tunnels, still attached to the gutter shelf. It protected the gutter in the gap between the traverse wall and the roundhouse, which was open to the sky and is undoubtedly of the same type as the later form of cover used to protect the guttering in the open ground between the nitrating and washing houses (see above). In addition to the gutter fittings, a row of rectangular sectioned wooden beams are embedded in the brickwork along the full length of the tunnel, 0.47m above the floor, spaced 0.61m apart. Their function is uncertain, though they might perhaps have supported pipe-work connected with the mains water supply. Mains water was required in the washing house to maintain the flow of water to the drowning tank, to cool or warm the nitro-glycerine as necessary during the washing process, and for general cleaning purposes.[18]

The gutter fittings were probably removed from the north-eastern conduit tunnel at the time of the demolition of Nitration House No. 2 in 1907–8. A row of square sectioned beams, embedded in the brickwork and sawn off at the wall, 0.45m above the floor, probably served a similar function to the similar beams in the western tunnel, possibly as pipe supports. There are no traces of iron wall brackets in the north-eastern tunnel, suggesting that the gutter support



KEY

A Upper conduit tunnel from Nitrating House
B Gutter from Nitrating House
C Brick arch
D Earthwork traverse
E Level of washing tank access platform
F Level of washing tank platform
G Position of drowning tank
H Position of filtration tank
I Ventilation chimney
J Lower conduit tunnel to Mixing Houses via Junction House
K Steam pipe support hooks
L Gutter support brackets
M Junction House pit

Figure 10.
RGPF South Site. Nitro-glycerine washing house. Section B-B2.

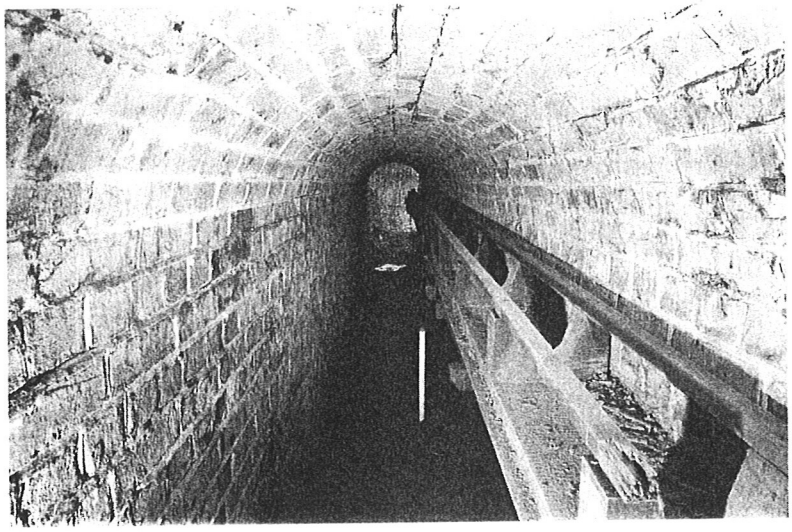


Figure 11. RGPF South Site. View along the north-west conduit tunnel of the washing house in 1996 (looking north-west), showing the nitro-glycerine gutter supports, attached to the north wall. The wooden shelf rests on iron brackets set into the brickwork (photograph by N. Macbeth for Essex CC).

arrangements surviving in the north-western tunnel are a late adaptation, probably associated with the conversion of Nitrating House No. 1 to the Nathan–Thomson–Rintoul design in 1903–4.

The 1.0m wide gap separating the roundhouse wall from the traverse revetment wall, housed any fittings that could not safely be installed inside the building, including electrical wiring for the internal lighting. An asbestos-lagged iron pipe and stop-cock, attached to the revetment wall on the northern side, is probably connected with the mains water supply, since a photograph of the washing house interior, taken in 1903, shows what appears to be a water tank, mounted on the interior wall, corresponding with the position of the externally mounted stop cock (Figure 7).

Construction of the washing house (Figure 8)

The roundhouse is of timber frame construction with a weather-boarded exterior. The interior of the wall is lined by vertical wooden boards. The upright posts of the timber frame are set 0.61m apart. The roof is timber boarded and covered externally by galvanised metal sheeting. The rafters rest directly on the wall plate, joining in a crown at the apex of the roof, and are braced against any lateral movement by short spacing timbers.[39] The relatively flimsy construction of the roundhouse was designed to provide minimal resistance to an explosion.

Lighting and heating

The building is lit by small, square windows around the top of the wall, hinged at the top and held open by wooden props when required for ventilation. There are also two five-light roof windows. Artificial lighting was provided by five electric 'danger building' lights, enclosed within glass globes lined with chicken wire. Of these, one survives intact. The bottom of the glass globes was originally filled with water, mixed with a small amount of glycerine to prevent freezing. This design was probably first introduced to the RGPF in the 1880s.[40] The cables for the lights run around the inside of the traverse revetment wall at roof level. They are connected to a cast-iron switch box formerly mounted on a timber

Figure 12. RGPF South Site. Interior of the Quinton Hill nitro-glycerine washing house in 1996 (looking north) (photograph by N. Macbeth for Essex CC).

'telegraph' pole on top of the mound, to the north, which was connected to the overhead power supply by Cordeaux type insulators with a single groove on the side and top, by Bullers Ltd, London.[41]

The washing house was heated by steam pipes, entering the building from the south via the lower conduit tunnel. The steam was probably pumped from the Cordite Section boiler and dynamo house (Figure 4, 527). Electrical power for the lighting was presumably supplied from the same source.

The washing house interior (Figures 7, 8 & 12)

The internal diameter of the washing house is 6.7m. At the north end of the building are the remains of a raised wooden platform with two levels, the lower of which formerly supported the washing tanks. Because of the weight of the tanks, the horizontal supports of the lower platform pass through the roundhouse wall and are set into the brickwork revetment.

The upper level, which is raised 1.89m above the floor, allowed process men access to the washing tanks. The 1903 photograph (Figure 7) shows that two step ladders, one on either side of the washing tanks, were mounted against the front edge of the platform, which survives in part on the north-east side of the building (Figure 12). Marks on the wall above the platform indicate the location of water pipes and a bench seat, which are also shown in the 1903 photograph.

The filtration tank was supported on a platform *c.* 30cm above floor level, no trace of which now remains (Figure 7). The washing tank platform is raised 1.40m above the floor surface. It was originally supported on four pairs of upright timbers (of which three posts remain *in situ*). The positions of the washing tanks are indicated by the fittings associated with the washing tank skimmer dish. The latter include two circular marks on the roof, with four brass screws remaining *in situ* on each, indicating the former position of fixed points from which the skimmer dish for each washing tank was suspended. There are also two circular holes, protected by lead 'eyes', located just below the wall plate, through which the skimmer dish pulley cables were carried outside the roundhouse to a counterweight (Figure 6).

The gutter from the nitrating house was originally linked to the washing tanks by an indiarubber pipe which connected to a fixed brass socket on the inside of the roundhouse wall. The socket remains *in situ c.* 0.6m west of the gutter terminal, just below the level of the wall plate. It passes through the roundhouse wall and is connected to a broken lead pipe. The pipe presumably linked to the gutter terminal via a 0.05m diameter hole drilled through the bottom of the gutter shelf.

Two wooden, stave-built barrels, bound by iron hoops fixed with copper nails, are preserved inside the building. Both are washing tanks, though neither is *in situ*, and both have had their lead lining removed. The tanks are 1.22m tall and have an internal diameter of *c.* 0.98m. The barrels each have two drain holes; one at the base, for drawing off the nitro-glycerine, and one 0.15m up from the bottom, for draining the wash waters (Figure 6). Originally the tanks were fitted with earthenware cocks. By 1903 these had been removed and replaced with moveable rubber pipes. When not in use, the pipes were bent upwards and attached to a socket on the front of each tank, to prevent any spillage of residual nitro-glycerine (Figure 7).

Compressed air, used to agitate the wash waters, was probably fed into the tank through a small-bore lead pipe, which pierces the barrel side at the bottom. To facilitate drainage of the nitro-glycerine, a groove ran around and bisected the base of the tank, which sloped down towards the nitro-glycerine drainage outlet.

A series of small pegs around the top of each barrel secured the hood by which the fumes were contained. A shallow, curving groove, cut into the top edge of each barrel may have been used to steady the indiarubber connector pipe, linking the nitro-glycerine gutter with the washing tank. During the washing process, the temperature of the wash water could be varied by pouring in warm or cold water, via a mains water pipe fixed to the side of each tank. The only surviving traces of these pipes are attachment marks on the roundhouse wall.

The filtration tank has been removed from the washing house without trace. However, the 1903 photograph of the washing house interior (Figure 7) clearly shows the tank, mounted on a low timber platform, with its rim slightly below the level of the nitro-glycerine drainage outlet on the washing tank, so that the nitro-glycerine could run between the tanks by gravity. The filtration tank is similar in appearance to the washing tanks, except that the sides converge slightly towards the top. The photograph also appears to show that the iron binding straps on all three tanks were enclosed by sheaths of lead or copper, to prevent sparking.

A lead-lined, wooden, rectangular drowning tank, kept full of cold water, was originally placed below the raised platforms, although no trace of it now survives.[42] The 1903 photograph (Figure 7)

shows that it extended underneath both washing tanks.

A wooden chalk board was found loose inside the washing house. The writing surface is divided into a table with headed columns, and rows numbered down the left hand side (as below). The board was used to keep track of the weight, temperature and settling times of each charge.

Two steam radiator pipes formerly ran around the inside of the roundhouse on the east side. An associated cast-iron condensing box is located adjacent to the southern conduit tunnel, in the gap between the traverse revetment and the roundhouse. Steam was pumped into the radiator pipes through a steam service pipe attached to the east wall of the lower conduit tunnel.

The lower conduit tunnel (Figures 8 & 10)

A conduit tunnel on the south side of the building housed the lead-lined outlet gutter, which was used to carry away the washed and filtered nitro-glycerine and the contaminated wash waters. Neither the gutter nor its timber shelf survive, though a series of iron brackets on which it rested are *in situ*. The level of the gutter support brackets drops by 0.45m over a distance of 13.1m (a slope of c. 1 in 30). A row of iron hooks, attached to the brickwork at a level slightly below the gutter support brackets, supported a steam service pipe. Two rows of square-sectioned beams, embedded in the brickwork at 0.61m intervals, all of which have been sawn off at the wall, probably reflect successive changes to the guttering and pipe-work in the tunnel.

The junction house and covered way (Figures 5 & 8)

Immediately to the south of the tunnel exit is a circular, brick-lined pit, 4.65m in diameter, which is all that remains of the junction house, built after the 1894 explosion. Photographs of the junction house taken in 1903, show a small rectangular or square, weather-boarded timber shed, with a wooden, stave-built tank mounted inside. The nitro-glycerine was transferred from the washing house gutter into the tank, then dispatched to one of the mixing houses along a gutter mounted inside the covered way. The latter was a long, narrow weather-boarded timber shed, housing a nitro-glycerine gutter and steam pipes. Both the junction house and the covered way were sunk within trenches below ground level. The transfer of nitro-glycerine between the gutter terminals and the tank in the junction house was carried out manually, using moveable indiarubber pipes.

DISCUSSION

The Quinton Hill plant formed part of the first government cordite factory. As one of only two buildings surviving from the early factory, the washing house is a historic building of national importance. The survival of many internal fittings from the turn of the century makes the washing house unique in Britain. The building has scarcely been touched since it went into reserve in 1907–8, except to strip out most of the extensive lead fixtures and fittings. The excellent state of preservation has been due partly to continuous government ownership of the site, ensuring restricted public access and protection from redevelopment, and partly to the difficulties of demolishing a building set in the centre of an explosives factory. As nitro-glycerine was thought to have leaked into the underlying soil after the 1894 explosion, the washing house was seen as a particular risk in this respect.

The primary sources of information about nitro-glycerine manufacture at the turn of the century are the technical papers of the time. These also provide specific information about buildings and equipment in use at Waltham Abbey, which was used as a model factory by private manufacturers as well as government establishments. Also of specific relevance to the washing house survey is the Sandhurst committee report on the explosion of 1894, which includes a plan and section of the proposed design for reconstructing the washing house and nitro-glycerine store. There are significant differences between this design and the structure finally built. The present survey

N.G.HOUSE											
TEMP'R P. WASH					TEMP'R		TIME OF SETTLING				
1st	2nd	3rd	4th	5th	MAX	MIN	1	2	3	4	5

Figure 13. Waltham Abbey RGPF. Late 19th century cordite workers, posing with an acid bogie and carboy (MOD photograph).

has highlighted a good deal of otherwise unrecorded detail, such as the original positioning of the washing tanks, the actual slope of the nitro-glycerine gutter and the means by which the nitro-glycerine was transferred from the gutter into the washing tanks. It is clear that the plant was subject to constant adaptation and improvement during its period of use, and some of these changes are apparent in the surviving structure. For example, the rows of wooden beams embedded in the brickwork of the conduit tunnels, hint at earlier forms of guttering than that surviving in the north-west conduit tunnel.

The survey has also recorded many ancillary features not directly related to the production processes, such as the danger building light fittings, the heating system and the shoe room. The design of the building demonstrates an overriding concern with safety. Many of the features incorporated into the rebuilt washing house after the explosion of 1894, such as the use of an earthwork traverse instead of a brick one, reflect the lessons learned specifically from that disaster. Other safety features, such as the widespread use of brass, instead of iron, for making screws, barbed wire and numerous other fittings to reduce the risk of sparking, had long been used at Waltham Abbey RGPF.

Highly visible warning signs, red painted doors, and lists of regulations were a common feature of danger buildings. By 1908, for instance, it was considered vital to keep heavy or hard loose tools out of the nitro-glycerine houses. As an aid to enforcement, 'Use Lists' of permitted equipment were posted by the entrance to each building. The only articles permitted in the washing house were 6 rubber buckets, 6 gutta-percha bucket covers, 3 flannels, 3 pairs of rubber overshoes and 3 thermometers. The same board also listed the quantity of explosives and the number of men allowed inside the building in accordance with safety regulations laid down by 'His Majesty's Inspectors of Explosives'.[43]

Postscript

In January 1996 planning proposals were submitted for the demolition, remediation and redevelopment of the 158 hectare South Site. Given the potential national importance of the complex a decision on the planning application was deferred pending an archaeological and building appraisal. Based on the advice given in Planning Policy Guidance Notes 15 and 16,[44] the record comprises historical research, a component sheet for each of the *c.* 500 buildings and structures, a computer generated CAD diagram with seven historic layers and a written report. This appraisal enabled English Heritage to make a decision on future policy for the site, and the buildings were recorded in greater detail before demolition and redevelopment. However, the nitro-glycerine washing house was dismantled so that it can be re-erected on the North Site, 1.5km to the north. Here, a programme of conservation as a heritage centre is being carried out by Waltham Abbey Royal Gunpowder Mills Ltd, using a

Heritage Lottery grant. Work is still in progress, but the plans for the heritage centre include reconstruction of the nitro-glycerine washing house for presentation to the general public.

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NOTES AND REFERENCES

Archive material relating to Waltham Abbey RGPF is held at four principal locations: Epping Forest District Museum, Waltham Abbey (EFDM); Ministry of Defence, Chessington (MOD Ch); Public Records Office, Kew (PRO) and Waltham Abbey RGPF (RGPF). Copies of RCHME report on the North Site can be obtained from the National Monuments Record at Swindon.

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Stuart Foreman *studied Archaeology and Anthropology at Durham University before becoming a Field Archaeologist. He was employed by Essex County Council Archaeology Section for five years and supervised an assessment survey of Waltham Abbey RGPF (South Site), including the survey of the nitro-glycerine washing house, presented here. The author is now working at the Oxford Archaeological Unit, where he hopes to continue his involvement in standing building recording and industrial archaeology. Address for correspondence: Oxford Archaeological Unit, Janus House, Osney Mead, Oxford OX2 0ES.*