

WASC 2349 ●

Railways of the
Royal Gunpowder
Factory

"Railways of the Royal Gunpowder Mills at Waltham Abbey" was first published in June 1989 as No.117 of the Industrial Railway Record. This new edition printed in conjunction with the Moseley Railway Trust has no changes in the original text. Appendices 1, 2 & 3 are added to bring the reader up to date with developments on the railway at the Gunpowder Mills.



ZLH locomotive in the woods on the North Site of the Gunpowder Factory with a rake of six cordite wagons. Note in the right foreground a large pile of cut Alder wood, which is indigenous to the site, drying in preparation for conversion to charcoal. (RARDE)

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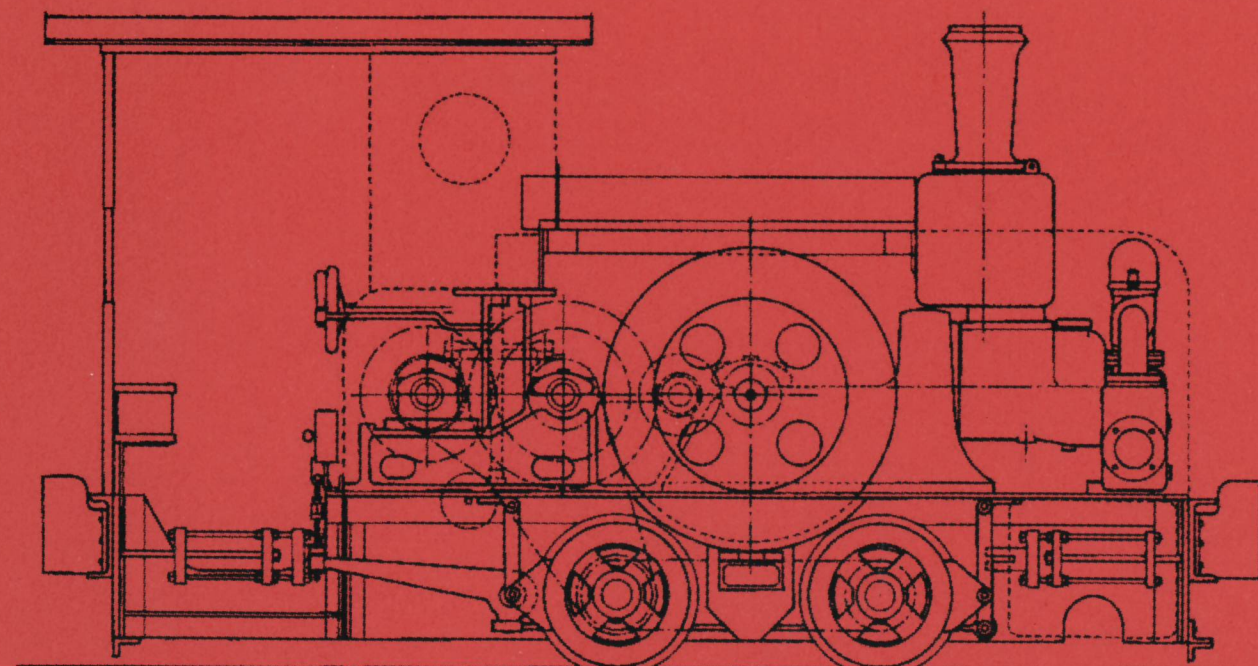
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RAILWAYS OF THE ROYAL GUNPOWDER FACTORY WALTHAM ABBEY

J.M. JENKINS



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**RAILWAYS OF THE
ROYAL GUNPOWDER
FACTORY**

WALTHAM ABBEY

J.M. JENKINS

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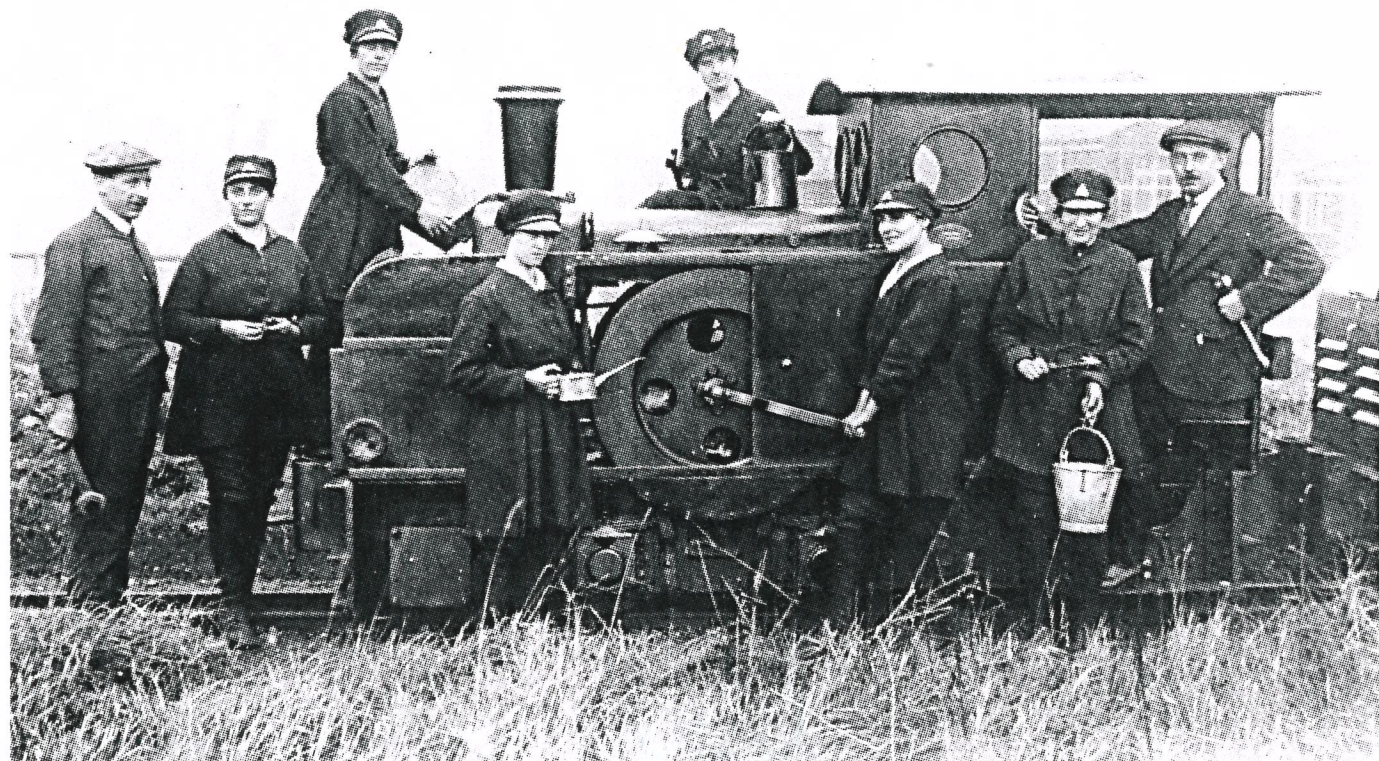
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The Ruston Proctor ZLH single cylinder locomotive shown above at the Gunpowder Mills is believed to have been photographed in 1917 shortly after the locos were delivered. Possibly this picture was captured one day after an initial training course for the women drivers. Many of the Mill's iconic photographs show women in charge of the trains. Carefully study every person; each individual is holding a spanner, oilcan, bucket, square petrol can etc. Note the open engine compartment door with starting handle located on the flywheel shaft. The louvred front engine cowling of another ZLH is just visible at the right of photograph. The brass triangular cap badge worn by the women indicated 'On War Service' and was distributed after 1916.

photograph Ray Sears

THE RAILWAYS OF THE ROYAL GUNPOWDER FACTORY, WALTHAM ABBEY

J.M.JENKINS

Introduction

Although employed for many years in the Government Research Establishment at Waltham Abbey, Essex, I successfully managed to ignore the remains of the narrow gauge railway system which operated in the Royal Gunpowder Factory (RGPF), before the site became the Royal Armament Research and Development Establishment (RARDE). When I paid a visit in late 1985 to the North Woolwich Railway Museum, one of the exhibits was a map entitled *Railways from Tottenham to Cheshunt* compiled by D.J.Taylor of the Great Eastern Railway Society in 1977. This map showed that there was a standard gauge connection from the Great Eastern main line at Brimsdown, through the Royal Small Arms Factory at Enfield, to the narrow gauge railway system in the Royal Gunpowder Factory. The transfer sidings between the standard and narrow gauge railways were located adjacent to a river wharf, on the boundary between the two factories.

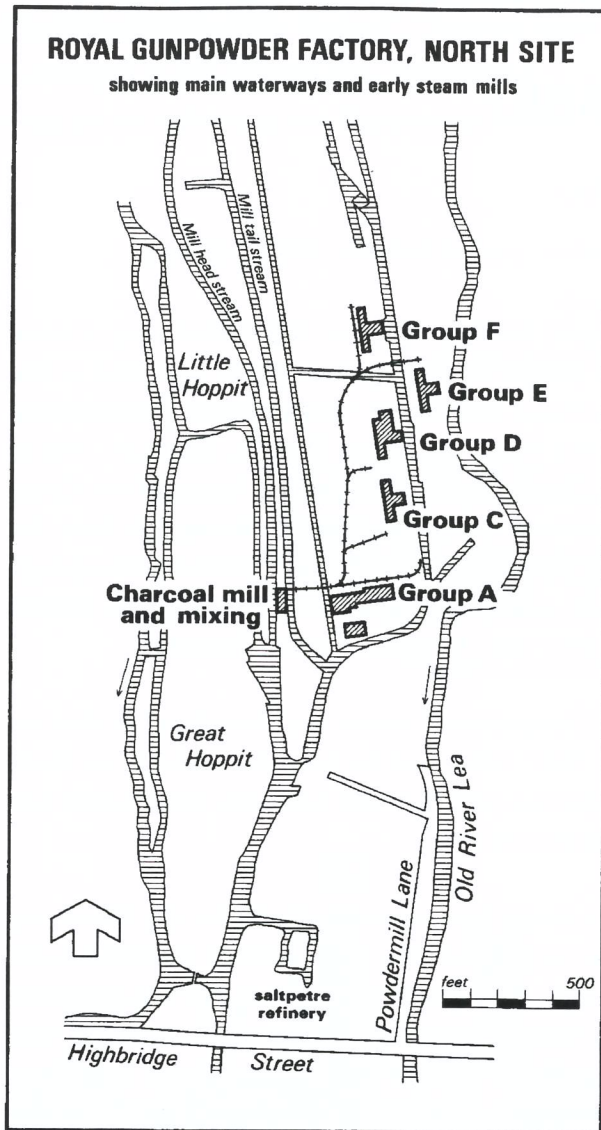
My interest was aroused in the internal railways of the Royal Gunpowder Factory and the object of this account is to record how its rail system grew during the period 1857-1943, and to describe some of its more unusual features, many of which were determined by the dangerous nature of the products transported and the presence of an extensive waterway system throughout the factory site.

Waltham Abbey is situated close to the River Lea, which here forms two separate channels; the River Lea Navigation and the 'Old' River Lea. The Gunpowder Factory, and more recently the Research Establishment, occupy a long site between the town and the River Lea Navigation. The Factory is divided into two separate areas known as the North Site and the South Site. The early operations were concentrated in what is now the North Site, and a map of this area is given overleaf to assist readers with the geography of the Establishment in its early days. The layout of the complete Factory can be seen from the 1923 maps shown on pages 28 and 29.

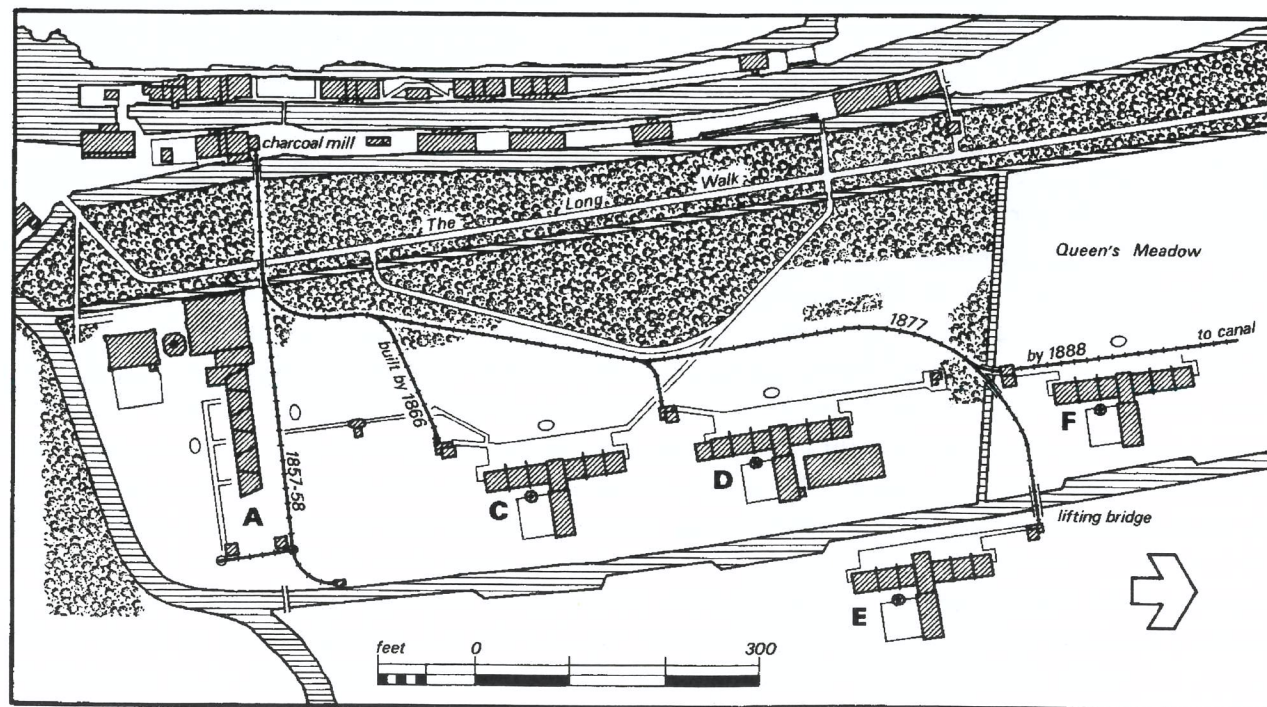
The Early Tramways

The origins of the Royal Gunpowder Factory stretch back to at least the mid 17th century. Until the second half of the 19th century, its sole product was gunpowder in its various forms; as an explosive or as a propellant for guns of all types and for rockets. In all this time, the transportation throughout the factory relied entirely on the waterways and hand carriage. In other industries, the development of tramways and railways was seen as essential as they provided a rapid and cheap form of transportation of raw materials and finished goods, both within factories and onward to customers. Collieries, iron and other works were very dependent on railways of some form or other from the late 18th century. The Royal Arsenal at Woolwich, which was under the same management as the Royal Gunpowder Factory (The Director General of Ordnance Factories) had iron railways from 1824. It would appear that the Royal Gunpowder Factory was reluctant to adopt a rail system, presumably because the existing waterway network was adequate to cope with the amount of production.

The development which appears to have precipitated the installation of a railway was the building of a new steam powered gunpowder mill on the North Site in 1856-7. Up until this date, all the mills at the Royal Gunpowder Factory had been water powered. The decision to install steam power may have been associated with the increase in demand for gunpowder caused by the Crimean War, which started in March 1854, and



Early maps showing the first tramways of 2ft 3in gauge that were to be the start of the later 1ft 6in railway system.



the consequent expansion of the Woolwich Arsenal.

The earliest reference found so far to any sort of tramway or railway is on a plan dated 19th January 1856, in the RARDE Waltham Abbey Historical Collection. It shows 'the dimensions and position of the proposed new buildings at Waltham Abbey'. This plan is of the new steam powered gunpowder mill that was later called the Group A mill. It depicts a raised tramway down the north side of the building, with two turntables at its eastern end adjacent to two magazines. Furthermore, the plan shows the cross section of the rail described as 'tramway iron' at full size. Such bridge rails, as they were called, were not uncommon at this time. No further reference has been found to this type of rail being used at the factory so perhaps it was never laid, or for some reason was replaced soon after laying. Other features depicted on the plan are the gunpowder mixing house at the start of the tramway, and the side view of the tramway platform over the mill tail stream. The drawing also indicates why this tramway and later ones were on raised platforms; a detail shows that the flood level was one foot above the ground level in the vicinity of the new mill.

The first stone of the new steam mill was laid on the 1st March 1856 so it can be assumed that the tramway did not operate before 1857 or even 1858. The earliest map which shows the tramway was drawn in February 1859.

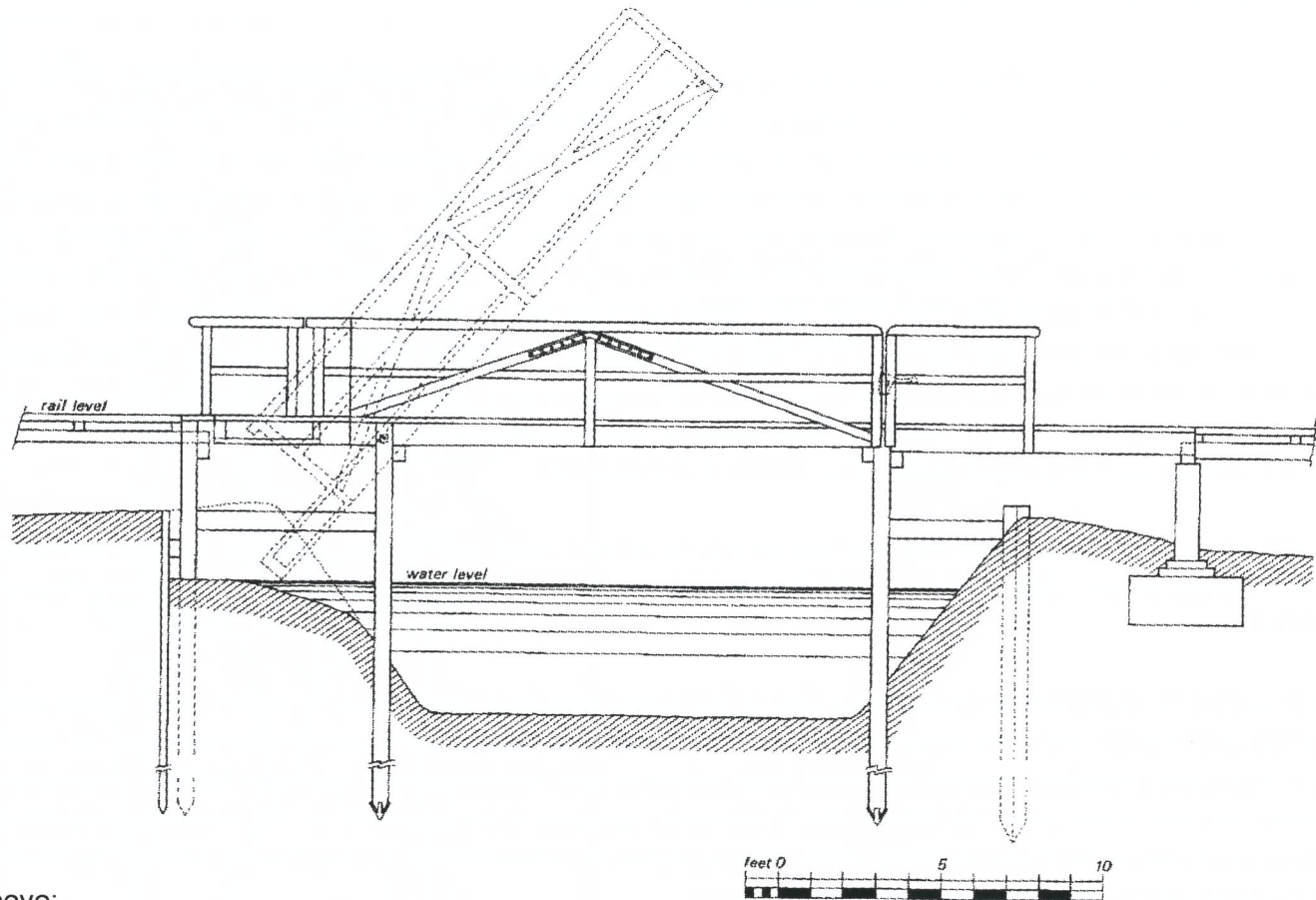
At this point it is necessary to discuss the use of the terms tramways and railways. On the early maps and drawings which show any form of railway the terms tramway and railway were used indiscriminately for what was a manually propelled system. An 1888 map refers to both tramways and railways, but the distinction between the two is not clear. By World War 1, tramway appears to be reserved for the manually propelled sections and railway for those sections which were suitable for locomotive or tractor hauled trains. The World War 1 usage will be adopted throughout this account.

The original tramway which connected the charcoal mill and gunpowder mixing house to the new steam incorporating mill was only about 600 feet long, and its function would probably be to convey the loosely mixed ingredients of gunpowder (charcoal, saltpetre, and sulphur) rapidly and safely from the mixing house to the incorporating mill. There the mixture or 'green charge' would be subjected to heavy rolling for several hours to give a homogeneous mix in the form of a hard cake known as 'mill cake'. The mill cake was then broken up carefully and placed into wooden tubs, which were stored in small magazines, prior to the next stage in the manufacturing process. Almost certainly, the tramway was also used to transport the mill cake to the two small magazines associated with the Group A Mill. On a map dated 1866, the relationship between the magazines, the steam driven incorporating mill, and the mixing house are clearly seen. This map also shows that the tramway ran on a platform for its whole length and that the wagons or trucks were turned by small turntables; these two features were to persist in the rail system of Waltham Abbey for many years. The 1866 map also reveals that a branch line had been built, which extended the tramway from the mixing house to the new Group C steam operated mill built in 1861.

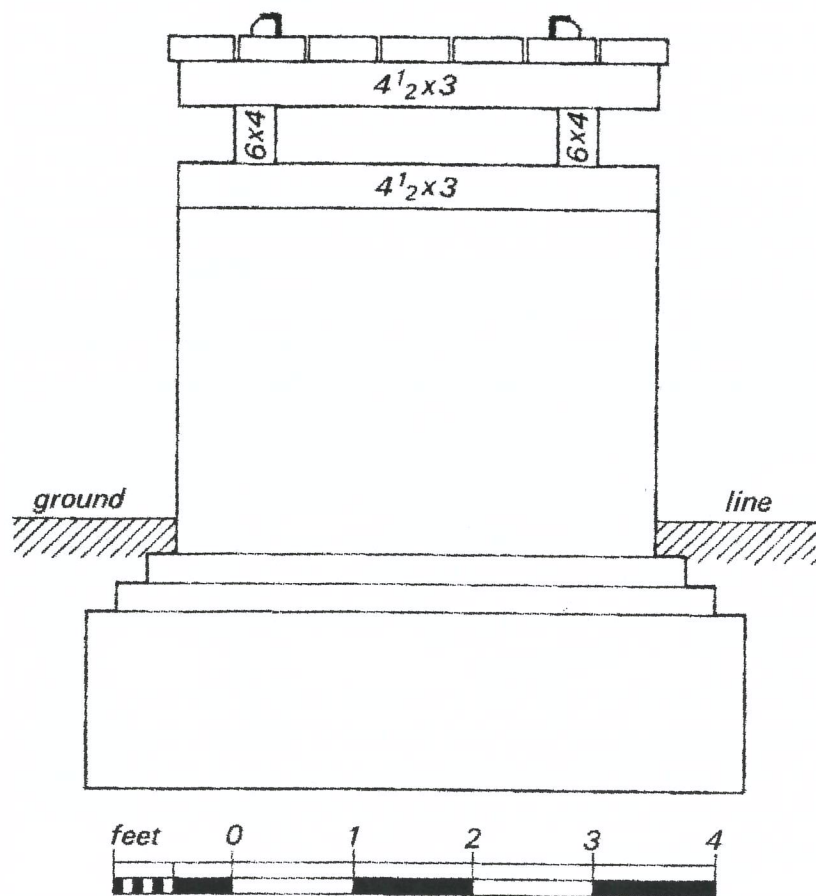
In May 1861, there was an explosion in the Group A Mills and a report, with sketch, appeared in the Illustrated London News of 8th June 1861. The engraving shows a round topped truck which was probably of the type used on the tramway. It is very similar in outline to that shown in a Strand Magazine photograph of 1895. The latter illustration also serves to give an impression of the tramway on a platform outside an incorporating mill.

During the period 1857-88, the number of steam incorporating mills was increased and the tramway was extended to join them. A novel feature of the tramway system at this time was the use of a lifting bridge over the canal which ran between the Group C, D and F Mills and the Group E Mills. On a plan dated 1877, showing the extension of the track on its platform to the new Group E Mills, is a drawing of the bridge over the canal. The bridge opened in the fashion of a drawbridge. (see page 6)

Part of the lifting bridge drawing gives details of the construction of the tramway platform. Close inspection



Above:
The lifting bridge from a drawing of 1877. The bridge was on the tramway extension to the Group E gunpowder mills.



Left:
The construction of the tramway platform, from the 1877 tramway extension drawing. The wooden rails are spaced at 2ft 6in centres giving a gauge of 2ft 3in between the inside faces.



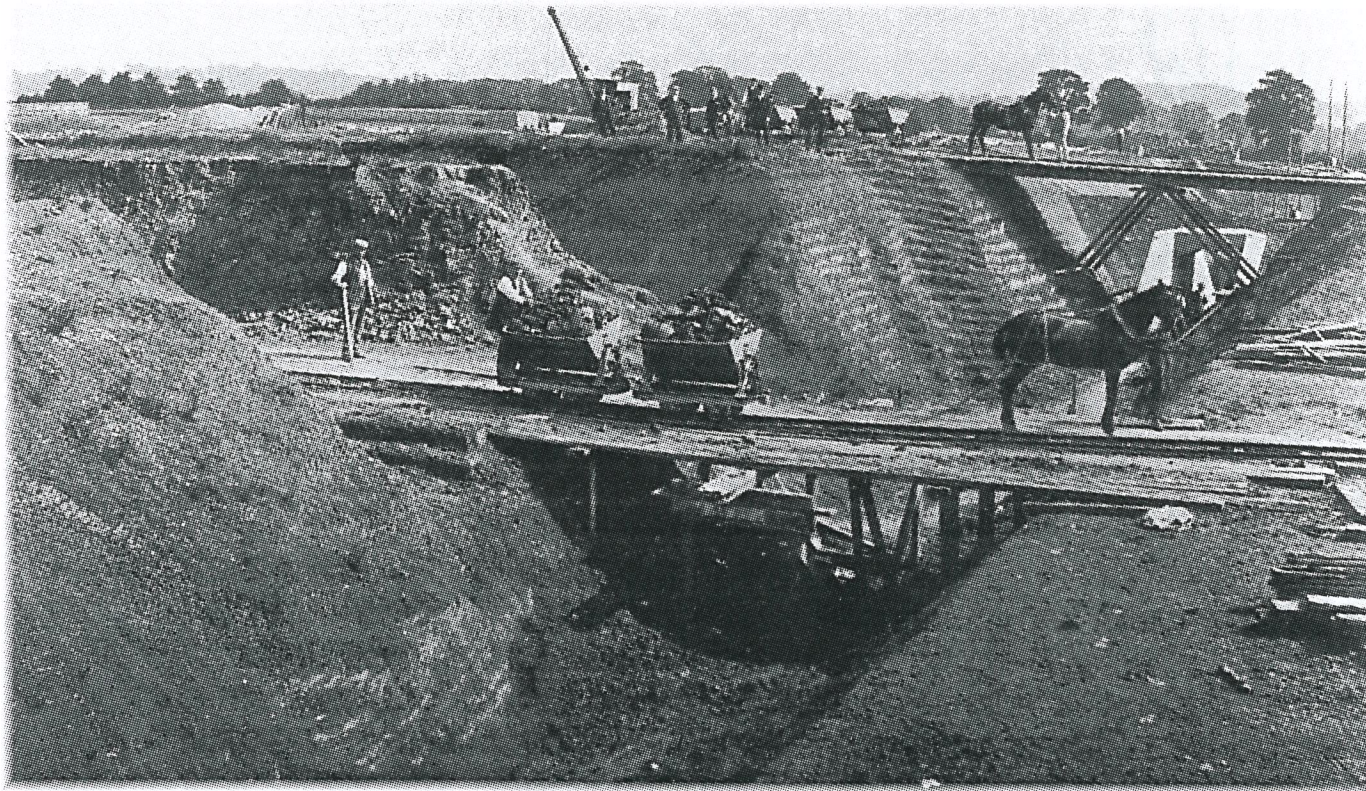
This photograph, which appeared in the Strand Magazine in 1895, gives a good impression of the wooden track and hand-propelled wagons in use at that time. The gauge of the track is thought to have been 2ft 3in.

indicates that the rails were wooden battens with the upper and inside surfaces protected by metal cladding of right angular cross section. Such rails can be seen in a photograph dated 1892 of the tramway outside the Group G Mill. The practice of armouring wooden rails with iron or other metal was adopted possibly as early as 1716 in colliery tramways, but must have been unusual in the late 19th century. The drawing also indicates that the gauge of the tramway was 2ft 3in, and that the platform upon which it sat was 4ft wide.

By 1888, the tramway linked the gunpowder mixing house with the Group A, C, D, E and F Incorporating Mills, and extended to the new canal cut, which terminated by the Group F Mill and its associated magazine. A drawing of the tramway bridge over Cobbins Brook dated August 1888 shows that solid metal rails of conventional cross section were being employed here. They were probably of steel by this time as steel rails became readily available in the 1860's. Thus in the 1880's and 1890's at least two types of rail were in use, conventional steel and clad wood. The latter appears to have been reserved for the track on the raised platforms, and photographs indicate that the clad wood was ultimately replaced by conventional steel rails.

A detailed drawing dated 1879 of the terminus at the new canal cut shows that a run round loop was necessary to allow trucks to stand outside the magazine without interrupting the return flow of trucks to the mills and mixing house.

By 1888, there appear to have been two new rail systems not connected with that already described; one



The two photographs above show the construction of the South site cordite stove complex, with horse drawn tipping wagons in use. (RARDE)

to link the Group H press house with magazines on the canal, and the other on the South Site of the factory which was described as a tramway. This tramway ran from a wharf on the old River Lea to the gun shed by the proof butts. These butts were part of the firing range used to assess the quality of the gunpowder and guncotton produced in the factory. The total length of rail system, including this tramway, was still not more than a mile.

The Advent of Cordite Manufacture

The factory began manufacturing the new explosive, guncotton, in the early 1870's. The first expansion, of the factory took place in 1885 when the North Site production of guncotton was found to be inadequate, but there was no significant extension of the railway system until the beginning of cordite manufacture at the factory in the 1890's.

Guncotton, or nitrocellulose, is manufactured by treating cotton with a mixture of nitric and sulphuric acids. Cordite is an explosive manufactured by the combination of guncotton with nitro glycerine, using acetone as a solvent. The main changes at Waltham Abbey consisted of the building of the guncotton works south of Cobbins Brook, the Quinton Hill nitro-glycerine factory, the cordite blending houses and the cordite drying stoves on the South Site. Following an explosion in the South Site nitro-glycerine factory on the 7th May 1894, there was a Committee of Inquiry into the accident, and Appendix 1 of that Committee's Report shows the extent of the South Site tramway at that time. This tramway is also clearly shown on the Ordnance Survey map of 1897.

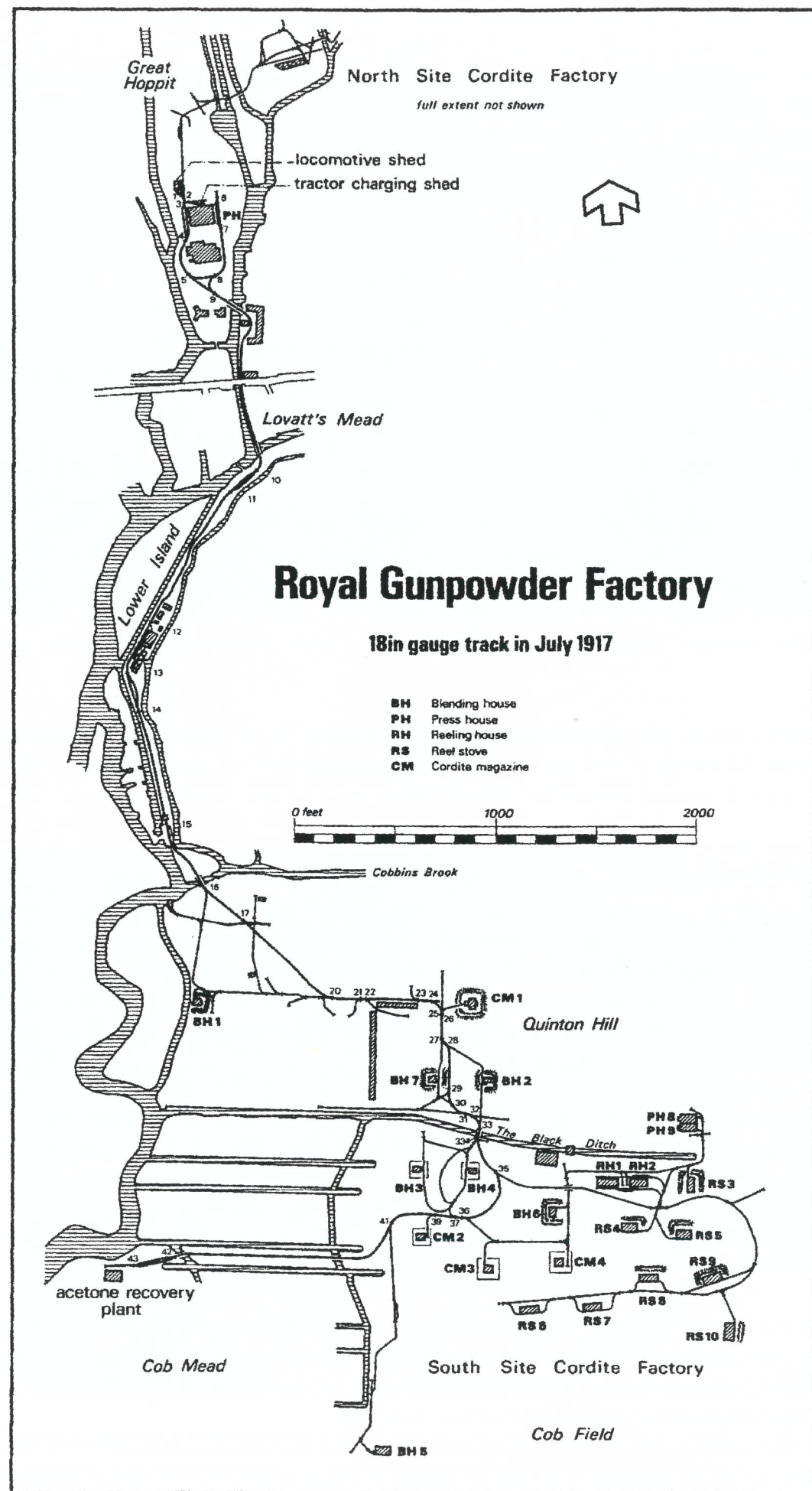
During this period, another nitro-glycerine factory was established on the North Site, and many of the existing steam powered gunpowder mills were converted to the manufacture of cordite. By 1911, the length of the tramway lines had increased substantially, although there were still many areas not served by them.

On the South Site, there were connections between the mills on Lower Island Way, the guncotton works by Cobbins Brook, the nitro-glycerine factory, and the cordite blending houses and magazines. There were no rail connections, however, amongst the thirty or so cordite tray stoves which removed the solvent used in the manufacture of cordite stick. The whole of the cordite tray stove complex was served by a system of canals off the River Lea. The internal transportation on the North Site was also still very dependent on the waterways. There was no rail link between the nitro-glycerine factory and the cordite stoves in Edmondsey Mead at the very north of the North Site, and no railway between Edmondsey Mead and the newly converted cordite factory based on the Group A to F Mills and press houses.

Tramway connections were established between these mills and the new cordite reel drying stoves and magazine built in 1904 on Great Hoppit Island. The original tramway between the gunpowder mixing house and the Group A Incorporating Mill had been severed by 1897, but the Eastern part was used to provide the link between the Group A to F Mills and new facilities on Great Hoppit Island. Although the extent of the track increased very substantially during the period prior to World War 1, there appears to have been very little change in the operation of the tramway.

The trucks continued to be manually propelled and as yet no evidence has been found of trucks being towed by horses or by any other means, except during the construction of the South Site cordite stove complex. A photograph taken at this time clearly shows that horse drawn tip wagons were used, possibly on temporary track as the project involved the excavation of a canal network.

The factory rules of 1914 emphasise the need to keep the trucks clean and for good housekeeping. The



trucks were to be pushed, not pulled, and workmen were instructed not to go faster than a walk. The rules also indicate that there were different trucks for different purposes, and that great care had to be taken with trucks containing dry guncotton or cordite paste. If trucks containing these materials were derailed then 'the assistant foreman or superior authority...to be informed at once to superintend'. The dry guncotton or paste had to be removed from the derailed truck before re railing was attempted. Derailment seems to have been a problem at times. In 1891 a memorandum to the Superintendent of the factory stated that 'the turntables on the 18in gauge tram line are very unsatisfactory. They continually throw the trucks off line, they jolt them in a very violent manner, and the catch is liable to catch the trucks. They also harbour water and in wet weather splash most disagreeably.' The Superintendent took note and instructed that the turntables be replaced with others of improved design.

The reference to 18in gauge in the 1891 memorandum is interesting, as it shows that the 2ft 3in gauge of the early gunpowder mill tramways was not used in later developments. Possibly the narrower gauge was introduced at the same time as the factory extensions associated with cordite manufacture. Problems with the tramways were experienced in this period, such as rails being laid in the wrong direction in part of the cordite factory, and there was some discussion as to whether rails in the cordite re reeling house should be of brass rather than steel for reasons of safety. The Superintendent supported the use of brass rails, but the Director General of Ordnance Factories considered them unnecessary. The Superintendent then issued an instruction to the Building Works Department stating that 'scraps of cordite fire under the trucks when steel rails are used... If such an accident were to happen inside a house which is full of dry cordite, the consequences might be serious. It would be better to use wooden rails if not brass.' Wooden rails were employed and the remains of such rails laid in World War 2 could still be found in the Establishment in 1989.

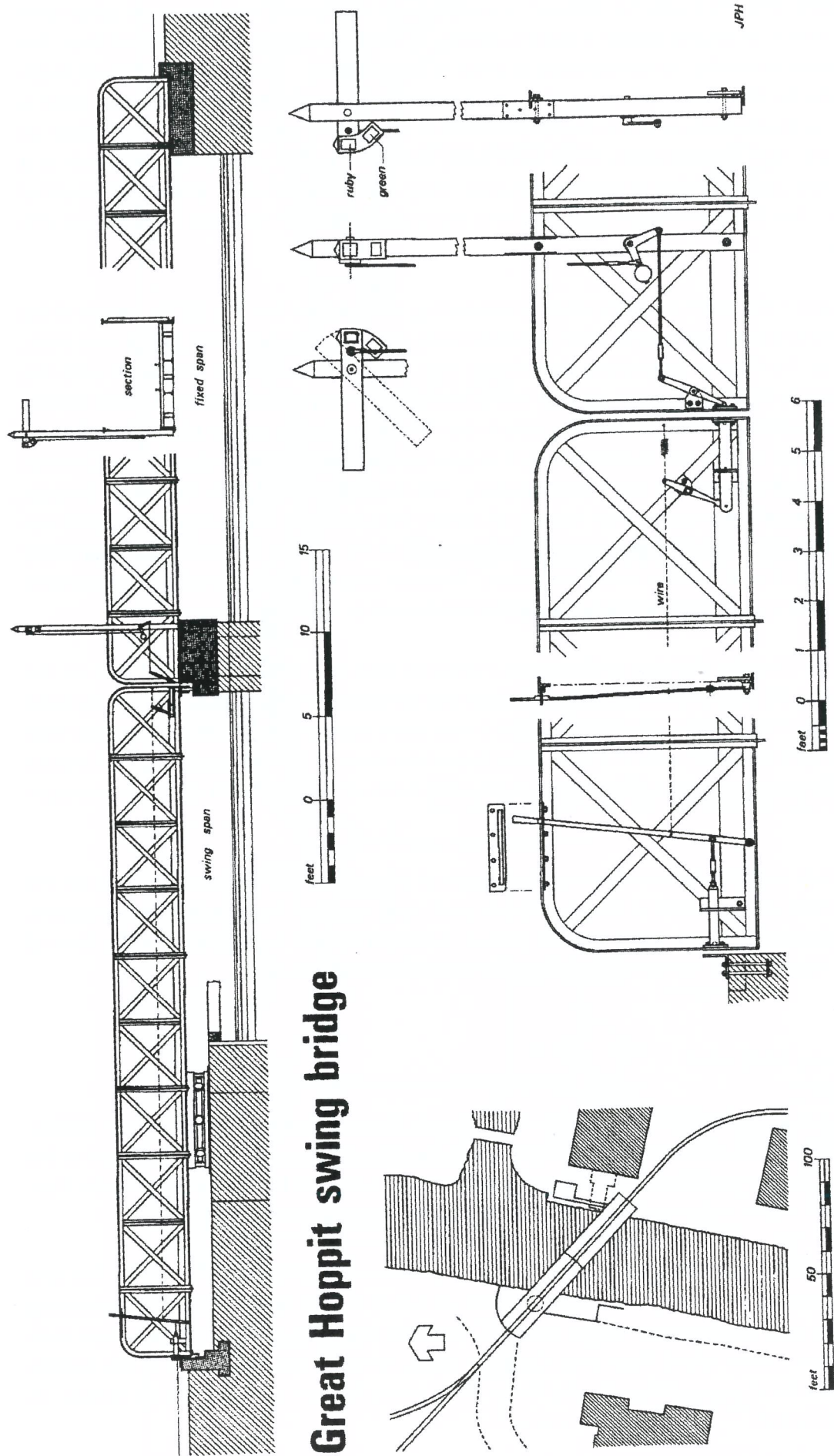
The Superintendent and the Director General of Ordnance Factories also had differences of opinion on the safety or otherwise of moving 75 pound lots of mixed guncotton and nitroglycerine by railway truck or by hand barrow down a steep incline. The Director General thought it was more dangerous in a truck, and two men should carry the box on a light stretcher, one at a time. The Superintendent of the factory noted the Director General's comments and presumably acted upon them. Such were some of the problems of senior management at that time.

The construction of the track appears to have been of two types at the end of this period. The track on the ground consisted of steel rails with a weight of 20 pounds per yard, held together by pressed steel sleepers. On the elevated wooden platforms, similar steel rail was pinned or spiked directly to the platform, this form of track construction having replaced the earlier system of metal-clad wooden battens.

The Narrow Gauge Railway 1916 1917

During World War 1, major changes in the rail system took place with the building of a narrow gauge railway, suitable for lightweight locomotives, and interchange sidings with the standard gauge railway adjacent to the Royal Small Arms Factory. The construction of the narrow gauge railway between the Royal Gunpowder Factory's North and South Sites was a major undertaking requiring some unusual engineering features.

The new railway was planned in 1915-16 and appears to have been constructed mainly in 1916. The line was 1-5/8 miles long and started south of the cordite reel store on Great Hoppit Island. It ran a meandering course over the canal at the end of the Island, under the main Waltham Abbey to Waltham Cross road, over the old River Lea, then down Lower Island Way over Cobbins Brook, through the main body of the cordite factory, to a coal siding and interchange siding with the Royal Small Arms Factory standard gauge railway on the south west edge of the factory.



Great Hoppit swing bridge

The drawing of Great Hoppit swing bridge is based on 'Drawing No.E 120' dated 7th February 1917 (WASC 901/282), which details the locking mechanism and signal. The photograph on page 14 shows a few details which do not appear on the drawing, notably the curved stays which support the bridge sides, and the electric light mounted at deck level on the operating span, presumably for the benefit of boat traffic. Also missing on the drawing is a steam line, which was carried in brackets along the North side of the bridge and supported by truss rods across the opening span.

The map of the narrow gauge system (see page 10) indicates that the points were numbered, and it is assumed that the 'mainline' followed the lowest numbers, from 1 (by the North Site locomotive shed) to 43 (acetone factory). It is unlikely that locomotives could use all this track but it is assumed that they ran along the 'mainline', from Great Hoppit Island to the Royal Small Arms Factory interchange sidings. The railway was 18in gauge throughout, and those parts which were intended for locomotive haulage had heavier rail (30 pounds per yard), some of which was laid on lateral wooden sleepers. The minimum radius of curvature was 30 feet, compared with 25 feet for those parts which were not used by locomotives.

The first noteworthy feature of the new railway, travelling from north to south, was the two road engine shed located on Great Hoppit Island. There were new sidings by the shed, presumably to make up and break down trains of trucks for the South Site. How much further north beyond the shed the locomotives worked is not known. From the vicinity of the engine shed the line went due south, then swung round to the east on the swing bridge over the canal.

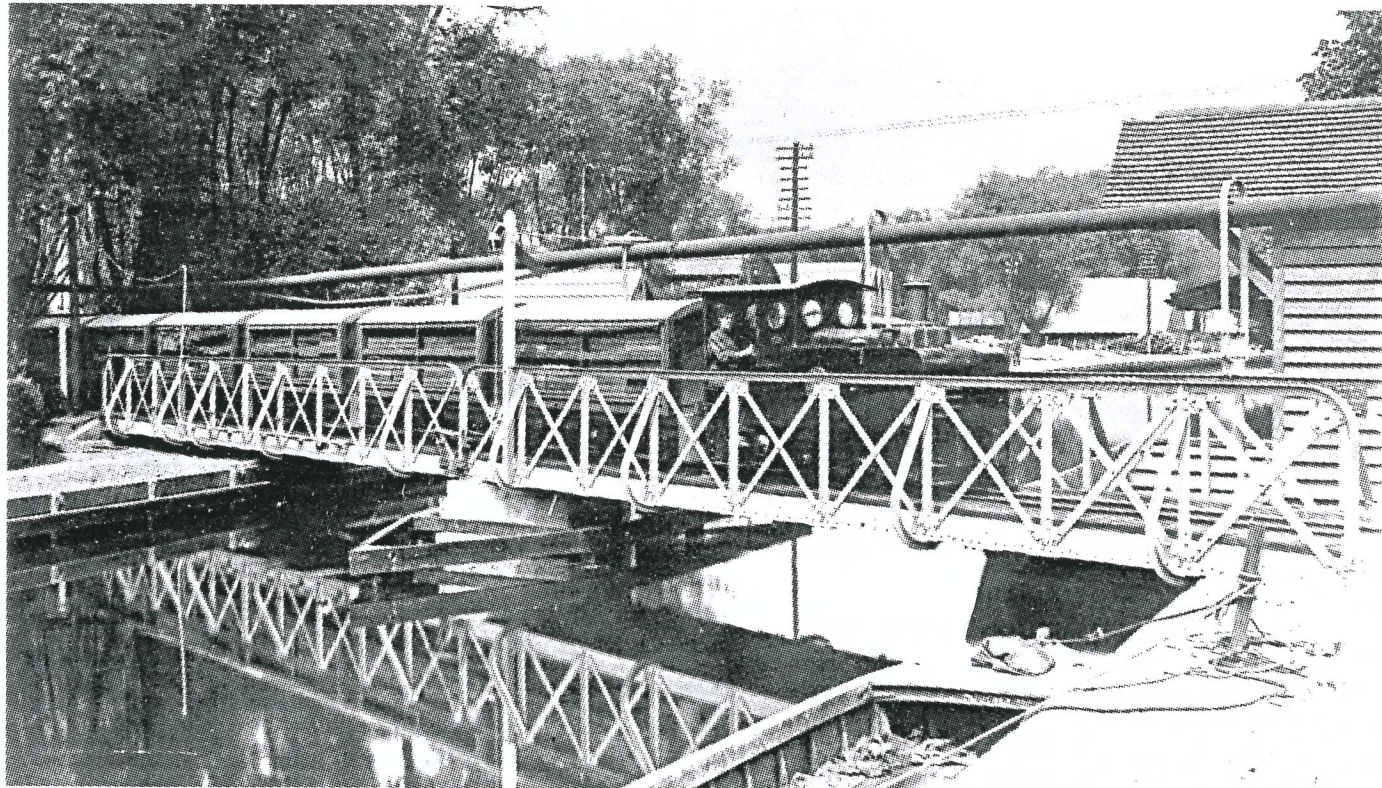
The swing bridge at Great Hoppit Island was necessary to allow water traffic access to the factory. The bridge was 76 feet long and split approximately half way along its length; the eastern portion being fixed, the other rotating about a turntable on the west bank of the canal. The two portions met at a concrete pier approximately in the middle of the canal. The swing span was operated by hand from the western bank. On the fixed span was a signal connected to the locking mechanism, so that if the swing span was not locked properly into position, the signal would remain at danger. It was impossible to move the bridge without operating the signal. (see opposite)

The bridge was constructed from steel lattice work with a wooden decking which carried the rails. Drawings of the bridge show the details of construction and the locking mechanism. After the swing bridge, the track headed south through a 64 feet radius curve between existing buildings, then dropped on a gradient of 1 in 60 to go under the main road that ran from Waltham Abbey to Waltham Cross. The gradient down to the tunnel was the most severe on the whole railway. The construction of the tunnel under the main road was no mean feat as it ran parallel to and alongside the river. A coffer dam had to be built in the river leaving a passage just wide enough to allow boat traffic to pass, and to permit work on the relocation of the town sewer and gas main which went under the river at this point. The tunnel and its approaches were concrete lined to make them water tight, as the track level at its lowest point was 3 feet below the normal water level of the river. The proximity of the railway to the river in the tunnel and the approach cuttings can be seen from the photograph on Page 18 and drawing on Page 15.

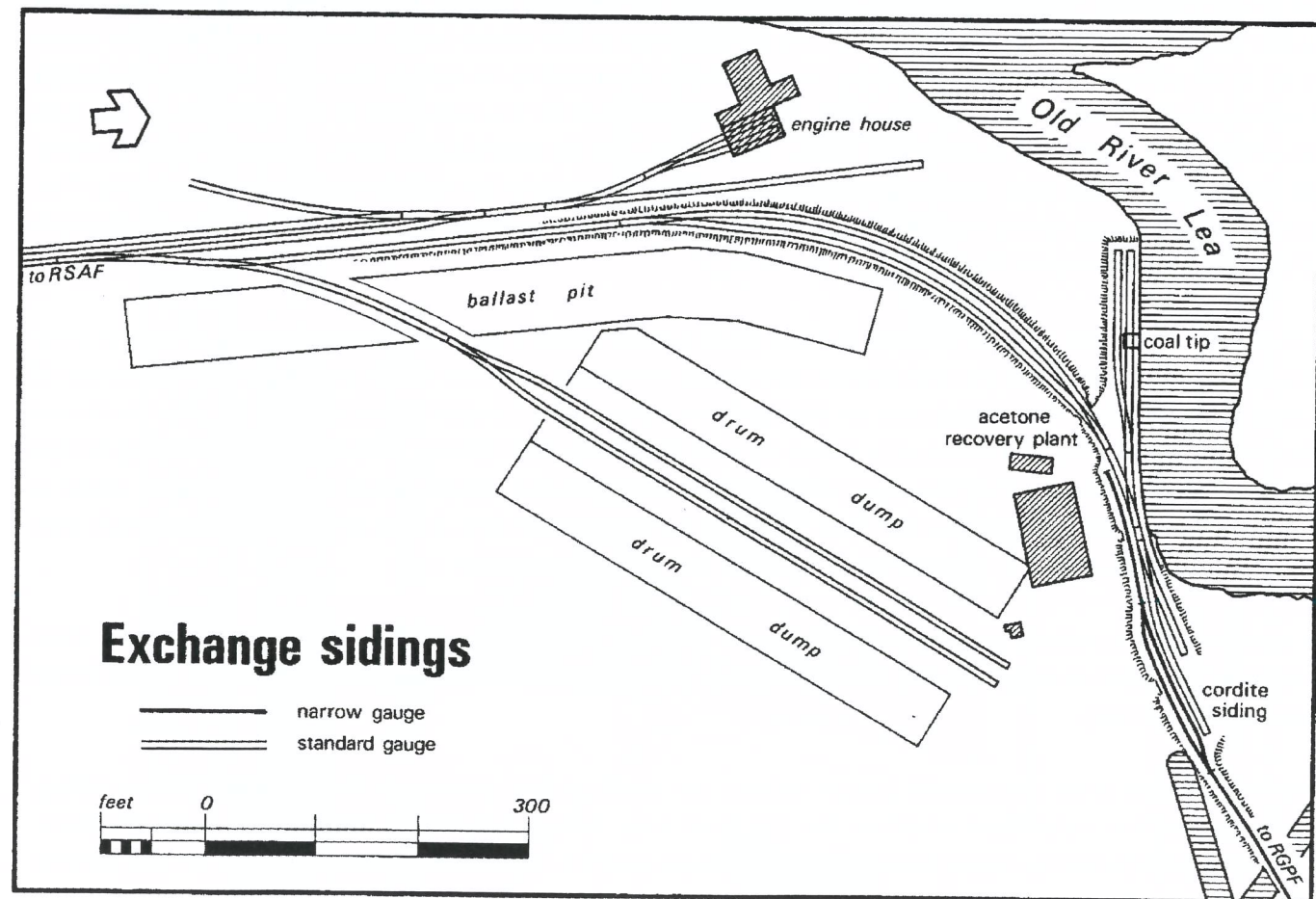
South of the tunnel, the railway crossed the old River Lea at Lovatt's Mead by another swing bridge of steel lattice construction similar to the one already described, excepting that this bridge pivoted about the centre of the river. The signal for this bridge was on the northern bank. From Lovatt's Mead bridge, the line continued down Lower Island Way and eventually linked up with the South Site railway system. A further swing bridge went over Cobbins Brook. This one was similar to the one at Great Hoppit Island in that it rotated about a shore based pivot, but its construction was different from the other two, it was an older bridge which was reconstructed, presumably to strengthen it, towards the end of World War 1.

The mainline of the railway passed in to the South Site and through the cordite blending house area, then swung over the internal canals to the acetone recovery plant and standard gauge sidings of the Royal Small Arms Factory Railway.

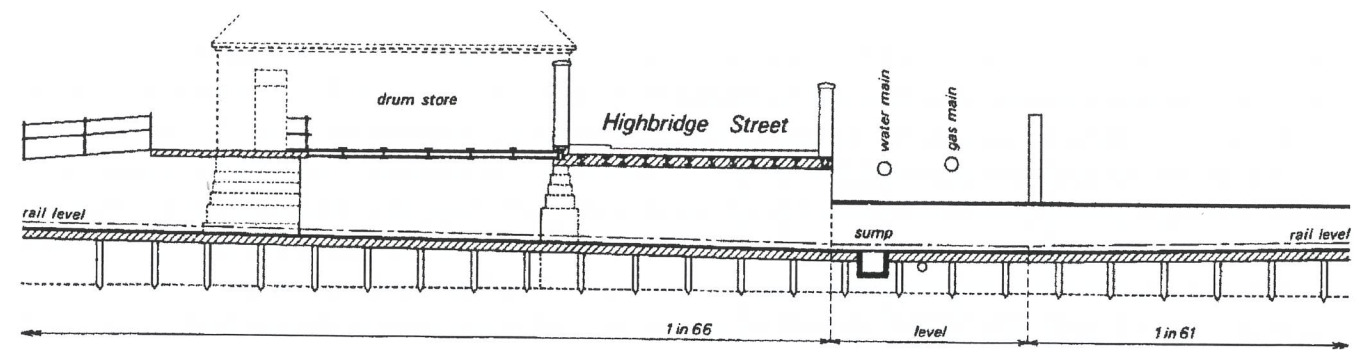
In the interchange area, the narrow gauge railway ran south of and parallel to the standard gauge siding, which occupied the water front wharf on the old River Lea, and terminated by the acetone recovery plant. Cordite was transferred by hand from the narrow gauge wagons to standard gauge vehicles on the parallel track.



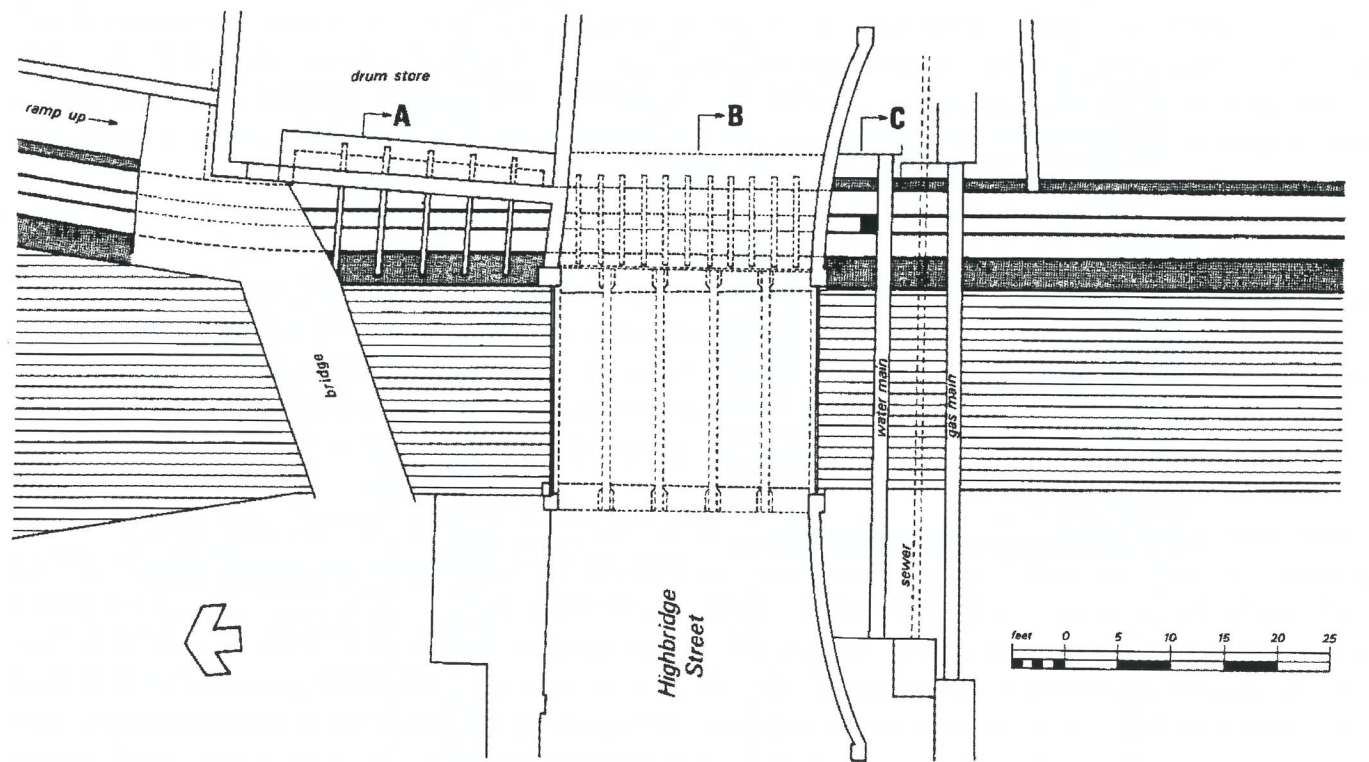
The swing bridge at Great Hoppit Island in 1917 with a train crossing, hauled by one of the Ruston locomotives. The camera is pointing North. (RARDE)



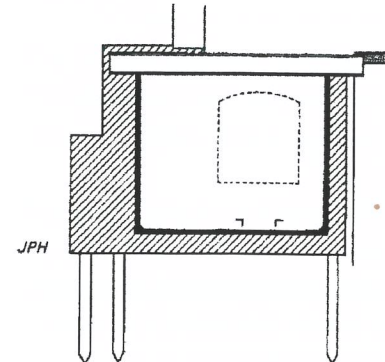
Section on tunnel centre line



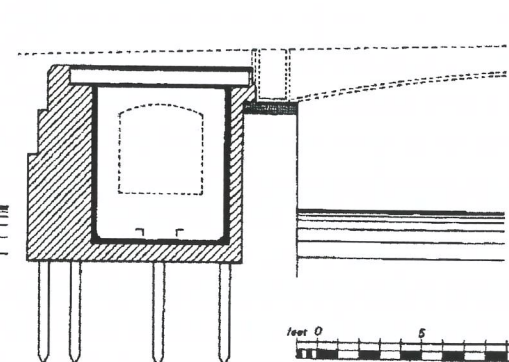
Plan of tunnel and river bridge



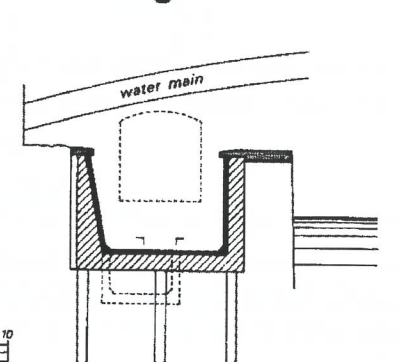
Sections A

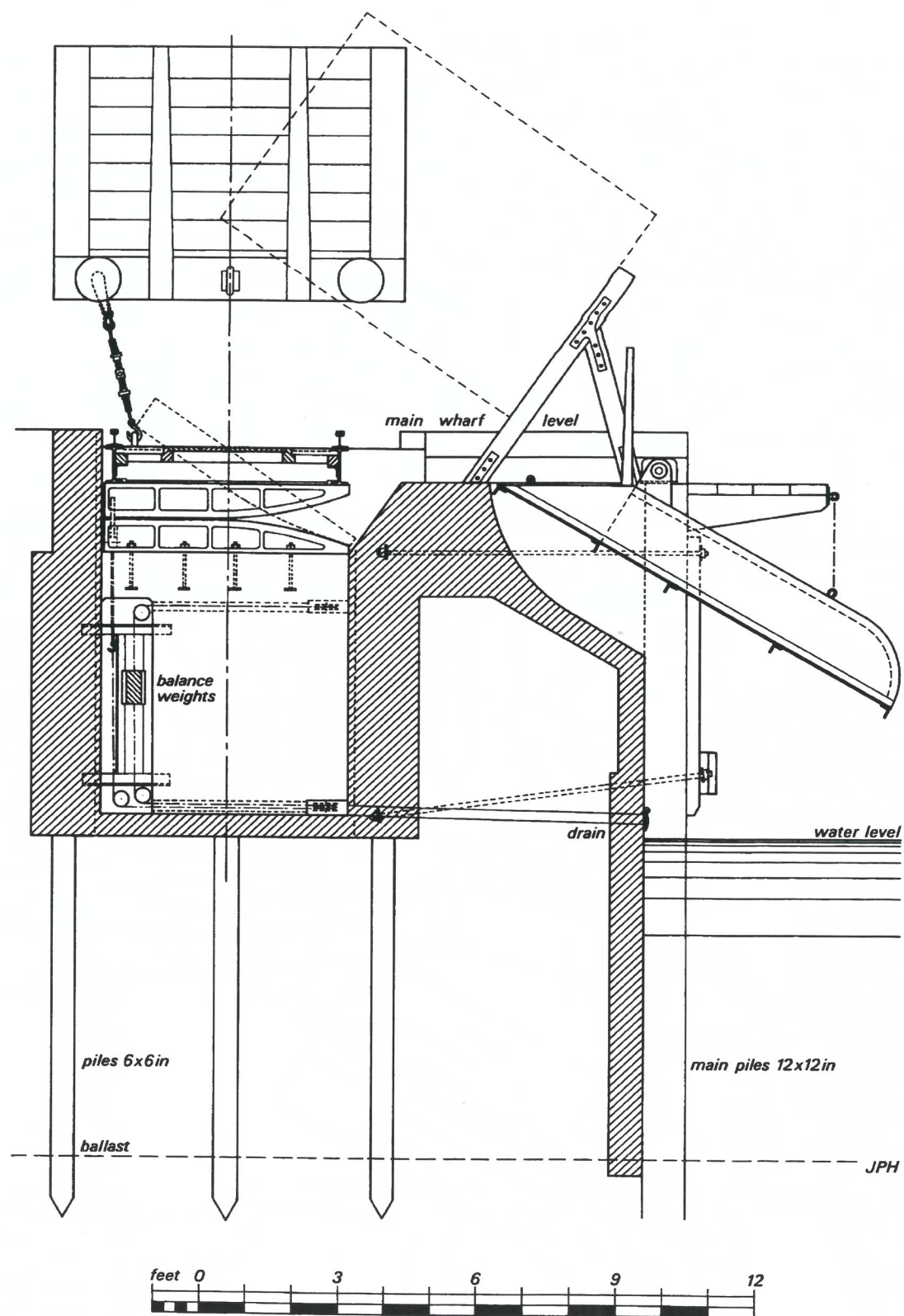


B



C





The coal tip at the river wharf, adjacent to the Royal Small Arms Factory. Coal was loaded from standard gauge wagons into boats, which then distributed the coal to points served by water within the Royal Gunpowder Factory.

The standard gauge railway also served an automatic coal chute on the wharf, a boiler house, and the alcohol drum dump. The coal chute was presumably used to load boats which then took coal into the factory via the waterway system.

At this point it is appropriate to say a few words about the railway of the Royal Small Arms Factory. This factory was established in 1804, but no railway sidings appear on the Ordnance Survey maps up to and including the edition of 1897. The standard gauge interchange sidings on the boundary between the two factories do not appear on the Royal Gunpowder Factory maps before 1916, although this does not necessarily mean that they did not exist until that year. The Royal Small Arms Factory was considerably extended following sanction received in October 1914, and improvements made during the first two years of the War appear to have included the provision of the railway siding from the main Cambridge line of the Great Eastern Railway. The branch, which joined the main line at the north end of Brimsdown station, also gave access to Brimsdown power station by 1924. Incoming stores intended exclusively for the Royal Gunpowder Factory were diverted to a separate delivery point within the Royal Small Arms Factory, ultimately passing on to the Gunpowder Factory's narrow gauge railway via the interchange sidings.

The first locomotive known to have been employed at the Royal Small Arms Factory was a Muir Hill petrol tractor of 1925 (works number A.120). It has not been possible to discover how the internal rail traffic was worked before this locomotive was obtained. Either the GER shunted the traffic with its own locomotives, or more likely a system of horse and or capstan haulage was employed. It is unlikely that steam locomotives were allowed near the interchange area, in view of the amount of explosives handled and the presence nearby of a plant producing acetone, an inflammable solvent.

The Royal Small Arms Factory and the Royal Gunpowder Factory were under common administration for the first two years of the War. The former came under the Ministry of Munitions, Director General of Munitions Supply in August 1915, control passing to the Director General of Ordnance Supplies in January 1916. In December 1917 the separation of the two establishments was completed when the Royal Gunpowder Factory finance and accounts were transferred from Enfield to Waltham Abbey.

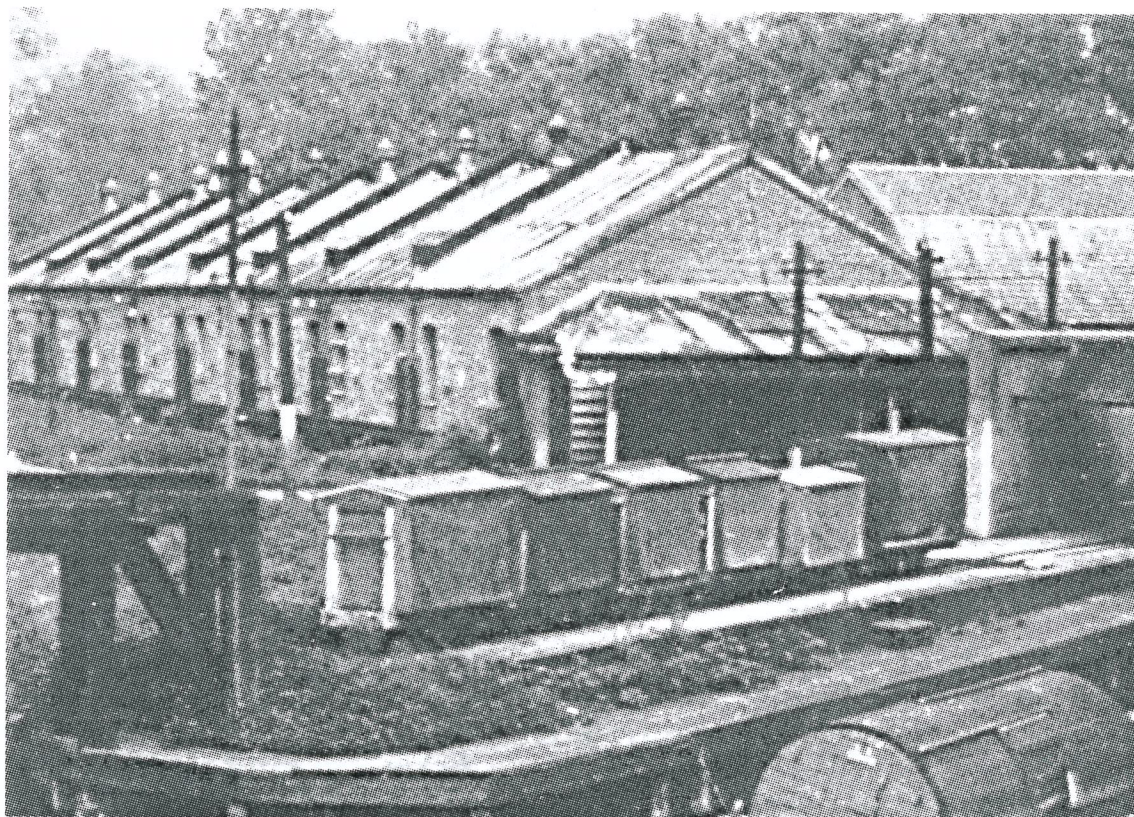
Towards the end of World War 1, plans for extensions to the Royal Gunpowder Factory railway were drawn up. The major one was to run from north of the nitro-glycerine factory on the North Site (the CE¹ clearing house) to a junction by the Edmondsey boiler house; the eastern branch was to go to the CE stove, then south over the old River Lea to the Experimental House. The Western branch was planned to run almost due south to the CE packing house and magazine, then south east alongside the Long Walk, past the gunpowder mills, and sharply west to join the existing railway. This extension would have nearly doubled the length of the railway. From a map dated 1923, it would appear that this scheme was not carried out and neither were any other major additions made between 1917 and 1923. The 1923 map does show that some of the proposed assembly sidings were built just north of the engine shed on the North Site.

Post World War 1

The factory continued to expand after World War 1, and the manufacture of TNT and RDX² was commenced. This development and that immediately prior to World War 2 caused little extension to the overall length of the railway system, but a greater proportion of the traffic was worked by locomotives.

The track length suitable for locomotive haulage was 3½ miles by 1940. Also the minimum radius had been increased to 35ft and the maximum gradient was 1 in 30. The figures for maximum gradient quoted at this time are significantly different to those previously cited in the gradient profile through the road tunnel. In view

1 CE is the abbreviation for an explosive known as 'Composition Exploding'
 2 RDX is the abbreviation for an explosive known as 'Research Department Explosive X'



An undated photograph which is believed to show a corner of the North site. Various types of covered wagons are visible and canal barges. (RARDE)



Ruston Proctor ZLH with a train of three wagons exit the Highbridge Road Tunnel. (RARDE)

of the length of track available for locomotive haulage, it is unlikely that the battery locomotives, which were in use by 1940, would be restricted to one site. Presumably, the gradients had been eased in the years between the Wars as a matter of policy to permit easier working of the rail system.

The factory began to run down in 1943, and manufacture of explosives ceased by October of that year. Operation continued as a Government Research Establishment, although the title 'Royal Gunpowder Factory' continued to be used until July 1945. By 1952, the railway link connecting the North and South Sites had been dismantled, but some of the railway and the electric 'tractors' were still in use in 1954.

Locomotives and Rolling Stock

The changes in the Waltham Abbey railway system, which took place in 1916, involved use of mechanical haulage for the first time. The motive power was provided by four locomotives built by Ruston Proctor & Co Ltd of Lincoln. These were oil fuelled machines of the maker's 'ZLH' type, numbered 51697, 51707, 51901 and 51927, which were delivered over the period from 30th January 1917 to 29th October 1917. They had 10hp single cylinder water cooled engines, were started on petrol and then ran on paraffin once warmed up. Such engines were considered to be a low fire risk compared with conventional steam locomotives.

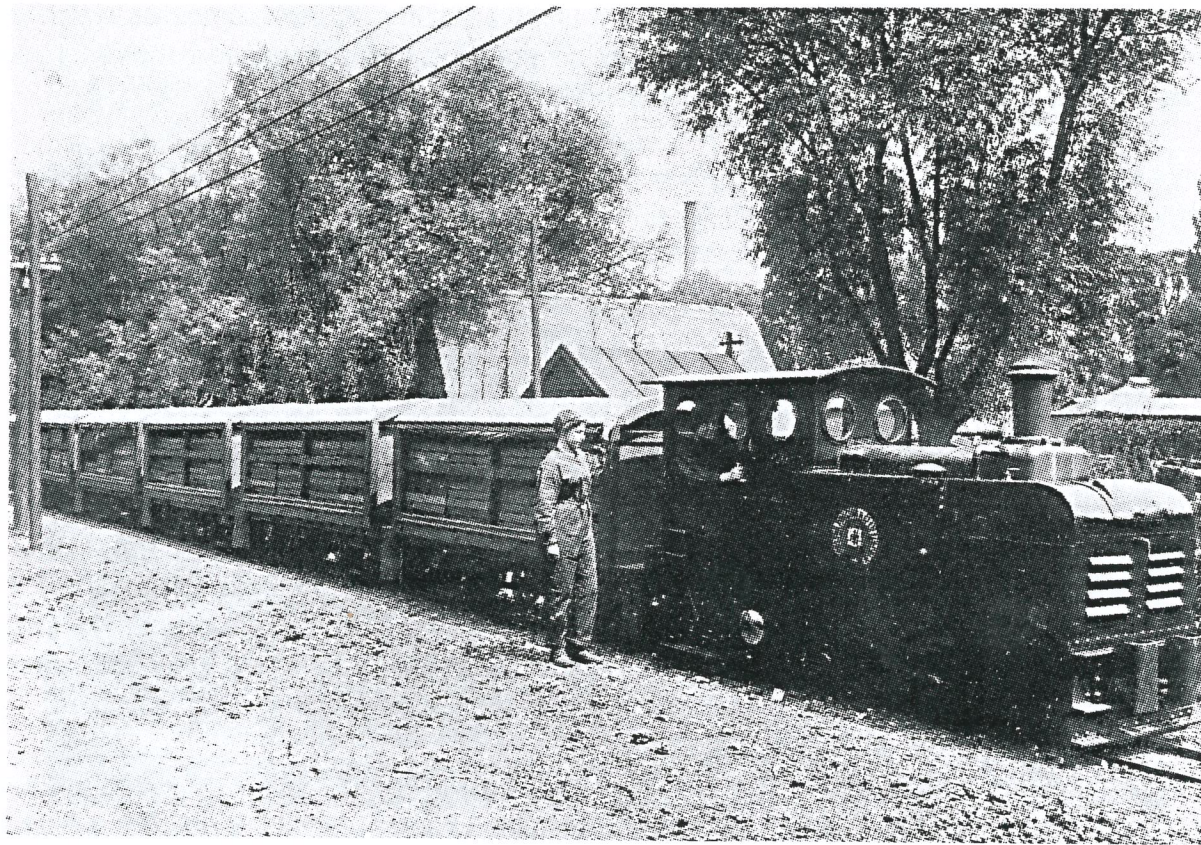
It is believed that Ruston Proctor's 'ZLH' type was based on a design produced by the Deutz Company in Germany, shortly before the War. Whether the engine resembled a Deutz design or not, the outline of the locomotive certainly did, and a detailed description appeared in the magazine Engineering of 30th November 1917. Each locomotive weighed 4½ tons, and measured 11ft long by 3ft 6in wide by 6ft high, the drawbar pull was 800 pounds. Two speeds were provided 3mph and 6mph in forward and reverse, and the builders claimed that the locomotives could be safely handled by relatively unskilled labour (including women!) Several photographs exist of these locomotives in service at the Royal Gunpowder Factory, and it is interesting to note that in all they are being driven by women.

It is not known whether these locomotives carried any names or identifying numbers while in service at Waltham Abbey, certainly none are visible in the photographs. Similar Ruston Proctor locomotives were used at the Royal Naval Cordite Factory at Poole, Dorset (2ft 6in gauge) and at the various explosives factories near Davington, Kent (3ft 3in gauge). These broader gauge locomotives had inside frames, unlike the Royal Gunpowder Factory locomotives which, being 18in gauge, had outside frames. Two examples of the inside framed type are preserved; one of 2ft 6in gauge, 52124 at the Museum of Lincolnshire Life, Lincoln, and one of 3ft 3in gauge (believed to be 50823) at the Narrow Gauge Railway Centre of North Wales, Gloddfa Ganol, Blaenau Ffestiniog. The latter now lies at Vale of Rheidol Railway at Aberystwyth, awaiting possible restoration.¹

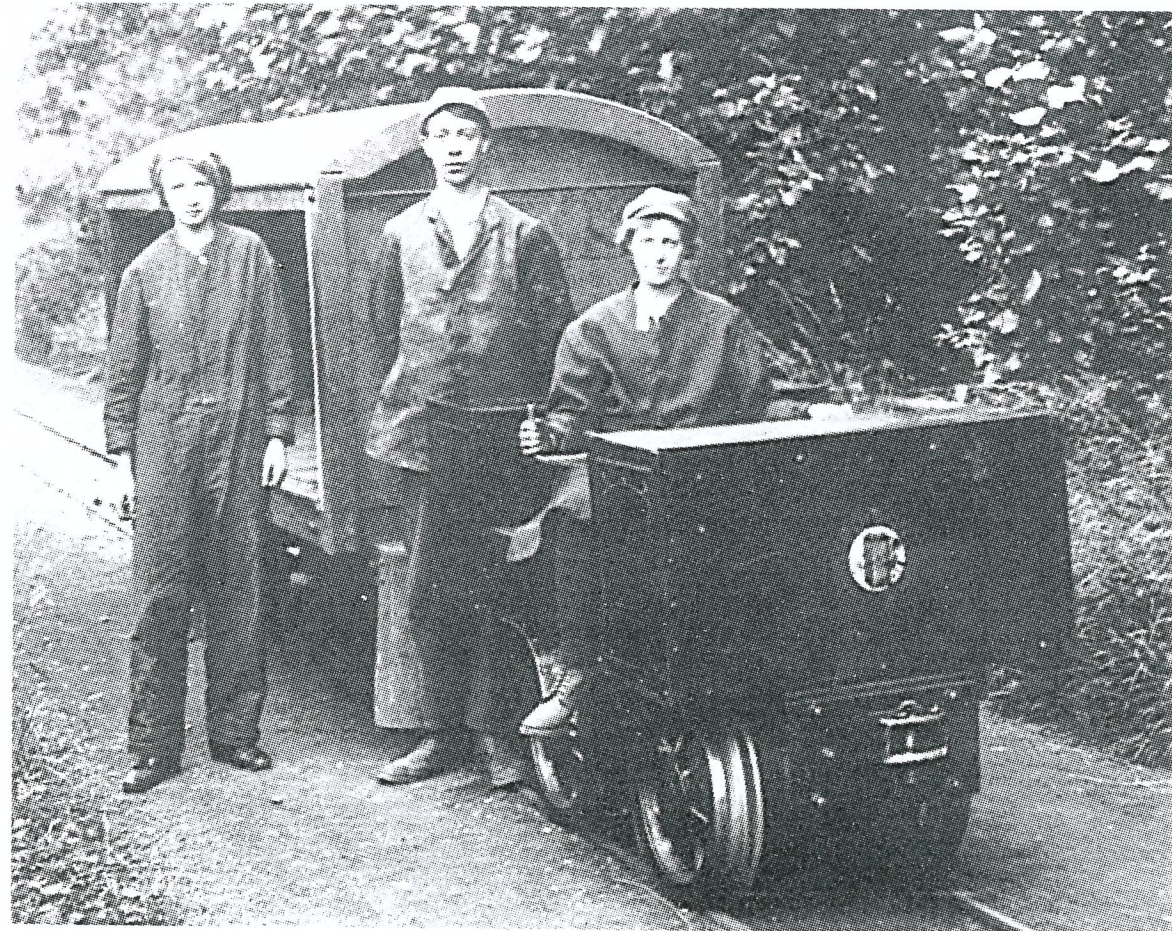
No record has been found of any other oil-powered locomotives at the Royal Gunpowder Factory, nor is it possible to say with certainty how long the Rustons continued in use. The only evidence concerning disposals indicates that one of the Ruston's found a later home in North Wales. An advertisement in the Machinery Market of 6th October 1933 stated that Harry Gardam & Co Ltd, dealers of Staines, Middlesex had for disposal a 2ft gauge Ruston oil locomotive. This was acquired towards the end of 1934 by the Oakeley Slate Quarries of Blaenau Ffestiniog, and correspondence in Oakeley records indicates that the locomotive was 51901. The alteration of the gauge to 2ft raises the question of whether the 18in gauge locomotives were built with the frames spaced to accommodate 2ft gauge wheels, in which case the alteration would be a fairly simple matter.

¹ During restoration in 2007 by Alan Civil at Uttoxeter, 50823 was found to be 51168. This was confirmed by works stampings found on engine components. The loco is now fully restored at Alan Civil's works.

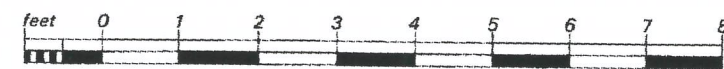
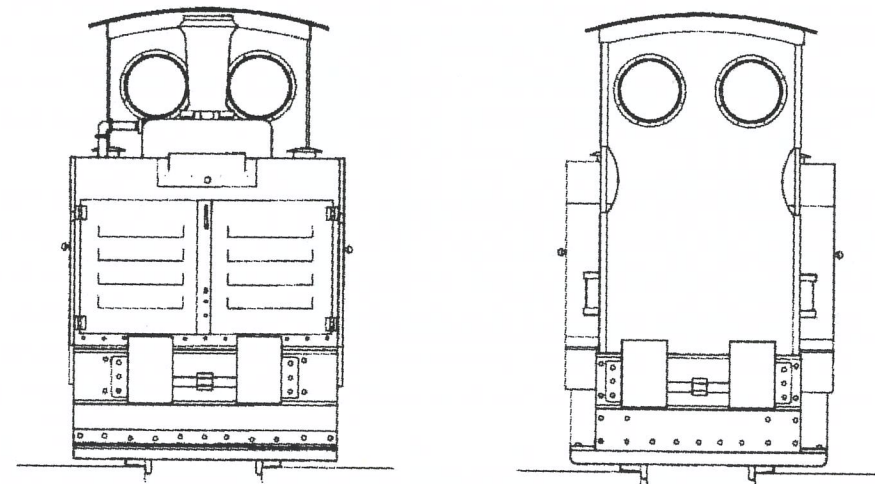
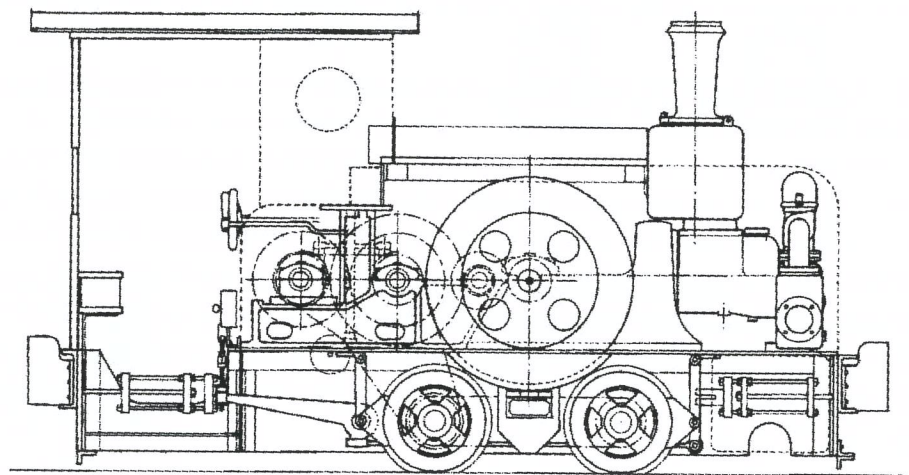
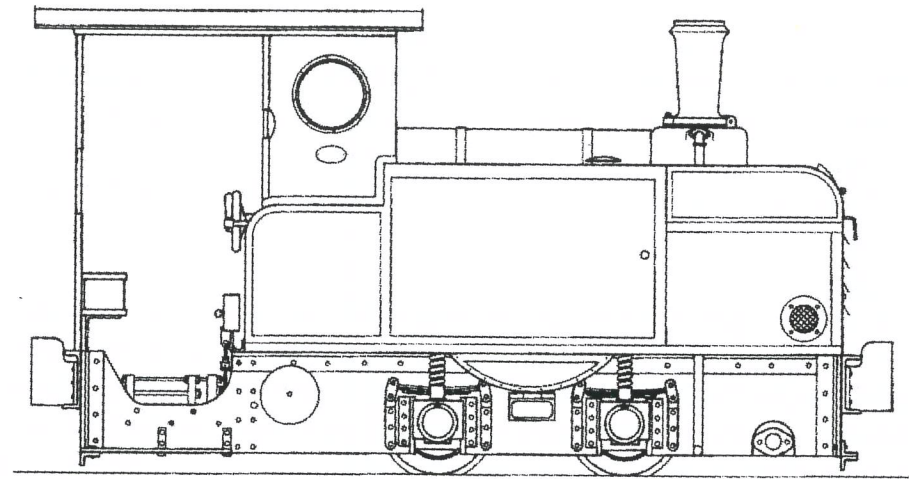
(R.J.Parkinson - WARGM Railway)



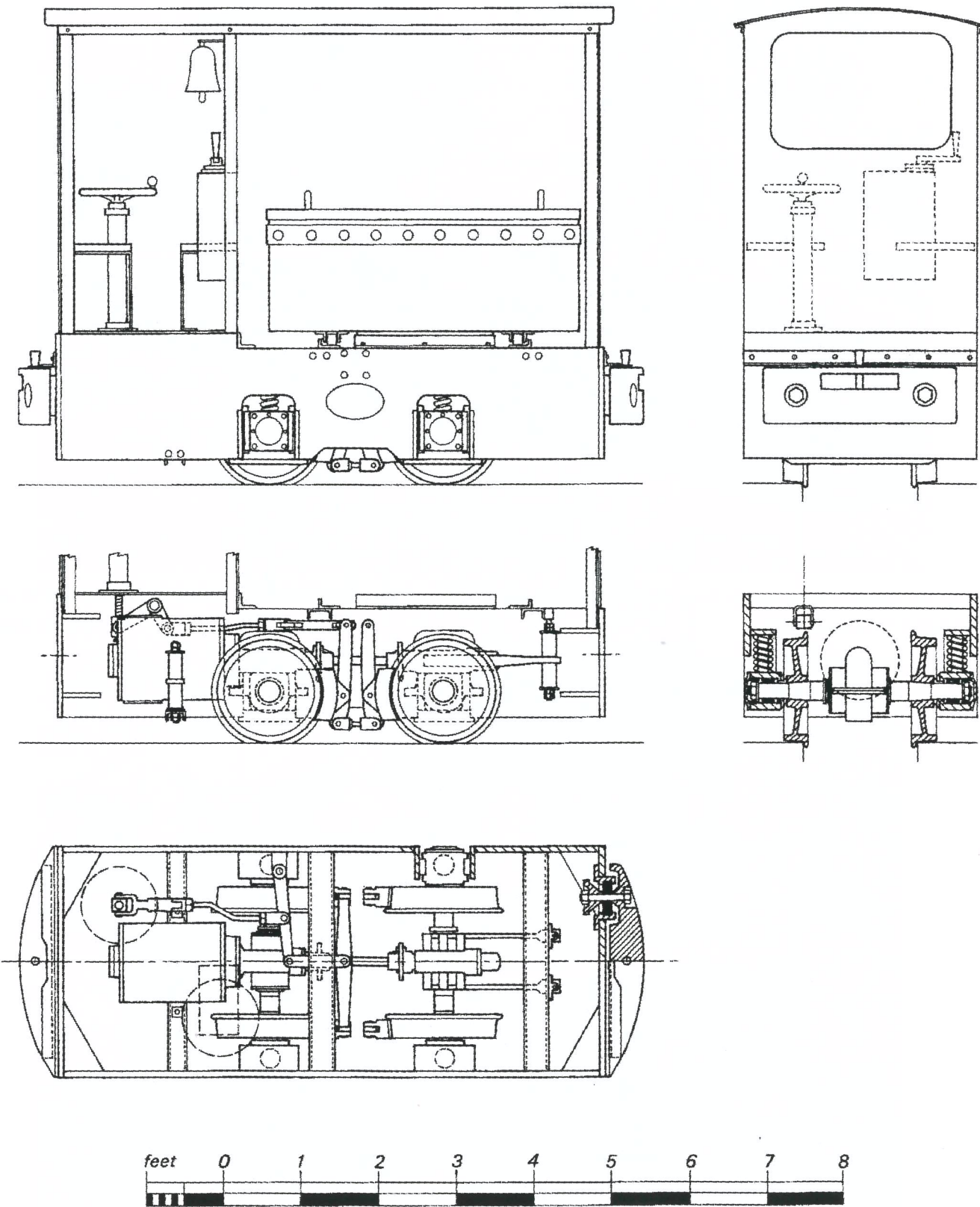
One of the Ruston Proctor locomotives with cordite wagons at the North end of the new railway on Great Hoppit island.
(Collection R.E.Hooley)



The early battery locomotive, photographed in July 1917. The battery box carries the name EDISON STORAGE BATTERY.
(RARDE)



This drawing shows the 18in gauge version of the Ruston Proctor 'ZLH' Class locomotive. Drawing by Peter Holmes, based on a sectional view which appeared in Ruston & Hornsby Publication No.3776, The Ruston Oil Loco, with additional details from Ruston drawings 19-1015 and 19-1016, supplied by courtesy of Ray Hooley. It is not known whether all four of the Waltham Abbey locomotives were identical.



The above drawing shows a Greenwood and Batley 'tractor' of the second batch, built in 1942. The four 1942 locomotives differed slightly in detail from the six built in 1940, mainly in the buffer end beam arrangement. Drawing by Peter Holmes, based on Greenwood and Batley outline drawing number T.1868, by courtesy of the Hunslet Engine Co. Ltd.

It is believed that 51901 worked at Oakley until February 1941 when it was sold to scrap dealer W.O. Williams of Harlech. It was last reported at R.S. Davies at Mold in September 1952, but had been scrapped by June 1953. Correspondence between Gardam and Ruston's revealed that the locomotive in question was built in 1925; possibly this can be taken as the date when the gauge was altered rather than the true building date. This might indicate that Ruston 51901, at least, was disposed of by the Royal Gunpowder Factory in or by 1925.

In addition to the four Ruston locomotives, there were during the World War 1 period an unknown number of small battery powered tractors. A photograph taken in 1917 shows a locomotive with two battery boxes and a central driving position, carrying a label 'Edison Storage Battery' on the front. No documentation has been found relating to this locomotive which might enable the builder to be identified, however it was possibly an 'Edison Automatic' product. A range of industrial electric vehicles were available under this name by 1919, having batteries by Edison, and mechanical parts manufactured by the Automatic Transportation Company of Buffalo, New York, USA. The batteries could have been made in either Britain or the USA, since in 1913 Edison Accumulators Ltd was formed in Britain as a branch of the parent company in the USA.

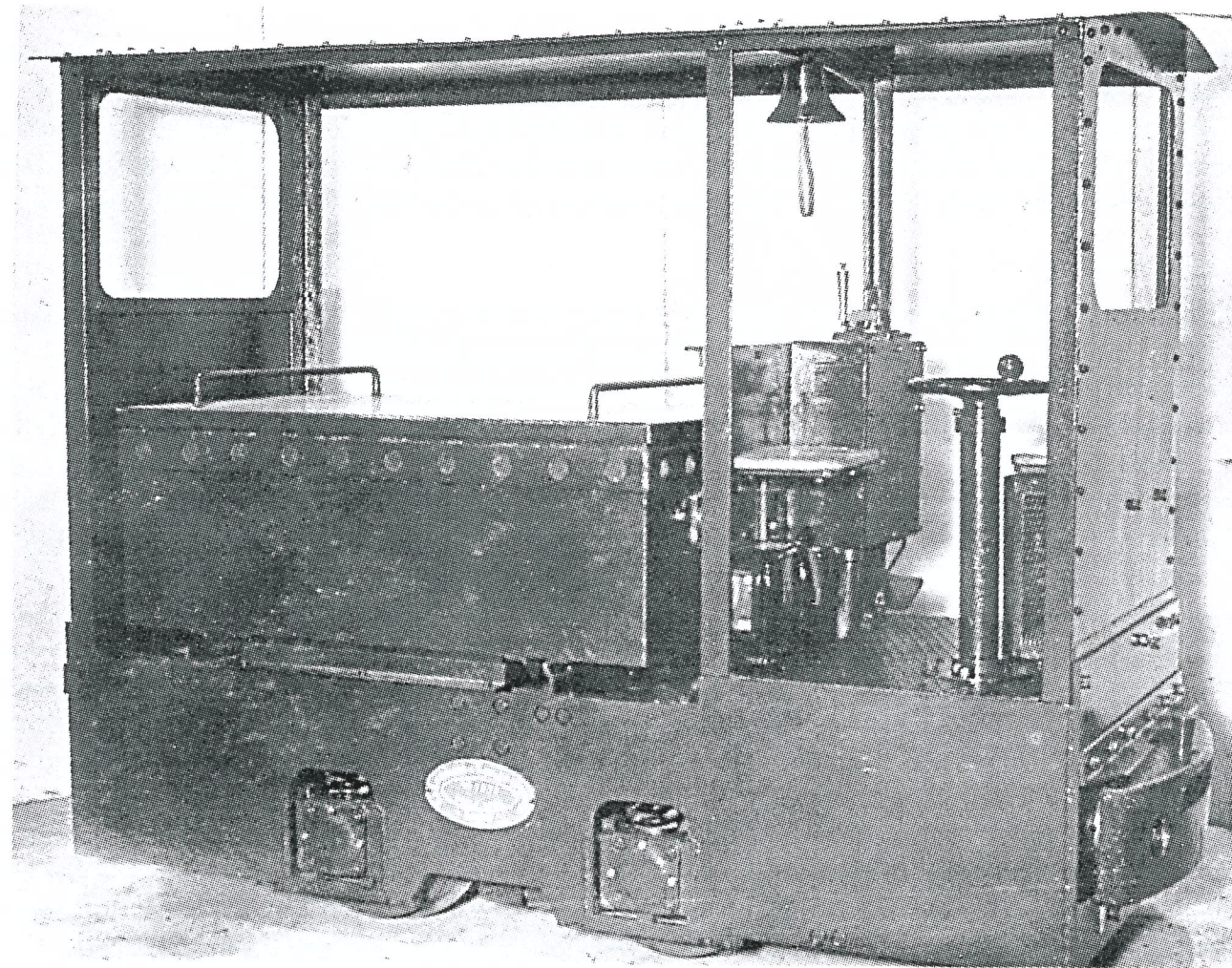
In the RARDE historical collection is a catalogue of H.C. Slingsby Ltd, truck builders of London, which was reputedly used when equipment was being ordered during World War 1. Under the heading 'Slingsby Automatic Electric Trucks' this catalogue illustrates a battery locomotive resembling the one photographed at the Royal Gunpowder Factory. These locomotives were apparently available for gauges between 18in and 3ft, and were fitted with a 48volt 'Automatic' type motor. Since vehicles of Edison Automatic make were available at around this time, it seems likely that the catalogue locomotive is one of their products marketed under Slingsby's name. The existence of the Slingsby catalogue at Waltham Abbey is of course no guarantee that Slingsby supplied the locomotive in the 1917 photograph; however the Automatic Transportation Company's apparent link with both Edison and Slingsby does suggest that they may have been the actual builder.

Another early electric 'locomotive' at the factory remains to be described. This was built by British Electric Vehicles Ltd of Southport, and was a motorised flat platform truck of their 'Giant' type. This type of truck was originally designed for road use, and although the one built for Waltham Abbey is believed to have been a rail mounted version, this cannot now be confirmed. The chassis number was 59 and the date was July 1918. This vehicle had a payload of up to 4000 pounds, officially described as 1 ton, and the delivery details are enigmatically given as 'Government Cartridge Factory, No.3 Blackpole, Waltham Abbey, Essex'. It has not been possible to find a picture of this vehicle, and its ultimate fate is unknown.

There is no mystery about a batch of battery powered rail tractors purchased in 1937. They were five in number and came from Wingrove & Rogers Ltd of Liverpool, a firm who had acquired the goodwill of British Electric Vehicles Ltd in 1926 and continued to use the 'BEV' trademark. These five locomotives carried serial numbers 1043 to 1047 and were of the maker's type W117, being 4 wheel battery locomotives with outside frames and shaft drive to each axle. The weight in working order was 2½ tons and the maximum load hauled was 10 to 15 tons. Full length canopies were fitted, and delivery took place in July and August 1937.

When further battery locomotives were required after the outbreak of World War 2, the Royal Gunpowder Factory turned to Greenwood & Batley Ltd of Leeds. Ten locomotives were acquired, via the Ministry of Supply, in two batches. The first six carried maker's numbers 1668 to 1673 and were ordered in December 1939 for delivery commencing 19th April 1940. A further batch of four locomotives which displayed numbers 1851, 1852, 1861 and 1862 were ordered in November 1941 and delivered in November 1942.

All ten of these tractors weighed 45cwt each, had a drawbar pull of 360 pounds at 4½ mph and could haul about 5 tons. They were 85in long by 36½ in wide and 75in high. Power was provided by a 5hp 40volt motor which ran off NIFE batteries. Basic weather protection was fitted in the form of a full length canopy and end



Official maker's photograph of Greenwood and Batley 'tractor' number 1671, built in 1940.

(Collection A.J.Booth)



Hand-propelled wagons with peaked roofs, probably photographed during World War 1. These smaller wagons were used within the process areas. (RARDE)

screens, and two seats were provided. These odd looking battery tractors were re charged in what used to be the North Site locomotive shed and probably in the two charging stations on the South Site; one in the guncotton factory and the other on Quinton Hill. These tractors were still in use long after the factory had ceased production and had become a Government research establishment. At least three of them were in existence as late as 1958.

No details of the early cordite and guncotton trucks have been found to date. It is known that some of them were made in the Royal Carriage Department at Woolwich Arsenal for a cost of £40 each. According to an order dated 1892 there were then at least four different types, namely trucks without brakes, trucks for carrying cordite reels, trucks for cordite boxes, and trucks for cordite trays. Further types followed as a later specification book lists trucks for cannon cordite to two different drawings, trucks for wet guncotton, and trucks for new rifle cordite.

From the photographs of the Ruston locomotives taken in 1917, it appears that the trains pulled by these consisted mainly of round topped trucks filled with what were presumably trays of cordite. Resembling the bogie vans on the 18in gauge railway at Woolwich Arsenal, these trucks were 12 feet long, had two four wheeled bogies, and weighed two tons fully loaded. Trains were normally restricted to a maximum of six trucks, although the Ruston locomotives had been found capable of hauling nine. The locomotives were also used to haul a wide variety of other loads, including acid retorts, baskets of laundry, and possibly guncotton.

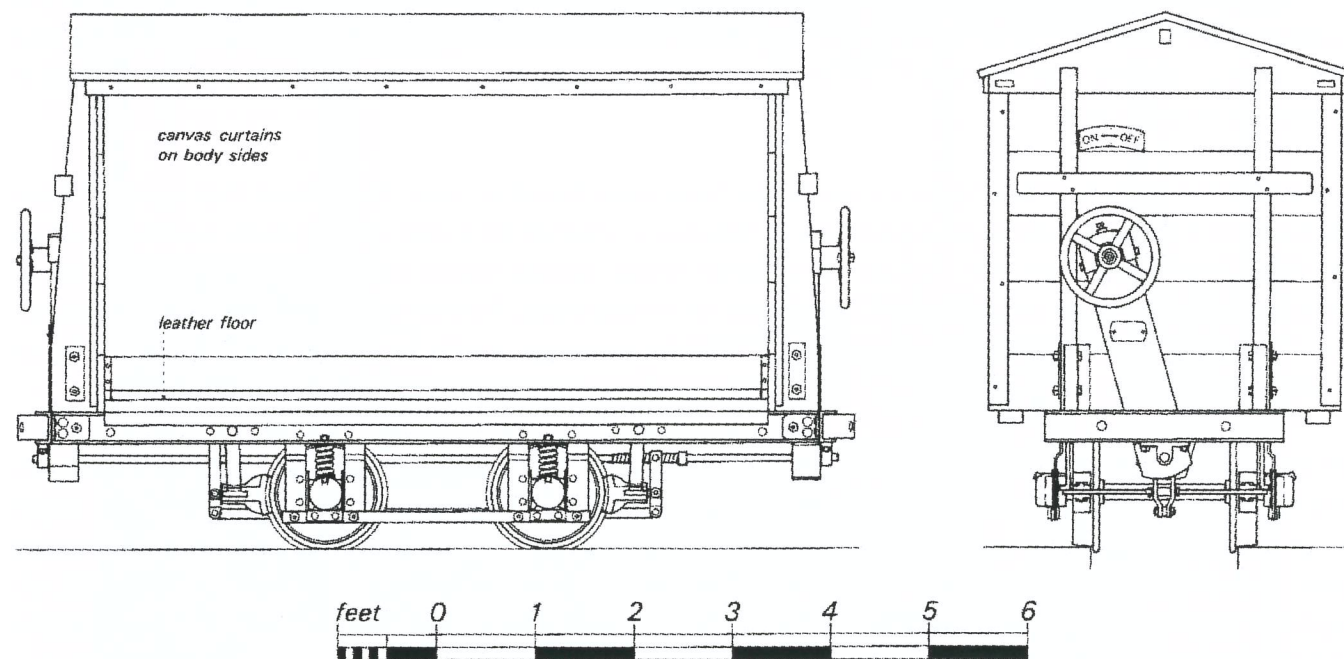
In addition to the larger round topped trucks, there were smaller four wheeled gable topped trucks. These seem to have been hand propelled and were restricted to the process areas for transporting items such as cordite paste. The weight of composition carried in these hand propelled trucks varied depending upon the nature of the load but it was substantial, considering that it was explosive. For example, the cordite trucks carried 1000 pounds of wet guncotton in 40 tins or 640 pounds of dry guncotton in 16 bags. No drawings of these or any other trucks have yet been found but a specification does exist. This specification is for the supply of 19 trucks to no fewer than 7 different drawings.

Trucks for wet guncotton were purchased to 'Specification 765' in 1938 from the Cambrian Wagon Works of Cardiff, and trucks for cordite were purchased in 1939 from Hudson of Leeds. It is interesting that these specifications refer to the same drawings as those in the 1914 order.

Operation

There is very little information in existence on the operation of the railway. It is apparent that there were running orders and traffic rules from amendments to a 1914 Royal Gunpowder Factory Rule Book, which are undated but presumably post January 1917, since locomotives are referred to. An appended note on Running Order 14 states: '*Substitute for first para Engine and Tractor drivers are strictly forbidden to allow any persons to ride on their locos, except Brakesmen or Pointsmen, Traffic staff, and others provided with Engine passes*'. This implies that the train crews were responsible for the operation of the points once the train was dispatched. The same Rule Book has an addition, but no more, to the Traffic Rules. It refers to Traffic Rule No.2 and states '*Add para. "Where tractor trains or specials are to proceed beyond Lower Island Lock, the Traffic Controller (Lower) must be informed and he will inform Traffic Controller (Upper). Such trains will run in the intervals between the regular trains"*'. This fragment clearly indicates that there was a system of control operated jointly for the North and South sites, and that there was a timetable of some sort for the trains.

In the same Rule Book, there is a short section of '*Rules for the Protection of the Railway*' which was added after the first publication of the Book.



The above drawing shows a cordite paste wagon built by R.Hudson Ltd., possibly one of the batch supplied in 1939. Drawing by Peter Holmes, based on measurements taken by J.M.Jenkins from the surviving wagon.



The most substantial relic of the Royal Gunpowder Factory railway is this Hudson-built cordite paste wagon, preserved on the RARDE North Site. (J.M.Jenkins)

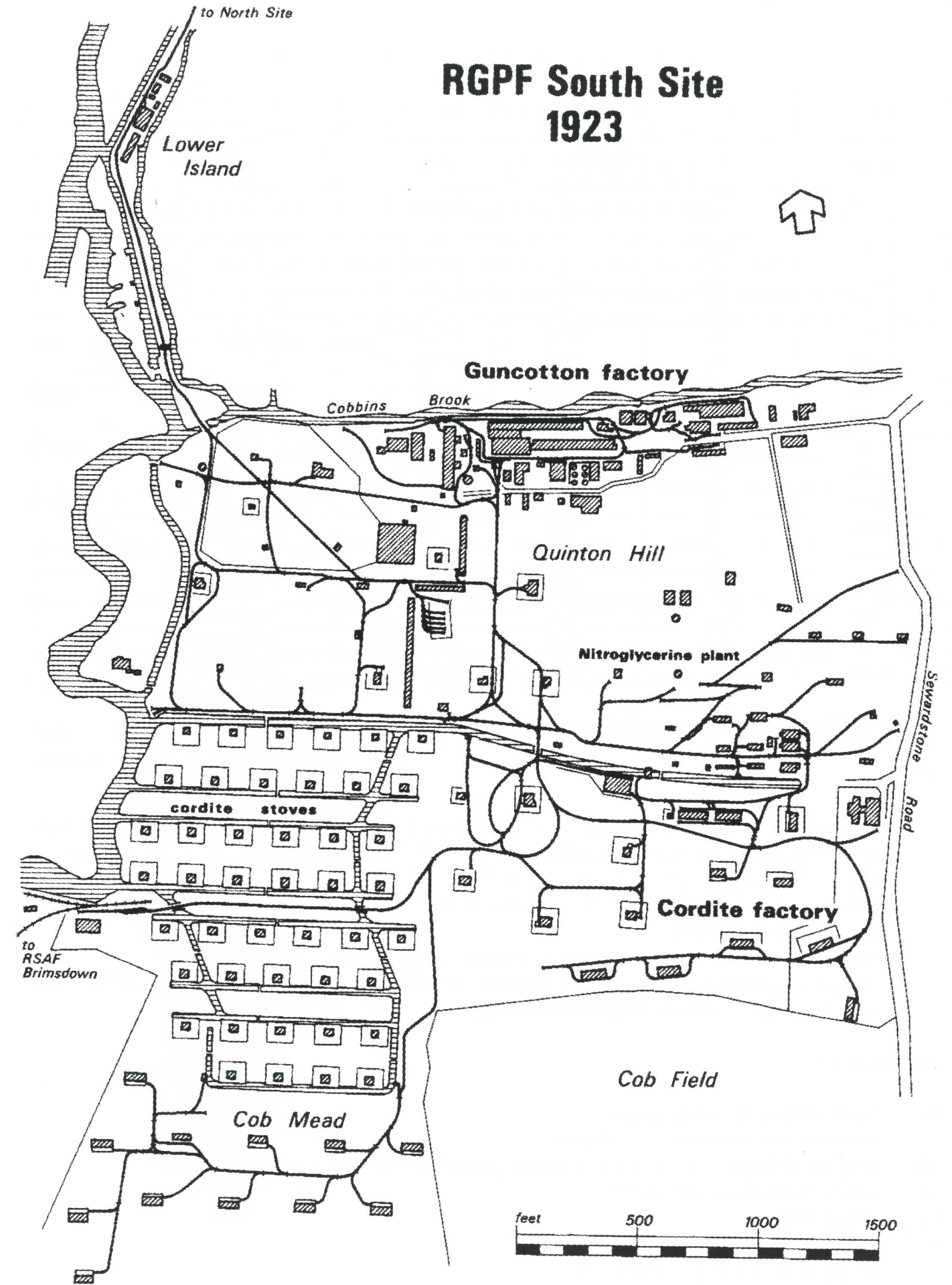
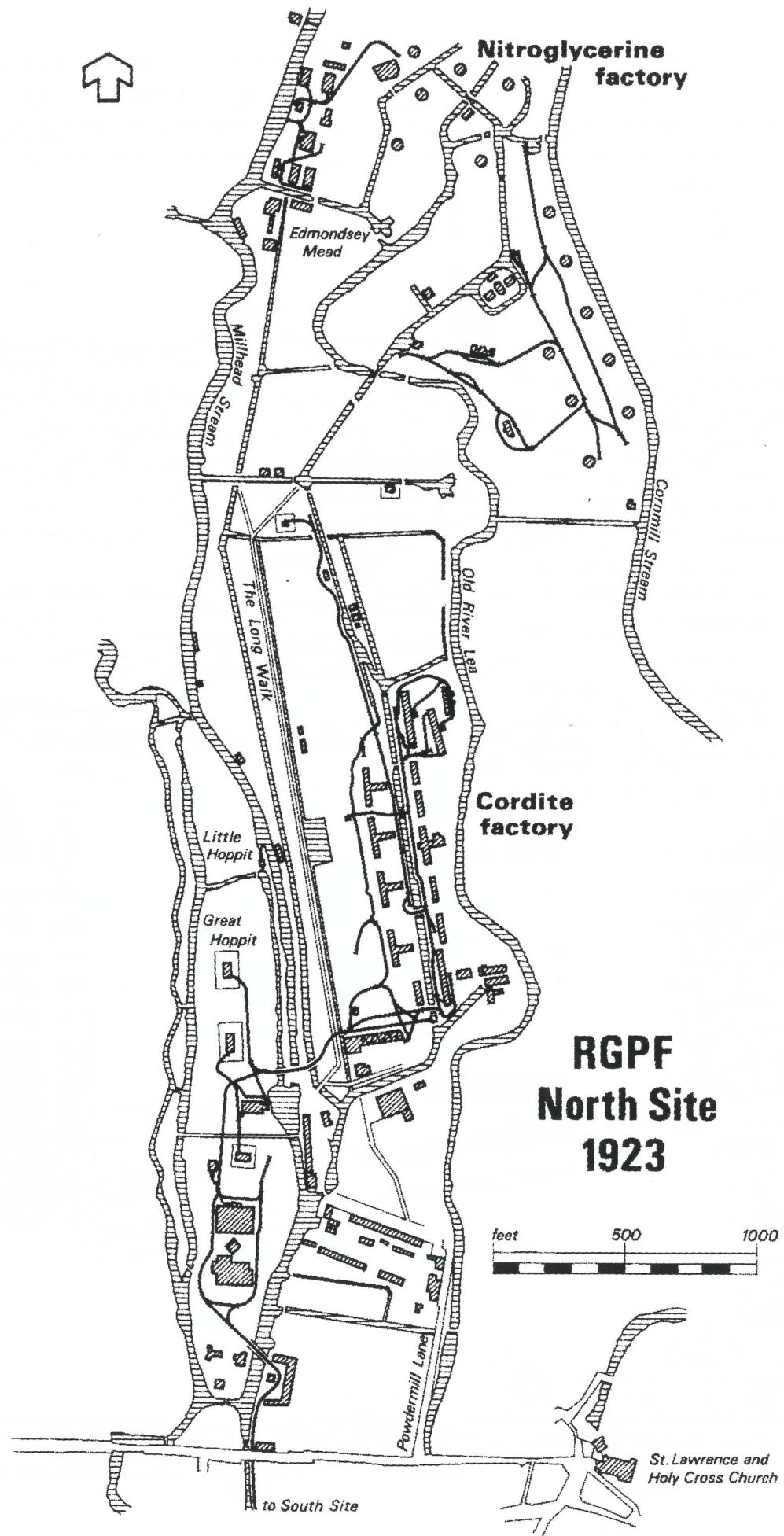
The four rules stated were to prevent obstructions on the railway. There were more extensive rules for the operation of the hand trucks, as already mentioned, and there were special rules also for the working of the trucks which were part of the process methods for the manufacture of the cordite. No truck was allowed to stop outside a building in which explosives or propellants were being processed. Red signals were raised during the processing to warn the truck operators. Even so, a truck containing 640 pounds of dry guncotton exploded in 1940, killing the two men who were pushing it. The explosion of the truck was caused by a nearby cordite mixing house exploding.

Remains of the System

At the time of writing there are a small number of relics of the railway system left in the Establishment, and these are mainly on the North Site. A few short sections of track remain, and there is a buffer stop for the tramway system near to a loading dock by one of the disused canals. In addition, one example of a set of points has been found, as have wooden rails. One 'rope ring' used for single line control through the tunnel remains as previously mentioned. As for the rolling stock, only one hand operated cordite paste truck is left. As can be seen from the photograph, it has been badly neglected of late. This truck was made by Hudsons of Leeds. It is situated on a short section of track which gives a clear impression of the steel sleepered track that was used for much of the rail system.

The engine shed built for the Ruston Proctor locomotives still survives as a metal rod store. The rails inside are embedded in the concrete floor. A reminder of railway days exists inside the building, in the form of a notice on how to charge the NIFE batteries, which powered the tractors used in World War 2. The only relic of the Great Hoppit Island swing bridge is the concrete pier in the middle of the river, although the fixed span and signal were removed as recently as 1987. There is little trace of the tunnel that ran under the main road as it was sealed off when the road bridge was rebuilt in 1967. Some evidence of the railway cutting on the south side of the bridge can be seen by peering over the parapet of the new road bridge.

It is hoped that the few relics will be properly preserved along with the drawings and documents so far identified. Several questions remain to be answered, such as the constructional details of the early trucks, particularly the 8 wheel trucks of World War 1; how long were the Ruston & Proctor locomotives used; what was the origin of the 'Edison' battery tractor; what were the Traffic Rules and operating procedures, and when was the Royal Small Arms Factory link with its coal chute dismantled? One of the difficulties is that most of the documents relating to the interesting World War 1 period of the railway now seem to have vanished, but we are fortunate that some of the drawings have survived.



LOCOMOTIVE SUMMARY

TYPE	Builder	Builder's Number	Delivered	Class	Disposal and Notes
4wPar	RP	51697	30.01.1917	ZLH	S/S
4wPar	RP	51707	16.03.1917	ZLH	S/S
4wPar	RP	51901	28.09.1917	ZLH	(1)
4wPar	RP	51927	29.10.1917	ZLH	S/S
4wBE	?				(2)
4wBE	BEV	59	30.01.1918	'Giant'	(3)
4wBE	WR	1043	31.07.1937	W 117	S/S
4wBE	WR	1044	31.07.1937	W 117	S/S
4wBE	WR	1045	31.08.1937	W 117	S/S
4wBE	WR	1046	31.08.1937	W 117	S/S
4wBE	WR	1047	31.08.1937	W 117	S/S
4wBE	GB	1668	1940		(4)
4wBE	GB	1669	1940		(4)
4wBE	GB	1670	1940		(4)
4wBE	GB	1671	1940		(4)
4wBE	GB	1672	1940		(4)
4wBE	GB	1673	1940		(4)
4wBE	GB	1851	16.11.1942		(4)
4wBE	GB	1852	16.11.1942		(4)
4wBE	GB	1861	30.11.1942		(4)
4wBE	GB	1862	30.11.1942		(4)

All locomotives were 18in gauge, and all those which are identified were delivered new.

Notes

- (1) To Oakeley Slate Quarries Ltd, Blaenau Ffestiniog, via H. Gardam & Co Ltd, Staines, Middlesex, 1934. This locomotive was rebuilt to 2ft gauge by 1933. It is not possible to say when it was disposed of by the Royal Gunpowder Factory, possibly Gardam did not acquire it directly.
- (2) Batteries made by 'Edison', chassis possibly built by Automatic Transportation Company of Buffalo, USA. Disposal unknown.
- (3) Not certain whether this was a road or rail vehicle. Disposal unknown.
- (4) Three of these locomotives were still in existence in 1958, and at least one survived until 1962, out of use. Disposals not known, but presumed scrapped.

Abbreviations

RP Ruston Proctor & Co Ltd, Lincoln
 BEV British Electric Vehicles Ltd, Southport
 WR Wingrove & Rogers Ltd, Liverpool (acquired goodwill of BEV in 1926).
 GB Greenwood & Batley Ltd, Leeds
 Par Paraffin engine
 BE Battery electric
 S/S Scrapped or sold, disposal unknown

Acknowledgements

Firstly I must thank Mr M. Mc Laren, also an employee of RARDE, who has considerable knowledge of the Royal Gunpowder Factory. He pointed out the location of maps, drawings and other records held by the Establishment and the Public Record Office. Without his assistance, it is doubtful whether this account would have been written. Dr D. Tod, also of RARDE, gave very valuable assistance with his considerable knowledge of narrow gauge railways. I must also acknowledge the staff of RARDE Waltham Abbey for their assistance and patience. Mr R.E. Hooley of Ruston Gas Turbines Ltd kindly provided photographs and drawings of the Ruston Proctor locomotives, and copies of contemporary literature. The Hunslet Engine Co Ltd of Leeds supplied details of the Greenwood and Batley locomotives and the drawing, while Adrian J. Booth provided additional information on these locomotives and the photograph. Frank Jux and Jim Peden provided details of the BEV and WR locomotives, and Gordon Green and Douglas Clayton of the IRS supplied further locomotive details. Lastly, but by no means least, I must thank my wife who tolerated a bedroom cluttered with boxes of drawings and maps for several months.

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- Winters W. Centenary Memorial of the Royal Gunpowder Factory, Waltham Abbey. 1887
- Engineering 30th November 1917 pages 569-571
- The Locomotive 1921 pages 46-48
- Simmons W.H. A Short History of the Royal Gunpowder Factory at Waltham Abbey. 1963
WASC 158
- Hogg O.F.G. The Royal Arsenal. Oxford University Press 1963.

'WASC' denotes RARDE, Waltham Abbey, Special Collection. There are many separate references in this collection, which are too numerous to itemise.

Appendix 1

WARGM RAILWAY 2001 – 2007

Since this article was researched and written by J.M. Jenkins in 1987-89 there have been many changes on the remaining North Site. The decontamination of the area in the early 90's required that many hundreds of cubic metres of top soil were removed for safe disposal in land fill sites, consequently much of the railway trackbed was lost forever, the engine sheds referred to were also demolished for the development of housing along Beaulieu Drive, the former Hoppit Road and the new visitor entrance road to the site.

However for the keen enthusiast some remaining track can still be found. One small section has been saved on the walk North and can be located near the Quinan Stove. A much longer section of 50 yards has been recently uncovered further North, just where the road bends above Newton's Pool. It is believed that this section ran South from the Grand Magazine. This section is unfortunately 'off limits' to walkers. A further section of track has been recently discovered in the 'off limits' area of New Hill, which terminates inside a storage magazine as wooden rail for the last 15 feet to reduce the risk of explosions from metal wheels on metal rail.

The 18 inch gauge points found in 1987 have been saved and are in storage on site and the Hudson built cordite paste wagon (see page 26) has been restored and is on display in the main exhibition.

In July 2003 the WARGM Trust Group was most fortunate to receive the donation of a working HUNSLET diesel hydraulic locomotive Works No. 8828 of 1978 and a range of Hudson based wagons from the now closed Royal Ordnance Factory at Bishopton in Scotland. This has been the catalyst behind the construction of a 2ft. 6in. gauge Industrial Demonstration Line, which is ongoing at present. The target is to have a line of some 1100 yards running from the new Engine Shed (building 83B) to near the main car park.

Recently Thames Water Plc. have donated some 1500 feet of 35lb rail from their site at the Crossness Works, so this project is now a reality, with a team of volunteers very busy three days per week. A further 22 tons of new 35lb. rail and Costain concrete sleepers set at 2ft 6in gauge were acquired in May 2006 and track laying is now 70% complete.

Those requiring more detailed information on the Ruston Proctor Model ZLH Oil Locomotive may consider the book :-

'RUSTON PROCTOR and HORNSBY AKROYD' Oil-Engine Locomotives' By Robin J. Parkinson

Published by The Moseley Railway Trust available from the Royal Gunpowder Mills bookshop or by post from:-

The Moseley Railway Trust,
23 Chestnut Walk, Cheddleton, Staffs., ST13 7BJ
Attn. Dawn Robinson.

Overleaf Appendix 2 gives a brief history of the Royal Ordnance Factory at Bishopton in Scotland. Interestingly, it was to this factory that production was transferred from Waltham Abbey during the early years of the Second World War. It was considered that an explosives factory near London would become an easy target for German bombers. Some sixty years later it is fitting that we now have railway material from Bishopton returning to Waltham Abbey.

Robin J. Parkinson - WARGM Railway

Appendix 2

ROYAL ORDNANCE FACTORY – BISHOPTON

Re-produced courtesy of David Hall of the Moseley Railway Trust

R.O.F (Royal Ordnance Factory) Bishopton is near the South bank of the River Clyde in Renfrewshire, Scotland and produces propellants for use in artillery shells and rockets. Construction began in 1938 and production commenced in 1940 on the site which at its height occupied 1926 acres within its perimeter fence and contained no fewer than 1097 buildings. There was a standard gauge system laid that totalled 17 miles and boasted 5 stations that were served by trains from the main line to bring the 22,000 workers in when the works was in its heyday during WW2.

The works is set out in 3 distinct areas, each of which has its own power station so that in the event of one being bombed, the others can continue production. The reason for our interest lies in the 2ft. 6in. gauge rail system that serves the various buildings and bunkers that are part of the production process and once had track totalling 45 miles. The narrow gauge initially used a fleet of 4 wheel battery electric locos supplied by Wingrove & Rogers type W 117 (the same model as at RGPF) and 'Cheese Trucks' by Greenwood & Batley. The cheese trucks were a self propelled battery electric wagon with a platform at one end for the driver and rectangular tank where the 'cheese' was carried. 'Cheese' is the name given to a particular type of rocket propellant that was made at the works and resembled the edible dairy product. In the late 1960's, the first of a new fleet of locos and cheese trucks were delivered that would eventually replace the Wingroves and Greenbats. These new locos were built by Brook Victor Electric Vehicles Ltd. at Burscough Bridge, Lancs. and Huddersfield, West Yorks. One of each type of Brook Victor vehicle is now in the MRT collection and both are privately owned by a member of the Trust. The rolling stock employed was varied and in 1977 consisted of 17 different types totalling over 800 wagons, most if not all were supplied by Robert Hudson Ltd. The most common type of wagon was the paste drying truck (Hudson ref. 4131).

The standard gauge lines have not been used for a number of years and have been almost entirely lifted, with only small lengths remaining where they cross roads or the narrow gauge. All raw materials and finished products are now transported by road. The works itself is a shadow of its former self and now employs only 300 people. This is partly due to the end of the Cold War and the fact that the M.O.D. now buy their ammunition from countries such as Belgium and India. In fact the whole works is due to close in two years time, leaving our armed forces at the mercy of foreign suppliers.

The narrow gauge system at Bishopton is still working today but in a much reduced form and with only 11 locos, two of which are unserviceable. The locos in use today are 42hp diesel hydraulics, built by the Hunslet Engine Co. Ltd. between 1979 and 1984. Three of these are 'Category C' (flame-proofed) types and are allowed in to more dangerous parts of the works and to enter buildings, something that the others are not allowed to do. The locomotives and rolling stock are maintained in a workshop that has four roads served by a system of turn plates with two four post lifts, one for wagons and one for locomotives that allow easy access to the underside of vehicles. With the system being so large there were many loco sheds dotted around and some are still in use today. The sheds are used to stable the locos when not in use and were also used as charging sheds in the days of battery-electric haulage. The system is still very interesting and almost the entire track is in situ even if it is not used. A walk around the system is intriguing as branches of track (which is all set in concrete) go off and disappear into mysterious tree-covered bunkers and miles of steam mains hiss and spit steam from some unseen boiler. The trees are conifer types and are managed and sold as timber as well as providing some blast protection in the event of an explosion.

This article was first published in 2001 in Moseley Matters, the quarterly journal of the Moseley Railway Trust. For further information on the MRT, please visit their website: www.mrt.org.uk

Appendix 3

THE WOOLWICH LOCOMOTIVES

In 2001 the WARGM Trust were able to acquire two Ex. Royal Arsenal Railway locomotives *WOOLWICH* and *CARNEGIE* from the Bicton Woodland Railway in Devon, which now proudly rest on display at Waltham Abbey and will form the nucleus of a future 18 inch gauge system. This chapter will give the reader some history of their early years.

Locomotives of the 'Charlton' Class were introduced to the Arsenal in 1916. *WOOLWICH* (Wks. No.1748 of 1916) is the only remaining example of her class, a product of the Avonside Engine Co. Ltd. at Fishponds, Bristol, specialists in strong and dependable industrial and shunting locomotives. The first company was founded in 1838 by Henry Stothert to supply the ever-expanding market caused by the expansion of the Great Western Railway. The original Avonside Ironworks factory was in the St. Philips district of the city. In 1841 the company's technical expertise was boosted when Edwin Slaughter – one of Brunel's Assistant Engineers from the Great Western Railway - joined as a partner. The new firm of Stothert and Slaughter became well known at home and abroad. It was re-named The Avonside Engine Company in 1864 and prospered, only to become bankrupt by the end of the decade, due to a failure to adapt to the changes in industry.

In 1882 Edward Walker of Fox Walker Locomotives set up a new 'Avonside Engine Company' and it remained a respected name for a further fifty years, moving in 1905 to new premises at Fillwood Road, adjoining Fishponds Station on the outskirts of Bristol. In 1934 the business was taken over by the Hunslet Engine Company of Leeds and the Fillwood Road works closed, only a few years short of the centenary of the start of locomotive engineering in Bristol.

In 1916 the Ministry of Munitions placed an order with Avonside Engine Company for sixteen locomotives of the Charlton Class (O-4-OT). These were to be the final class of steam locomotive to be used on the Royal Arsenal Railway. The first six, *BRISTOL*, *GLASGOW*, *LIVERPOOL*, *NEWCASTLE*, *DERBY* and *WOOLWICH* were oil-burners, designed to be fired on waste oil and allocated to work in what were classified as danger buildings such as the magazine and filling factories. The remaining ten coal-fired locos were allocated to duties in non-danger areas such as coal and passenger haulage. All this class were fitted with conical spark arrestors but there were other subtle physical differences. Initially rear sandboxes were fitted below the footplate then moved to the tank tops. On *MANCHESTER* and *ENFIELD* the front sandboxes were fitted on tank tops, although these look ungainly. The first four units had small water tank cut-outs. On later units this was made longer. On *SHEFFIELD*, *CHARLTON* and *DERBY* a wooden toolbox was mounted on the left tank top, which may have been an in-house modification. The rear portion of each tank was sectioned off for 50 gallons of fuel oil, which was preheated via a steam coil before atomisation through a Kermod burner. It is presumed that on the coal fired units this 'oil tank' would have served as coal bunker. Overall the Charlton's were sturdy and presentable locomotives, with a tractive effort of 4,980 lbs. They were quite happy to work around curves of 35ft. radius and could manage a tight bend of 25ft. if required.

All the Class were constructed with outside frames to accommodate the 25in. dia wheels, at the Arsenal gauge of 18in., and the now standard axle centres of 3ft. 3in. Operating at a steam pressure of 160 lbs/sq. in., Walschaerts valve gear was employed to the 8½ dia. by 12in. stroke cylinders. The oil-fired units had a side tank water capacity of 260 gallons, a balance pipe connecting the two tanks, and boiler feed by two Gresham and Craven injectors. Unfortunately, no photographs appear to exist of *WOOLWICH* operating on the RAR system, however others of the class *DERBY*, *CHARLTON*, *SHEFFIELD* and *MANCHESTER* are well documented.

In the mid 1920s, after the First World War, manufacturing had declined at the Royal Arsenal and work was dispersed to other WD sites across England. During the mid 1930's the advent of diesel and the expansion

of the standard gauge lines in the Arsenal meant that many narrow gauge locos were sold off or scrapped. After World War II manufacturing again declined and by 1947 *NEWCASTLE* and *COLCHESTER* were taken out of service and scrapped, *MANCHESTER*, followed a similar fate in 1951.

The only survivor of the class, *WOOLWICH*, was put into storage in around 1954 on sidings at the Royal Arsenal before being disposed of in 1960 to dealers Messrs E.L. Pitt & Co. of Brackley, Northampton, having been extensively overhauled and possibly a new boiler fitted during her last days at Woolwich. During her time in the yard at Northampton the conical spark arrestor chimney was replaced with one of conventional design. In April 1962 she was put back into steam on blocks by J & W. Gower of Bedford, prior to sale and moved to Devon on 11th April 1962. There she was to assist with track laying and run on the newly constructed 18in. gauge line at The Bicton Woodlands Railway. During her life in Devon an air braking system was fitted to be compliant with HMRI regulations, which is fed from a steam driven Stuart pump mounted on the rear of the cab. To accommodate the air reservoir the rear cab wall has been extended back some 6in. The believed original RAR livery of green lined out with yellow was changed to blue with yellow lining.

Unlike so many of our heritage locomotives that have rusted to oblivion, or have been cut up for scrap, *WOOLWICH* was well cared for in the last 40 years. It is likely that 100 years of working steam will be witnessed yet again to celebrate the durability of British Engineering in the post Victorian era.

Hunslet Diesel Locomotives were introduced to Woolwich in 1934. By this date the reliability of true diesel engines gave the Arsenal another opportunity to try another interesting locomotive. A high-powered locomotive was required, and it had to be capable of traversing the thirty-foot curves of the 18in. system. This was their first articulated type of loco. This wheel arrangement was essential to traverse the exceptionally sharp curves. Named *ALBERT*, Wks. No.1722 of 1934 had an 0-4-4-0 configuration and made an interesting comparison with the much earlier double-bogie Akroyd Hornsby No.6234. built in 1903.

The power unit for this first Hunslet was a McLaren Benz MDB 4 four-cylinder engine developing 75hp at 1,000 rpm CAV fitted with Bosch injection equipment. Accessibility was seen as an important feature and embodied the "Hunslet" design of loose side shutters which were easily removed by one man, leaving the whole of the engine, starting gear and transmission open for inspection, lubrication and cleaning. The starting was carried out by a Scott two-cylinder two-stroke engine, which automatically engaged and disengaged with the main diesel engine. The two-stroke was hand started from inside the cab. The "Hunslet" pre-selective change gear was employed; at that time the smallest locomotive to use this system. The main drive from the engine to the gearbox was through a multi-plate clutch, followed by a Hardy Spicer flexible coupling in order to prevent any cross strains in the frame set up by the articulation of the bogies. From the gearbox, which was mounted centrally in the frames, the final drive to the wheels was by means of a worm, on to the jackshaft, the latter being coupled to the crank by rods, giving preselected speeds of 4 and 8mph. This jackshaft arrangement had been fully tried and proved in the first "Hunslet" standard gauge locomotive manufactured for the L.M.S. Railway. No.7401 and had successfully operated for 35,000 shunting miles without need for mechanical overhaul.

It was to be twenty years later before the next double bogie locomotive Hunslet *CARNEGIE*, Wks. No.4524, arrived in 1954. This was to be the last locomotive to arrive at Woolwich and was a direct development from *ALBERT* with a very similar external appearance. This more modern loco was fitted with a McLaren 88hp engine, electric start, lighting, cab heating improved braking, and two gears in both forward and reverse. Westinghouse air braking was fitted to both bogies, compressed air being supplied by a two-cylinder compressor driven from the main engine, with the screw hand brake arranged to work in conjunction with the air brake and compensated for operating correctly on both bogies. Air sanding gear was fitted for operating in both directions. Disposed of in 1961 to F & J Darnell in Essex, she was purchased in 1966 by Bicton Woodlands Railway and operated on this line until 2000.

