LOW MOOR IRONWORKS BRADFORD

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At high temperatures in a blast furnace where iron ore is heated with coke and limestone cast iron is produced with a carbon content of 3-5 per cent. This high carbon content makes cast iron very hard and brittle, and it cannot be forged with hammer blows. The cast iron is run from the base of the furnace into moulds and this configuration resembles a sow suckling a litter of piglets. Hence the name pig iron. Iron could be cast directly into moulds at the blast furnace base or remelted from pig iron to make cast iron stoves, pots, pans, firebacks, cannon, cannonballs, or bells hence the name "cast iron"). Casting is also called founding and is done in a foundry.

It was discovered around 1784 that cast iron could be converted into the more useful wrought iron using a puddling furnace. The work was carried out by a skilled worker called a puddler who by stirring the molten pig iron to reduced the carbon content. The process was critically controlled by the puddler who would gather solidifying iron into a single mass and work them under a forge hammer, and then the hot wrought iron would be run through rollers (in rolling mills) to form flat iron sheets or rails; slitting mills cut wrought iron sheets into narrow strips for making nails. This wrought iron with a carbon content of 0.02-0.08 per cent is tough and malleable and can be forged. This is the material which drove the early Victorian Industrial Revolution and was first made at Low Moor in 1801until production finished in 1920. This is the process that was refined until it produced for over a century the famous wrought iron.

The Low Moor Ironworks, Bradford

I The Origins of Low Moor Works

The name of Low Moor is associated with the site of the once extensive ironworks situated some three miles south of Bradford in the West Riding of Yorkshire. For over a century the works manufactured what was regarded as 'The Best Wrought Iron in the World', and round it grew up the township of North Bierley. Originally known as Wibsey Low Moor, the area occupies the dip slope of the escarpment south of Bradford, and is rich in the number and quality of coal seams that occur there together with the onetime-famous Low Moor Clay-band Ironstone.

Much of this area was occupied by the Royds Hall estate of the Rookes family, the remainder being largely in the hands of the Beaumonts of Bretton Hall, Wakeficld. Mining for coal in the district dates from 1360, although the first mention of a mine being developed on Royds Hall land appears to be 1673. By1744 the estate was in the hands of Edward Rookes Leedes, who started vigorous development of the coal mines; one of his coal-trials brought to light the copious spring water which gave Bradford its first piped supply.

By 1763 the coal trade was sufficiently prosperous to support two coal yards in Bradford, at which coal was sold at 3 $^{1/2}$d per corf, and in 1774 the Bradford Canal Company opened its basin in the town. This gave further stimulus to mining in the area, as coal could now be exported cheaply to outlying districts via the connection with the Leeds & Liverpool Canal. Equally important for Bradford was the fact that limestone for burning, and later for iron-smelting, could now be brought in cheaply.

In or about 1780 a wooden railway was constructed to link the various collieries at Low Moor, together with others at Horton, to the coal yard in the centre of Bradford. It is not clear whether this was financed by Leedes himself (he was heavily in debt by this time) ,or by the lessees of a large pit on his land at Low Moor, Messrs Hird, Jarratt, Preston and Balme, who were also, after this date involved in transporting limestone on the canal and operating limekilns at Bradford. Two contemporary observers mention this early line: Ree's *Cyclopaedia* reports, 'In the year 1783 we remember seeing an inclined plane or waggonway ... on which the coal wagons descended down the hill from Wibsey Slack to the town of Bradford ... their velocity regulated by convoys. About 1844 John Cartwright of Bradford wrote: 'Sixty four years ago, I saw railroads and waggons descending on them by their own momentum. A railway was constructed to supply coal for the supply of Bradford. . . . The rails were of ash wood; the carriages of the same form and size ... as those now in use'. In fact chaldron waggons of this type remained in use at Low Moor until after World War I.

In spite of these developments, Edward Rookes Leedes was forced into into bankruptcy in 1781, with accumulated sporting debts of £60,000, and in 1782 the stock and contents of Royds Hall were sold. The estate was offered for sale in the Leeds Mercury on the 19th March of that year, but no purchaser appeared. Leedes himself took his own life in 1785.

Other attempts were made to conclude a sale but nothing took place until 1789. A sale was then effected by John Hardy a Bradford solicitor, to himself, Richard Hird, John Jarrat and the Rev. Joseph Dawson. Hird and Jarratt had been involved in the partnership which has been mentioned above. They were woolstaplers and had joined with Dawson some time earlier to exploit some coal mining interest at present unknown (apparently in 1778). The purchase price of £33,220 paid over on 23 September 1789), and new company of Hird,Jarrat,Dawson and Hardy ., later to be known as the Low Moor Company, had come into being.

Of the partners in the new enterprise, Joseph Dawson was the most interesting. Born in1739 to humble parents, he was educated by an unknown benefactor. Later he was able to visit the Dissenting Academy at Daventry, where he may have made the acquaintance of Joseph Priestley, the chemist. Our knowledge of Dawson is still scanty, and although nowhere does Priestley refer to him by name, yet there are strong indications that Dawson was very familiar with the scientific ideas of the man, if not his associate, at some period. James, writing in 1841, some thirty years after the death of Dawson, speaks of his scientific knowledge and connections.

Dawson was a Unitarian, as was Priestley, and became minister of the chapel at Idle, near Bradford in 1768. He was very interested in scientific and technological matters, and opened coal pits on the hill beside the chapel. After a period of poverty, he began to amass considerable means, and after much neglect of his religious duties (he paid his miners before Sunday chapel) left the ministry to become a full-time colliery operator, as already indicated. He was the only member of the Low Moor partnership to possess technical knowledge, and it was apparently on his advice that a decision was made to conclude the purchase of the manor of Royds Hall, to develop the coal and ironstone deposits, and to enter the business of operating blast furnaces for iron smelting. These were rather impressive decisions to have made, and it is tempting to accept the local tradition that Joseph Priestley was consulted over the advisability of the undertaking. It would certainly seem that Dawson's chemical knowledge was substantial, and that he must have carefully studied the matter of iron-making, probably through the medium of Bergman's *Chemical Essays* (1783).

Certainly, given the excellent quantity and quality of the Low Moor minerals, the partners were commencing operations at an auspicious time. The second half of the eighteenth century was a time of great expansion for the British iron industry, and many famous works were founded during this time. Trade improved, and demand for iron with it, following the end of the American War of Independence. The number of British blast furnaces rose from fifteen in 1788 to twenty-five in 1796, while the average annual yield per furnace doubled over this period. Low Moor was not the only iron-making enterprise to be founded in the Bradford district at this time. Birkenshaw Furnace was founded in 1762 by John and William Emmett and partners, while the famous Bowling Ironworks was set up in 1788 by John and William Sturges and Richard Paley. Both were within a mile or so of the Low Moor site.

2 The Early Years at Low Moor

Soon after the purchase of the Royds Hall estate Joseph Dawson moved his family to Low Moor, living a little to the north of the future site of the ironworks . Shortly afterwards he took up residence in Royds Hall itself, and the old manor remained afterwards the residence of succeeding managers of the works until the change of ownership that took place after World War I.

Construction of the blast furnaces, casting shops and other essential plant began very quickly, actual construction operations dating from June 1790. Messrs Hird, Jarratt, Dawson & Hardy engaged Edward Smalley, of Wigan, as company engineer. In his contract dated December 1791, Smalley agreed to serve for ten years in return for £150 per annum, with house and coals provided free. At

Wigan, Smalley had made the acquaintance of Thomas Woodcock, a stonemason and builder, who was then engaged in erecting the blast furnaces at the Haigh works of Lord Balcarres. Smalley suggested to the new proprietors that Woodcock should offer to design and construct the two furnaces planned for Low Moor. The offer was made and accepted.

The furnaces were erected on a marshy section to the south of Wibsey Moor known as Black Syke. The ample supply of water was turned to good account, since dams were needed to drive the machinery later to be erected on the site, which, incidentally, was leased from the Beaumont family. Woodcock designed his furnaces, and presented his plans for inspection at Low Moor in April 1790. Work then began, and all was ready for operation in August 1791. During this time Smalley had been working on the power unit which was to supply cold blast to the furnaces. This was a large reciprocating engine of the type invented by Smeaton. It had a cast-iron cylinder, 8ft 5in in diameter, with an open bottom that discharged into the reservoir, and was fitted with four valves in the head to admit air. The reservoir was very large, being made of flagstones set below ground and sealed with cement. It ultimately fed three furnaces on this site. This primitive compressor was activated by a condensing engine with a 60in cylinder. Its origin is not known, but, the plates for the boilers that supplied steam to it were made at Kirkstall Forge, near Leeds.

The blowing engine itself was made at Emmett's Birkenshaw ironworks, and bore the legend 'Emmetts Founderers Edward Smalley Engineer 1791'. The present pattern of main roads at Low Moor did not then exist, and the engine was hauled to the site with great difficulty, via Woodhouse Hill, the site of the later Bierley ironworks, along the bad, narrow lane that can still be seen today (SE167302), unchanged except for remains of a later tramroad. Both blast furnaces carried commemorative plaques, viz 'H J D & K 1790'. Thanks to action by Low Moor Best Yorkshire Iron Ltd, these exist today.

The first casting of Low Moor iron took place in August 1791, and this event was afterwards celebrated for many years in ale provided at company expense. The furnaces themselves were of square section, narrowing to the top, and 50ft high. They had a linking bridge from which they were charged by hand. At first, goods of a domestic nature were produced for which there was a ready sale in local markets. Soon items for the textile and engineering trades were being made, and in 1793, for example, Low Moor provided Benjamin Gott's Bean Ing mill at Leeds with a cast-iron dyepan and fittings. In 1795-6 the works supplied steam engine parts to the value of £158 8s 7 $^{1/2}$d to Elsecar colliery, near Barnsley.

Thanks to James Parker, a local historian of the nineteenth century, the following sole fragment of early company records has survived:

Items of Expenditure for the Building of the Low Moor Works, 1789-90

	£	s	d
Item paid for Day Work, from Nov 7, 1789 to Feb 6, 1790	98	18	7
Feb 13, 1790, Stone getting, 2 weeks	2	0	0
James Crosely, Brick making	3	15	0
Thos. Taylor, walling two pits	0	18	0

Jas. Pickard & sons, leading wood	0	5	0
Thomas Constantine, 2 bowls	0	1	2
Bought three horses, May 1, 1790			
Jonathan Tordoff—Two Horses	50	5	0
Wm. Hartley—One Horse .	21	10	0
S. Wilkinson—Two Horses	46	4	0
May 22, 1790—Thos. Woodcock—Wages	2	2	0
Mr. Smalley—Wages	5	5	0
Buying a Spirit Level of Joseph Priestley, May 22, 1790			
To Dr. Joseph Priestley, for a level	7	16	0
Geo. Beanland—Bellows and Anvil	5	5	0
First Digging for Low Moor Works, June 5, 1790			
Paid Joseph Thorns—For digging, first	3	6	0
Paid Eli Pickles & Co for pit opening	1	4	6
June 5, 1790—Sundry masons with Thos. Woodcock	12	8	5
July 3, 1790—Tordoff and Wilkinson—For Slate and Flag	24	17	10
July 3, 1790—Jonathan Whitley—For Slating Counting House	1	11	4

Although there is a reference to Dr Priestley here (who did visit his relatives in the area in 1790), it has been suggested to the writer by E. Robinson that it was not Joseph Priestley the chemist, but Joseph Priestley the engineer of the Leeds & Liverpool Canal, who supplied the level.

Although the Low Moor ironworks were a well-established industrial concern by the end of the century, yet the partners continued to run the estate, acting jointly as 'squires'; thus the manor court was held as usual, the joint lords of the manor fixing rents and making leases to their tenants for farm and pit-working. This feudal procedure (much of the commons was still unenclosed) was kept until late in the following century, and developed into that industrial paternalism that marked some of the great enterprises of nineteenth-century British industry.

3 The Progress of Low Moor Ironworks in the Nineteenth Century

The outbreak of war with revolutionary France in 1793 gave a stimulus to armament manufacture, and Low Moor succeeded in gaining government contracts for this purpose, the first guns being cast in 1795. These, together with shot and shells, became an important branch of the output of not only this foundry but also of neighbouring Bowling Ironworks, until after the Crimean War, when newer types of weapon began to compete successfully. It is not clear at present whether locally mined iron was used for this purpose. Most likely imported iron from the Baltic or Holland was used initially, as was the case at Kirkstall Forge. Such iron with its low content of phosphorus and sulphur was of higher mechanical quality, and was specified by the Crown until 1803 for the manufacture of forged items for naval and ordnance purposes.

However, an increase in the import duty on iron stimulated home production and it was probably at this time that trials were made at Low Moor to compare the quality of iron made with the various local coal types and the Black and White Low Moor clay ironstone balls, with that brought from abroad. These trials would have brought to light the particular suitability of the lower horizons of the Black Bed ironstone (lying above the Black Bed coal), and the high quality of the coke made from the Better Bed coal . It was on these two raw materials that the reputation and prosperity of the Low Moor Company was to depend for the next 120 years.

By 1797 the works had firmly established itself as a producer of iron goods, and Thomas Butler of Kirkstall had begun to feel competition from the Bradford works. By 1799 production of pig iron was running at about 2,000 tons per year. The price list issued by Low Moor for 1799 shows that besides guns a very wide range of products could be supplied. This included steam engine parts, gear wheels, including Sun and Planet wheels, shafts, and load-bearing columns for the fireproof mills then being erected. Rail and tramroads were then coming into use in mining areas, and Low Moor was offering to supply iron wheels for corves at 18s 8d per cwt, and iron tram plates at 12-14s per cwt, depending on weight per yard. Parts for textile machinery, oil, wind and sugar mills, domestic items such as beds, railings, grates and garden furniture, were all included, and also brass-casting work was undertaken.

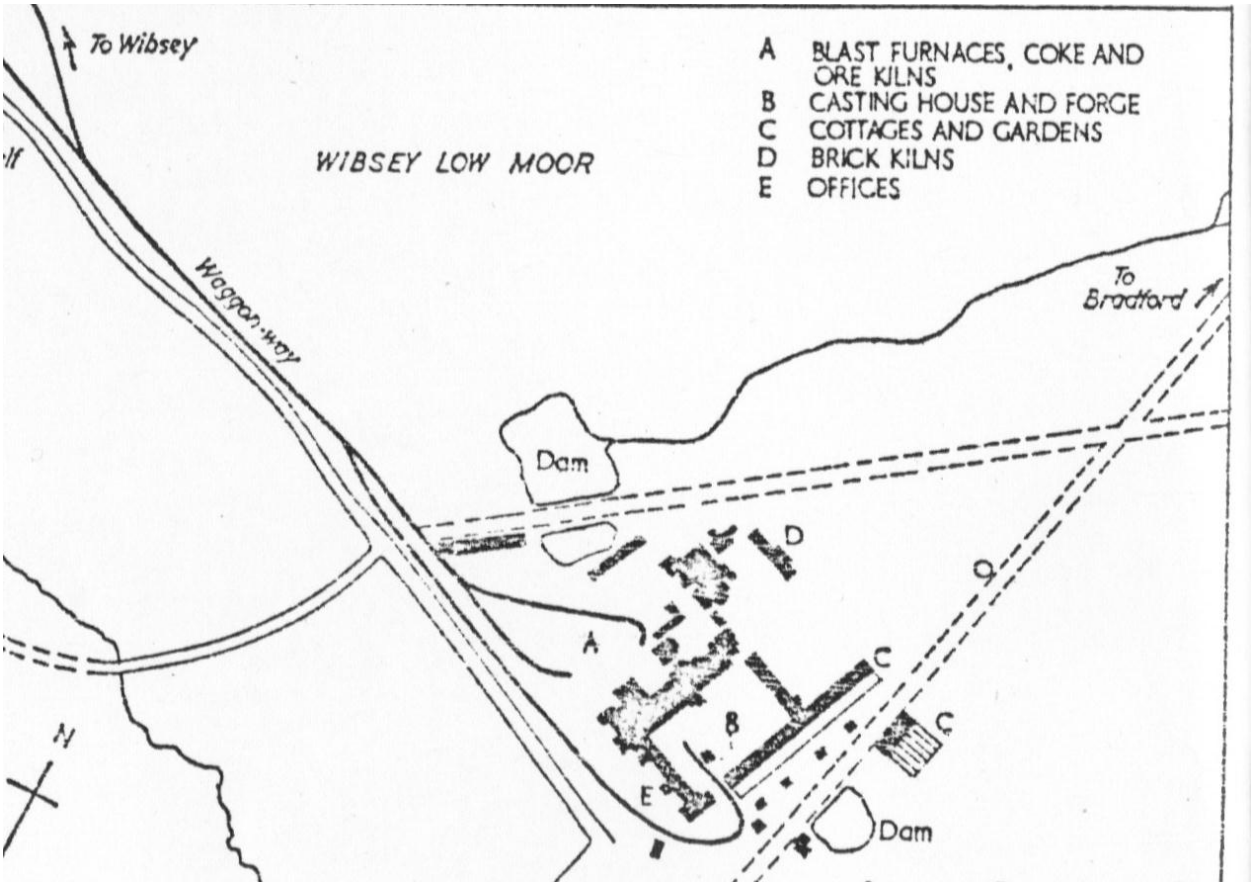
The scale of casting operations meant that serious accidents would occur from time to time, and in August 1801 George Brooke was crushed to death by a large mould while working in a pit.

After ten years' experience in iron-smelting the company decided to make wrought iron and a forge was set up in 1801. Probably imported bars were used in the forge at first, although the rapid expansion in use of Cort's dry puddling process meant that there was plenty of good-quality British bar iron available. In fact by 1801 Low Moor was supplying Kirkstall Forge with pig in large quantities. However, charcoal fires were used for the first year or so in the new forge. In 1803 refinery fires were set up, and a few sand-bottomed puddling furnaces started, and Low Moor pig iron was made into wrought iron for the first time. It was rapidly found that Better Bed coke was ideal for use as a fuel in all forge work. The aim of refining and puddling was to remove as far as possible all the carbon, sulphur, silicon and arsenic in

pig iron. The use of this grade of coke, with its freedom from the usual impurities, made what was later known as 'Best Yorkshire Iron', a metal of great ductility, strength, and resistance to all corrosion media.

A slitting mill for nail rods was erected in 1801, and a pair of nose-helve hammers, driven by a low-pressure reversing engine in 1805. With the development of puddling, a small plate-rolling mill was installed also in 1805. Meanwhile some mechanisation of the smelting side had occurred. In 1800 hand-charging of the furnaces had been replaced by a self-tipping inclined railway, chain-driven from an adjacent waterwheel. This was supplied with coke and calcined ironstone from the adjacent kilns by an overhead tramroad, whose trolleys were then lifted on to the incline.

In 1799 the ironmasters of Yorkshire and Derbyshire began to have regular meetings in 'Friendly Association", with the aim of holding both technical and commercial discussions. These were later devoted almost completely to price-fixing activities, but some initial lectures were given. Joseph Dawson was elected president at the first meeting. In his lecture to the ironmasters given at Barnsley in March 1800, he mentioned many details of Low Moor practice. It is here that our only direct evidence of his scientific abilities lies, and while his knowledge reflected the gaps and misconceptions of that time, nevertheless it is clear that these were Joseph Priestley's own theories which { Dawson was trying to apply. It is hard to resist the idea that the two men were in fact friends.



Low Moor Ironworks, near Bradford, (From a survey by George Leather, Junior,1811

Coal was made into coke at Low Moor by heating it in kilns which were partly closed to the atmosphere or by 'torrefying' it by slow combustion in heaps on the ground. These kilns, afterwards known as 'beehive ovens', were introduced into Britain in 1759. Although they gave a higher yield of coke, yet Dawson held that coke made in open piles was more 'beneficial' for smelting purposes. Oven coke, it was thought, stronger mechanically, did not make iron of equivalent quality. The ironstone was exposed to the weather in piles for some time, and Dawson believed this to be of importance. It was then mixed with coal and burnt either in open piles, or in firebrick-lined conical kilns with open tops, heated by direct fires. Dawson noted that the ore lost one-third to one-quarter of its weight by this process, that it changed in colour from grey or black to deep red or brown, and that it became magnetic. He advocated research into these effects, but strangely does not seem to have been aware that the loss in weight was due to the formation of carbon dioxide, Priestley's 'Fixed Air'. Dawson seems to have represented Low Moor at these meetings till 1810, when he, together with Sayle of Brightside and Butler of Kirkstall, visited the Ironmasters Meeting at Gloucester. In the following year the signature of his son, Christopher Holdsworth Dawson, appears, and shortly after, in 1813, Dawson died. Jarratt then left the business, and the firm was afterwards known as Hird, Dawson & Hardy, or the Low Moor Co.

Dawson had become a powerful man in his lifetime. In 1803, he and Jarratt had leased mining rights on Walter Spencer Stanhope's Silkstone estate, at the head of the Barnsley Canal. The mine did not prosper, owing to poor coal prices and the bad state of that canal, and the two men had by 1806 lost the considerable sum of £46,000, including the cost of a steam engine. Yet this venture did not bankrupt Dawson. His letters show him to be a mild, yet determined and painstaking individual, and events at Low Moor seem to confirm this.

The Low Moor Company became accustomed to employing the services of George Leather Jr, civil engineer and surveyor of Stanley, Wakefield. He made assessments in 1806 of the coal works at Silkstone for Dawson, and made a survey map of the Low Moor holdings in North Bierley and Wibsey in 1809. Unfortunately this plan, and all others except for his survey of 1811, is at present lost, although some titles have been recorded by the National Register of Archives. Part of tithe 1811 map is reproduced above in this article. By this time the company had been able to gain control of a considerable acreage in the district, which ensured adequate reserves of ironstone and Better Bed coal measures. The map uses the name Low Moor Company, and shows that they held the land round Rooley Hall, bordering on the Lindley Wood estate then being mined by their neighbours, the Bowling Company. The plan also shows the extent of unenclosed strip allotments that were to survive until the 1880's. The reproduction shows the rectangular layout of the works at this time. On the western edge was a large reservoir, fed from the dam in the grounds of nearby Royds Hall. The west part of the plant was taken up by the casting house and forge buildings, and on this side too were the blast furnaces and the coke and ironstone kilns and heaps. The southern, eastern, and part of the northern sides were taken up by workers' cottages, all of which were stone built. The eastern ones were known as the Long and Short Rows, and have only recently become uninhabited. They are now partly demolished, leaving their back walls as a perimeter fence to the present works. In the yard stood a small two-storey

octagonal building that served as counting house, with the board room upstairs. The present offices by the south-east main gate were only built in 1842.

The map shows the layout of the waggonways, one running into the yard, and one, with two spurs, serving the coking area. The main line ran along what is now New Works Road, and it seems that this was an iron plateway of the type found elsewhere in the district. A plateway for carts existed on this site until about 1930, when it was dug out and melted down. Seven hundred yards from the gates the line forked, one branch running to Wibsey Slack, close to Shelf Furnace, which has entirely disappeared The other branch ran NNW along the present Abbscott Lane, through Buttershaw to Little Horton. This waggonway apparently connected with the line of the old 1780 railway from the original Low Moor colliery, which ran downhill to Bradford. Rees's Cyclopaedia mentions the line as still in existence in 1805, and for many years the company maintained a landsale coalyard close to the head of the canal in Bradford. No doubt the line was used to haul limestone back to the blast furnaces at Low Moor.

It is not known with any degree of certainty when iron rails were first laid on waggonways outside the works area. The abrupt ends of the lines shown on Leather's 1811 plan would seem to be plateways, by their sudden endings at roadways, and we know that tramplates were being cast at the foundry. Examination of some of the unmetalled lanes in the Low Moor area has shown that other tramroads were in use. The remains of stone sleeper blocks and iron chairs suggest that these were laid in the period 1805-10. Apparently very broad iron plates were used to assist the passage of heavily laden carts from the outlying mines to the various ironworks around Low Moor. The present A64I and A58 were not turnpiked until 1824 and 1833, and the only route by which coal and ironstone could pass from the mines being developed in the Scholes area was via one of these all-weather plateways, traceable between SE 167260 and SE 169277.

The growth of the ironworks at Low Moor led to the urbanisation of the district which became known as North Bierley. The first dwellings built for the workers were the Long and Short Rows beside the works, but as more processes began to operate, more cottages were built nearby, and also across the moor at Buttershaw and Wibsey . These are often recognisable today. They generally consist of little closes of single-storey, stone-built cottages and are now generally surrounded by modern property. The partners in the works had early taken up residence close to the furnaces, and did not move away for many years, contrary to the fashion amongst the textile magnates of the 'Heavy Woollen District'. Dawson lived at Royds Hall, overlooking the works; Hird lived at Low Moor House from 1791, and Hardy at nearby Odsal House from 1795. Through the efforts of Joseph Dawson a school was established near the end of the Shelf waggonway, at Moorside. Boys employed by the company attended this, Sundays included. Later known as School Close, the building was only demolished recently. As trade grew, it became necessary to employ more boys, particularly in the pits, and by 1794 it had been decided to provide a hostel so that boys could be brought to Low Moor from the distant parishes of Leeds and Halifax. Buttershaw House was established, a farmhouse which had twenty acres of useful mineral bearing land to it. It lay beside the waggon way to Bradford, not far from the works. The boys who boarded here received schooling and clothing at company expense. A fragment records that William Bastow in 1794 paid For Lads Meat and Clothes at Buttershaw House, £1-8-6. It is not known when this hostel ceased to function, but the building had been converted to a public house by 1830, one of several maintained by

the company. As lord of the manor, the company not only owned and controlled the various inns, but also the annual Wibsey Fair, while it also had to undertake a fair proportion of highway repairs, on account of the large amount of property owned by it in the district. Waste material from the furnaces was employed for this purpose.

When the war with France commenced again after the brief Peace of Amiens, companies of volunteers were raised all over the country and Low Moor was no exception. John Hardy raised a corps of 1,001 members, who were apparently smartly attired and well drilled, though of course they never saw active service. Their existence was recalled in the name of one of the little closes of houses near the works, 'Soldier's Green'. Because of the shortage of minted coin at this time, the Low Moor Company began in 1803 to issue its own banknotes, in common with many other enterprises. These had face value of one guinea, and bore the names of Jarratt, Dawson and Hardy and were withdrawn in 1811, but £1 notes were then circulated from 1812 to 1826.

It would appear that with the growth of the settlement around Low Moor, the original school, intended for the sixty or so lads of the Buttershaw hostel, had become too small and inconvenient. In 1814 another school was erected for about 100 children, and it appears that the Hardy family were mainly responsible for this development of social service. It was a stone-built, single-storey building, with gothic windows and with a massive central roof beam, cast in the works. The southern gable end bears an engraved stone plaque with this inscription: 'Erected By The Low Moor Company, Anno Domini 1814'. It was extended in Victorian times, and records show that at one time had over 300 pupils, apparently in three shifts. The first master, Mr Sutton, served till 1838 while the next remained till 1882, and gave his name to the school—'Scott's School' . It is still serving the children of Low Moor today, lying just outside the works area, and no plans exist to demolish it.

It is worth recording that many of the families employed at Low Moor in the early years remained in employment down the years. Thomas Woodcock, the builder of the furnaces, stayed until his death in 1833, and also his sons and grandsons to the fourth generation (H. B. Woodcock, works manager, 1902), and even the fifth generation (F. S. Woodcock succeeded H.B.).

In common with other great ironworks, the Napoleonic Wars brought prosperity to Low Moor. It is very probable that the outbreak of war with America in 1812 gave further stimulus to the production of guns. Possibly, the return to peacetime conditions in 1815 caused the same distress at Low Moor as it did in the iron-making areas of South Wales, but there are no records of this. However, the nearby Birkenshaw furnace and foundry gave up work in 1815, and neither Low Moor nor Bowling appeared to wish to purchase the site, although existing ore stacks were taken over. It appears that pig-iron output at Low Moor had reached a maximum at the end of 1814, with 33 tons per week. But iron prices fell after the war, and remained low for a long period. There was a revival after 1822 owing to the growth of the gas industry. Gas light had been pioneered round the turn of the century by Boulton and Watt, but it was only after 1817 that it gained general acceptance, and companies were set up in all the major towns. Bradford's Gas Light Company was established in 1822. Price fixing agreements were made by the Yorkshire ironmasters for the supply of gas pipes and other items, and the following interesting list was taken from the minutes of their Friendly Association for 1824.

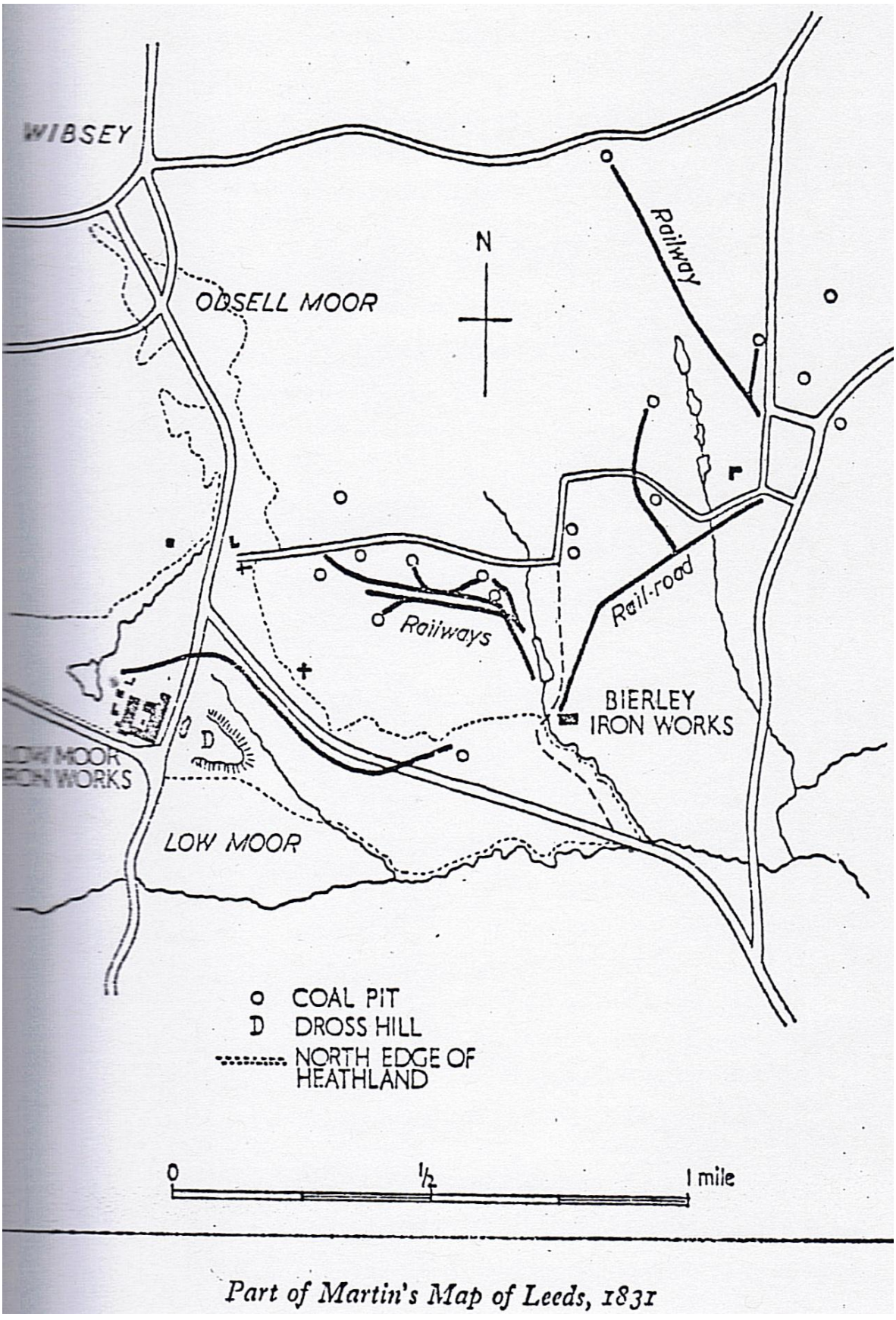
Six inch and upwards pipes	£9	per ton
Four to five inch pipes	£9-10s	per ton
Two to three inch pipes	£10	per ton
Plain lampposts	£9	per ton
Flutted lamp posts`	£10	per ton
Pig iron No.1.	£7-10s	per ton

Signatures were given by H. H. Hird for Low Moor, and Henry Leah for Bierley works. This was a busy period for the Bradford ironmakers. Thomas Butler wrote in 1825:

The furnaces of Low Moor and Shelf worked in conjunction. They have a large contract for Shot for the East India Company. Four air furnaces going daily are making a quantity of 20 tons per day of 18 and 24 pounds and are as busy as bees in a hive. Certainly they are making 100 tons of Shot per week, Small shot for Grape and Carronade are being made at Low Moor. Week after week they have melted 250 to 270 tons into Shot and Shells.

He also mentioned.' that they were very busy in the Steam Engine department, although held up by a 'rebellion', and fourteen of the, troublemakers had been given notice to quit. However, these arms contracts were intermittent, and by 1828 the works was fruitlessly seeking another, although the demand for engine work was still good. Butler referred in his diary to what was apparently an amalgamation of Low Moor and Shelf ironworks in 1824, when there was a need for extra supplies of pig to meet production requirements. Shelf had been founded in 1794 by John Crawshaw, Samuel Aydon and John Elwell. The latter had been one of the founding partners at Bowling some years earlier. By 1797 they were known only as Aydon & Elwell ; they purchased mineral rights in the Wibsey area, and by 1806 were operating two blast furnaces. Always in competition with their larger neighbour, they built up a good reputation, and survived the failure of their bankers, Swaine & Ramsbotham, in 1807 according to some of their old bills of exchange. They supplied cast rails to some of the early colliery waggonways of West Yorkshire, and are best known for casting the 'Pollard' bridge over the River Aire, close to Kirkstall Forge, in 1811. Shelf works was connected at this time by waggonways to the tracks at Wibsey, and directly to Low Moor.

The development of rail transport to these ironworks is of great interest. Some light on this is thrown by the two maps of Bradford published by Henry Teesdale in 1828, and by S. D. Martin in 1831. Both show that the line originally serving the Bradford Canal stopped short at the company's Horton coalyard. Martin’s shows that a line ran from near the blast furnaces,round the northern side of the works and across the present A638 to a pit near Bierley ironworks. This was the site of a later mixed-gauge line with a spur to Low Moor LYR Station. It would appear that the extensive network of standard and narrow-gauge lines serving the mining field to the south of the works dates from 1831. It is interesting that network of railways is shown which connect Bowling and Bierley woks to their coal and iron pits; however, certain tramroads, already mentioned, are omitted.



Part of Martin's Map of Leeds, 1831

The Prussian engineers von Oeynhausen and von Dechen visit Low Moor in 1826-7, and recorded that the rails then in use were rectangular bars of cast iron which had cast-on lugs for attachment to the sleepers, which were the usual stone block pattern. Such sleepers found on the remains of waggonways which had remained in use until about 1900 bear the marks of rail supports of an uncommon type, suggesting that rails of this pattern remained in use for a long period. Star-shaped holes were made in the blocks to receive the rail fastening. The dates of further mineral purchases show how mining of the Black Bed ironstone and Better Bed coal developed . Important acreage was still unworked in the Wibsey area, and significant purchases were made in 1828 and 1831. However, it was now necessary to look further afield, and the first purchase in the Leeds area seems to have bet made at Beeston in 1834. Acquisitions of land in the Wyke area to the south of the works were made in 1838, when Wyke colliery was acquired from the neighbouring manor of North Bierley. It was in this area that the extensive Low Moor narrow-gauge railway network gradually developed over the next seventy years.

The extent to which Low Moor works was developing can be judged by the accounts of two eye-witnesses. The first, John Nicholson, wrote the following ode in 1829, a few lines only being quoted

When first the shapeless sable ore

Is laid in heaps around Low Moor

The roaring blast, the quiv'ring flame

Give to the mass another name

White as the sun the metal runs

For horse shoe nails or thund'ring guns

The trembling hairspring of a watch,

An anchor or a cottage latch—

Most implements the farmers have .

And those of steamers on the wave

The tailor's needle or the shell

That levell'd once where princes dwell

The engine, boiler, cobbler's awl

The carronade, the pond'rous ball;

The place where steam first moves his wings

The nails in beggars' shoes and kings'

The anchor's chain, the fisher's hook,

The sword—the latchet—and the crook

The sounding anvil, all the blades

The cause of many thousand trades;

No pen can write, no mind can soar

To tell the wonders of Low Moor.

Nicholson goes on to describe the boring of cannon, and the smashing of any defective guns. He also mentions that old guns were made up into railway material. In 1835 Sir George Head visited the works, and gave a long detailed description. Apparently the old blast furnaces were still unmodernised, and he mentions the huge piles of slag, on which vegetation was beginning to sprout. He quotes the output of finished iron goods as 21,600 tons, which must have included some bought in material. Although no change in methods of wrought-iron-making had yet occurred and cold blast was being used, some machines were in use. Thus Head described a large lathe which was being used to turn out a 46in cylinder. It was, however, water-powered from a wheel. The works was at this time very busy with the manufacture of sugar pans and mills for the West Indies.

As a result of this period of prosperity it was felt that what is now known as Old Works (or Top Shop), was no longer sufficiently large nor completely equipped to handle the volume of trade to be expected in the future. The original site was now occupied by kilns and blast furnaces for smelting iron, a large dross hill, reservoirs, puddling furnaces and forge engineering department offices, and workers' housing, besides brick kilns, smithies and sundry other buildings

Thus, in 1835 work began on levelling and erecting the New Works on nearby site known as New Biggin, lying just to the south east. Two open-topped blast furnaces and a casting hearth were erected here, and in 1836 were blown in, each having a capacity of 70-80 tons per week. There were now six furnaces at Low Moor, with a further three at Shelf works. In 1835 the forge was extended at Old Works, with a new bar-rolling mill.

The increasing production of pig iron meant an extension in the tonnage of ironstone raised in the nearby mines, and it seems the drainage was becoming a problem. In 1836 Low Moor and Bierley works began a joint project to ‘unwater’the mines of the district with the sinking of a new shaft, the 'Oakenshaw Lift'. This served a wide area including mines on the high ground at Wibsey Slack. Pumping began in 1840; power being supplied by an engine from Fentorn, Murray & Co of Leeds. The expansion of mining, as Low Moor' began to work its reserves in the Wyke-Scholes area, entailed a new pumping shaft farther down the open Valley at Taylor Mills, Hunsworth, SE 184270. Short soughs were driven to lead water to this lift, and these are indicated on the first edition 6in Geological Survey of Yorkshire. This lift, which operated right up to 1928, must also have given some assistance to the nearby mines of the competing Bowling Co.

The decade 1840-50 saw great developments in the field of railway and marine engineering. There was substantial demand for high-quality wrought-iron products, and modernisation proceeded rapidly to keep pace with demand. As this material slowly approached its zenith, soon to decline under the severe competition of mild steel, so did Low Moor works create for itself the reputation for quality which was to ensure its survival as an operating unit long after other operators had closed down for good. In 1842 a larger plate-rolling mill was installed to meet the demand for boilers for more powerful engines. More powerful forge hammers were installed to cope with larger forgings. Designed by Low Moor engineers, these helves came into use in 1843. There were four pairs of these, each pair being driven by a 30 hp low-pressure steam engine via a central, 3 armed camshaft. They remained in use until 1904.

These helves proved unsuitable for the forging of locomotive cranks, and this was the main reason why the company agreed to install one of the first of Nasmyth's steam hammers in 1844. The steam hammer had been conceived for the forging of paddle crankshafts for the steamship Great Britain. Brunel's influence led to the adoption of screw propulsion, however, and the hammer remained unbuilt. Construction was carried out by French engineers at Le Creusot who had been shown the design by Nasmyth, and shortly after this a hammer was built at Patricroft. For reasons of conservatism and trade depression ,British ironmasters were reluctant to adopt the hammer, and indeed it was not until Low Moor had gained practical experience with their new helves, that the directors of Low Moor would consent to a trial. Difficulties occurred, partly owing to prejudice and partly owing to lack of control of the action of the hammer, and Nasmyth was informed that his 4 ton hammer was too heavy, and that $2^{1/2}$tons would have been more suitable. However, Nasmyth must have persevered, and development was put in hand at the forge, and a control system was evolved which the force and length of stroke of the steam hammer could be regulated. This 4 ton hammer was later used, in 1857, to forge the piston and connecting rods, crank pins and other items for Brunel's steamship Great Eastern.

The increased forging capacity necessitated the extension of the puddling and reheating furnaces, and a new puddling section was tested in 1846. Perhaps metal bottoms were introduced at this time, it had been found that these gave a purer iron than the old, Cort-type, sand bottoms. It was probably the extent of the modernisation, and the increasing importance in the production of heavy engineering items that prompted the decision to cease production at Shelf iron works in 1849. The furnaces there were blown out, and the connection to the Low Moor rail system taken up. The district was surveyed in 1847 for the first edition of the 6in Ordnance Survey. This map is doubly interesting, for not only does it clearly show the changes in land use which had occurred in North Bierley since the plan of 1811, but it records the development narrow-gauge railways and tramroads to link the ironworks to the mines. Also the standard-gauge companies had reached Low Moor at this date, and both sections of the works had gained connection to the West Riding Union Railway via Low Moor Station. Shortly afterwards the Manchester & Leeds branch of the later Lancashire & Yorkshire Railway was opened, and this reached Low Moor via the tunnel of that name which was built underneath Royds Hall estate. The Ordnance Survey shows that the Low Moor narrow-gauge tracks had reached mines in Wyke close to the A58 main road. The gauge of these was apparently 3ft 10 $^{i/2}$ in, and this unusual gauge was still in use until 1928.

Apparently, the engineering department at Low Moor supplied Cornish pumping engines to the York Waterworks Co in 1849 to replace a Newcomen engine installed by John Smeaton in 1784 in the Lendal Tower, York. In 1851 the works was visited by George Searle Phillips at the invitation of managing director Henry Wickham descendant of the Hirds. He noted the heavy pail of smoke that normally hung over the area, fed by the many chimneys. The new blast furnaces were about 70ft high, and had blue flames emerging from the top. He saw the casting of 'balls, bomb-shells and hand grenades' at this time, and noted that although the engineers were working only four days out of six, yet two of the largest boilers up to that time were being made, while two guns were being got ready for show at the Great Exhibition, one of 10in bore, and the other a thirty-pounder. The wage bill of the works was, £1,800 weekly, with 3,000 hands on the payroll. Wickham stated that although the average wage was 12s, yet a forge man could earn as much as £6 while a skilled craftsman received £3 10s. There were by then 400 company-owned houses in the area and three schools, while workers and their families received free medical attention. There were also some fifteen public houses round Low Moor, some owned by the company; some had names inspired by the works, such as the Patent Hammer Inn, which still exists. It appears that about the date of Riepe's British Patent of 1850, the Low Moor Company acquired a licence for the manufacture of puddled steel by this process. This was much the same as the wrought-iron making method, except that the cycle stopped short of burning out all the carbon, leaving what was effectively mild steel. It must have been a difficult process to control, and apparently a high price was put on the steel, thus limiting its acceptance. By 1858 about 1,000 tons had been made, and had been supplied mainly to Naylor, Vickers & Co of Sheffield, who used it for cast steel bells . No mention seems to have been of this in those company records that survive, and there is no knowledge that the process was ever operated amongst surviving employees of Low Moor Works.

In 1854 Low Moor acquired its neighbour, Bierley ironworks, which had been founded in the prosperous times, just after 1800, when Leah, Marshall, Clayton & Co had leased the site and mines from the manor of North Bierley. They soon were operating a prosperous land sale coal and pig-iron-making business, using the same minerals as Low Moor and Bowling. By 1830 two blast furnaces were in operation, and a network of tramroads had been laid around the works and its mines, with an extension running north to the B6148 road, along which carts loaded with pig iron climbed some 200ft. This works was connected to Low Moor via the narrow-gauge railway system and still remained in use till 1905. The dams which had served the works can still be seen, and so can the base of one of the furnaces.

The outbreak of the Crimean War in 1854 kept the Low Moor foundries very busy, several tons of guns, mortars, shot and shells being turned out in in during each week of the war. The shot-casting house at New Works became known as Sevastopol at this time. After the war came the Indian Mutiny, and Low Moor supplied guns to replace those lost to rebels. But after this time the production of cast-iron guns declined and the arms trade passed into other hands.

During the period 1860-75 wrought iron remained the prime material for many heavy engineering applications, and about half- way through this period Low Moor was at its peak as a vertically integrated works. This involved operating its own mineral reserves, and manufacturing engines, chains, and boilers as well as supplying rods, angles, plates and oil rolled products. In 1855 it had been the biggest iron producer in Yorkshire, with 21,840 tons annual output, but this position was lost as the

manufacture of mild steel gathered momentum. Yet in the sixties demand for what had become known as 'Yorkshire Iron' remained good, and Low Moor's grade was specified by consulting engineers wherever safety was an important factor. Iron of equivalent standard was made by the Bowling Co, and by three other makers in Leeds. These were Farnley Iron Co (founded 1846), Monkbridge Iron & Steel Co: (1854), and Taylor Bros & Co (1857). They formed a rigid price-fixing agreement, which was later known as 'The Ring'. The Admiralty in 1856 had carried out careful tests on various wrought irons available and concluded that Low Moor, Farnley, and Bowling iron were all of equal merit, in the highest class.

Low Moor iron was reputed (and claimed) to be superior because it was made only from the company's Better Bed coal and Black Bed ironstone. However, in 1864 Percy claimed that at 1,700 tons per acre Low Moor could not produce enough of the latter to account for its total iron output, and that the famous quality was due only to special methods of manufacture. Whatever the truth at this time, 'bought in' ironstone was being used by 1886. However, mining operations on the local deposits were at their zenith, and Baines records that in 596,628 tons of Black Bed ironstone were raised and valued at £149,157. The Geological Survey noted a minimum output from the deposits of 175,000 tons in 1859, and a maximum of 785,628 tons in 1868, of which 617,628 tons was Low Moor ironstone. In 1850 Low Moor had thirty-eight pits in the surrounding districts, and by 1860 this figure had become fifty-one, including sixteen 'open work' pits. Nineteen pits were still open at Wibsey, but this area was becoming exhausted after long extraction. However, by 1869 the acreage being worked in the Wyke area had been extended, with royalty payments of £70 per acre for Black Bed coal, £60 for the ironstone, and £50 per acre for the Better Bed coal. The company had probably acquired collieries near Brighouse in 1852, and was definitely mining there by 1862, according to the list of Low Moor mine plans. Also it seems that between 1858 and 1870, Low Moor was working part of the Farnley Iron Co reserves in the Beeston area of Leeds.

Bains noted that coke was still being made in heaps and that ore was left to weather in piles for months before calcination. It consisted of brown-black spheroidal lumps that had to be freed from a matrix of shale. The only usable material was the 1/2in thick layer of Top Balls of the White Bed stone and the 2in thick layer of Middle Balls of the Black Bed deposit.

In 1863 the works was employing 3,600 workers, of whom 1,993 were miners, 770 were forgemen , 420 were furnacemen, 323 were engineers, and 94 were agents and managers. By 1864 it was found that another steam hammer of 8 tons load was needed to produce the heavy forgings being demanded, and this worked alongside the Nasmyth hammer. There was a growing demand for wrought-plates at this time as the result of the development of iron ships; the existing 18in plate mill at Low Moor was replaced by larger mill having rolls 24in in diameter and 7ft 6in long. A 7 ton steam hammer was built in 1871 to supply this mill with slabs. Demand for plates of an even larger size grew, and another mill was provided in 1878, for which the forgings were made at the works. It had 32in rolls, which were 11ft wide and was one of the largest rolling mills in the country at that time.

A critical appraisal of 'Best Yorkshire Iron' by Skelton in 1884 showed that the superiority of these plates lay in their strength across the grain (i.e. at right angles to the direction of rolling). Thus, whereas

a good 'Treble Best Staffordshire plate' showed an extension at break of only 7 per cent, a Yorkshire plate showed an extension of 12 per cent, moreover this great ductility was accompanied by great corrosion resistance, and Low Moor and Farnley plates were mainly used in boilers, which had to use dirty water, and in fireboxes . It was not until about 1880 that the members of the 'Ring' would agree to be bound by mechanical tests, and many engineers were content to specify the name of the maker only. The price of Low Moor plates etc. was two to three times that for mild steel. There were many attempts to copy, and railway axles made at Low Moor bore that name, the date, and the mark 'Double Faggoted'.

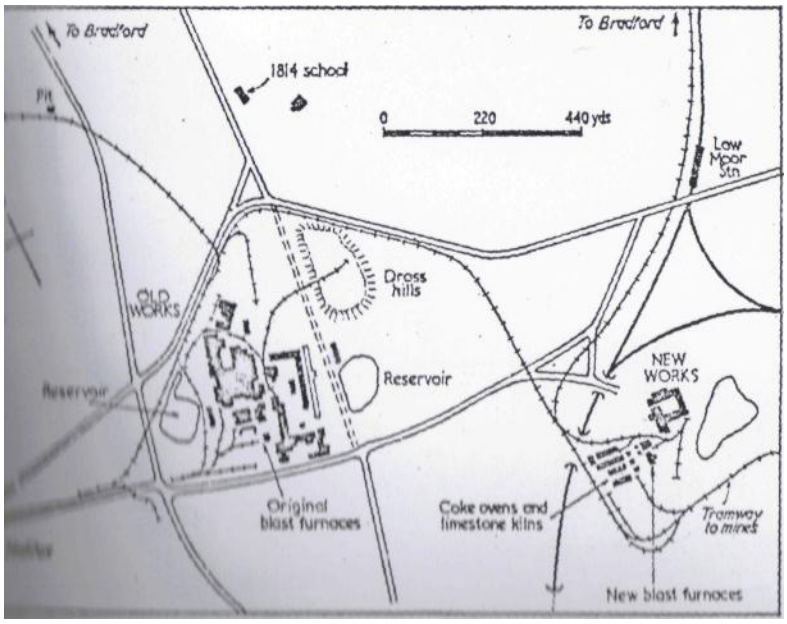
By 1886 the company was beginning to feel the effect of competition made worse by its antiquated iron-making plant and widely spread mines. A mineral survey was made by Sir W. T. Lewis of the Bute Mineral Office, Aberdare. It shows that the company were now obtaining ironstone from some eight pits around Leeds, some of which like Osmondthorpe, were being worked by longwall mining, which was unusual in British iron mines. Better Bed coal was not obtained from this district, and the company had to depend on its mines in the Wyke area, which in turn could not produce ironstone economically because of a geological separation from the Black Bed coal. The company was buying in much iron ore at 16s 5d per ton, compared with its own production at 14s. The source of these supplies is unknown, and attention was not drawn to the change. Low Moor continued to claim that its superiority was due to the properties of the local coal and ironstone.

This report showed how inefficient the Low Moor transport network had become. Comparison of Lewis's map of the network with the of map of 1847 shows that many branches had been abandoned, but that connection had been made to Walker's 1844 tramway from Hartshead village to the canal basin at Brighouse . Bierley works had direct rail connection, and a branch ran to Kaye pit which lay well towards the Bowling Company's mineral area. Indeed, the Low Moor policy of building up reserves had limited the scope of that company rather severely in the whole area. There were, however, various gauges and sizes of trucks in use. Haulage was partly by loco and partly assisted by nine stationary engines. Some lines, like that joining New and Old Works, were mixed gauge. There were the Low Moor 3ft 10 ½ in gauge, plus the Clifton, and the Bierley gauge in use and perhaps others. Costs were 3 ½ d per ton mile on the Low Moor and 5.1/2d. on the Bierley lines. Locomotives were first used on the Low Moor lines in 1854, and, although no details are known, yet it is likely that these were standard gauge. It was recommended that locomotive haulage be adopted throughout the system, except in the Norwood Green area, but this never done. Underground, things were similarly organised. Corves varied in size from pit to pit amongst the forty-five then at work around Low Moor; they held 3, 3 1/2, 5 ½, and 8 cwt , and it seems that boys were extensively used to push them to the horse-worked roadways. It was pointed out that economies would be made if the room and pillar workings were opened out to admit horses, and if power-driven rope haulage was introduced. Boy-power was 30 per cent more expensive than horse power at 6s per ton mile.

The picture of the company that emerges from this survey of 1886 is one of inefficiency and obsolescence. Old furnaces were being kept in blast, transport methods had not been brought up to date, and mining methods were in need of rationalisation. Small pits had to be maintained to conserve 'premium' raw materials. Moreover, competition from mild steel must have begun to affect the market

for large high-quality plates. Yet the fact that any management study was carried out at all shows that the directors were aware that something he done if the works was to continue. A programme of modernisation was decided upon, as will be described in the next section.

Low Moor Company Ltd, 1888-1919



Low moor Ironworks in 1905(based on Ordnance Survey maps)

In spite of the progress of the mild steel industry, and the disappearance of certain markets for wrought iron (e.g. the rail market), nevertheless Skelton stated that 'Best Yorkshire Iron' remained the choice of engineers for rivets, chains, railway axles, couplings and cranks, for firebox use, and similar situations where safety was of paramount importance. Government departments remained important customers. It seemed that this situation must persist for many, many years, and to face the future, it was decided to turn Low Moor into a limited liability company, so as to take advantage of the protection offered by the Acts of 1862-86. The new Low Moor Company Ltd formed in 1888 with a registered capital of, £300,000 in Ordinary shares, and £500,000 in Debentures. Control of the company remained in the hands of the descendants of the original founding families,

It was decided to continue to manufacture 'Best Yorkshire' if only, to serve the needs of the market described above. By contrast, nearby Bowling Company seems to have attempted to break into crucible steel trade some time before 1877, according to Griffiths. Their attempts to make both steel and 'Best Yorkshire Iron' do not seem to have been particularly successful, since they were forced cease operations in 1896, their mineral reserves being exhausted. Steps were taken to modernise the pig-iron-making plant at Low Moor. Two new blast furnaces were planned for New Works, at a cost of £130,000. These were 70ft in height and were enclosed in iron plate. One had a hearth of 8ft diameter and could make 340 tons per week. The other was slightly smaller and could make 240 tons per week. They were fed with cold blast from one of a pair of single-cylinder steam engines. These worked at 80psi, and blast at 6psi. These were built at the works and had 40in steam and 84in air cylinders, and occupied four floors of an engine house built close to the furnaces. It was

widely believed that cold-blast superior to hot-blast iron for many purposes and this was the reason for the retention of such a high cost method at Low Moor. Apparently a trial of the hot blast had been made as early as 1830 at Low Moor but had been rejected. However, some economy was effected by using the waste gases from the furnaces to raise stream for the blowing engines. These furnaces were commenced in 1890, the first one coming into work in1872

Calcination of ironstone was carried out in three large Gjers kilns erected between the furnaces and the coke plant. These were squat steel towers lined with firebrick, and fed with a mixture of ore and 5per cent coal slack. Standard gauge wagons approached them via an embankment part of which still exists, and a viaduct. These trucks travelled via the mixed gauge line from the Old Works. Coke was made in two rows of ovens of modern type set in brick. They were probably heated by combustion of the gases and volatiles given off during the coking process.

The centenary of the works was celebrated with a banquet in 1891. There were now about 4,000 men on its payroll. Low Moor directors had helped vote the township of North Bierley into being in 1865, and once Laurence Hardy, had chaired the committee that enclosed the remaining commons of Low Moor in 1881, to provide roads and recreation facilities. The Hardys had been very active in the district. They founded three churches, and in 1869 had set up the New Works School. They inspired the Low Moor Company to give 21 acres of land close to Old Works to be opened as a park in 1885

In order to modernise the works it was decided to replace steam drives for all but the heaviest machinery by electricity. A power station was built in 1905 at New Works whose boilers were fired by gases from the blast furnaces. Superheated steam at 155psi was supplied to a horizontal compound engine of 550 HP. This drove a 1000kW, 3 phase alternator. Transmission of current at 1000 volts was by bare overhead cable, with 3-core underground cable at road crossings. This war transformed down to 250 volts for lighting. At this time operation finally ceased at Bierley works. It had only carried out a small amount of foundry work for some years.

The coming of war in 1914 turned Low Moor over to maximum activity. Records show that the modernisation of the works since the formation of the limited company had not brought any but very modest prosperity. Trade had picked up in the two pre-war years, and a new coke plant had been put in in 1914. This consisted of 25 Koppers ovens with regenerative heating, which took a charge of 12 tons in 24 hours. As the demand for steam engines fell off the works had tried to compensate by beginning the manufacture of machine tools. Now with the outbreak of war, the engineering capacity was greatly extended to comply with the requirements of the Admiralty and Low Moor began the manufacture of shell cases and drop forgings. The shoes for the caterpillar tracks of the first tanks were made here. The profits from shells were to exceed the annual surplus of the works for any year since 1888.

The effects of the war on the iron-making trade are less clear. Griffiths reported that the works had forty puddling furnaces in 1871, although some of these may really have been balling furnaces. Nevertheless only twelve puddling furnaces were worked from 1915 to 1918 and these somewhat irregularly. This must have been due to shortage of manpower, since the two post-war years showed a remarkable, but short-lived prosperity, in spite of the cessation of the munitions work, which must be attributed to a resurgence of wrought-iron work,

The blast furnaces continued during the war, making four grades of cold-blast pig. Production was interrupted on 21 August 1916, when the picric acid plant of the Low Moor Chemical Company, sited next door to the New Works, caught fire and exploded, igniting the nearby gas holders, and reducing much of North Bierley to a 'blitzed' state. Many people were forced to leave the area, and some houses were never rebuilt, while New Works School was never reopened. Contrary to legend, the New Works was not destroyed, but the plant managers, Messrs Poole and Forster, were awarded the OBE for remaining on site to shut down the furnaces and coke ovens amidst great chaos.

A by-products plant had been run from the coke ovens, for tar and benzole recovery, and this was extended with the addition of new coke ovens in 1917, and in 1919. The power station was also modernised in 1916 with a new BTH 2000kW turbo-unit, giving current at 3000, 1000 and 400 volts. The old unit went to a Burton brewery.

Naturally the production of ironstone declined with the war. From 175,681 tons in 1882, output had fallen in 1915 to only 15,592 tons, and was not in excess of 30,000 tons in 1920. Since about 1900 Low Moor had been obtaining ore from Spain and also from Cumberland. In 1919 an extensive holding in the Carnforth Haematite Iron (1915) Co was obtained.

Thus the end of the war was a time of difficulty for Low Moor. The directors must have felt some uncertainty about the future of wrought iron in the post-war world, as well they might. Thus, it was decided to amalgamate Low Moor works with the somewhat larger Staffordshire iron-making firm of Robert Heath & Sons Ltd of Biddulph Valley Ironworks. In November 1919 it was decided that the joint enterprise should be known as Robert Heath And Low Moor Ltd. The published prospectus made it appear that Low Moor was acquiring control of Robert Heath, and not the other way about. The new company had an Ordinary share capital of £1,000,000; of the old directors, only R. W. Whickham remained, as works manager, and the office was transferred to Biddulph.

5 **Subsequent Developments at Low Moor, 1919-68**

It is clear that Robert Heath's took over Low Moor in order to gain access to the premium trade in Yorkshire Iron, or such proportion of the market that still existed. But they inherited the problems of Increasing costs, not only in the aging coal and iron mines, but in the cold-blast furnaces and also in the refining and puddling processes. It is difficult at this late date to discover what occurred at the time of transfer in the works, but it seems certain that by 1917 the operation of the old refinery furnaces was becoming uneconomic. It was their function to de-siliconise the iron prior to puddling. Their use was discontinued, and they were replaced by a reverberatory furnace of the Siemens type. However, the quality of the refined iron was not comparable with the old process. This process was itself discontinued when the process of dry puddling was stopped in April 1920. Wrought iron continued to be made by the process of Pig Boiling', also known wet puddling, in which iron was heated and 'poled' in a reverberatory furnace, haematite being added to supply oxygen for the de-carbonisation reaction. This process had been invented by Joseph Hall in about 1832, but had not been operated at Low Moor in earlier years for it gave iron with a higher sulphur content than was produced by dry puddling which was inclined to hot-brittleness. Good-quality Low Moor coke was used, and waste heat boilers were installed to generate blast for the furnace, as some measure of economy. The 7 and 8 ton hammers were also worked from this supply. Apparently, the best grades of iron were still made by rolling the puddled iron, faggoting, and hammering, followed by re-rolling. Mechanical tests were carried out at each stage—and also chemical analysis was later used probably when any variation in scrap or ore supply was involved in the process.

The two New Works blast furnaces continued in use, making good grade of pig that commanded a price some three times that of ordinary pig iron. This pig was very suitable castings for hydraulic work and for roll-making. It had a silicon content of about only one cent, and was used also for applications such as gas retorts where freedom from grain-growth during high temperature service where essential. In contrast to other irons, Low Moor was still workable at this low silicon content, and was definitely a speciality. But demand for this pig was low and could be satisfied by working only a few months of the year. For use in the Low Moor forge it was partly replaced by other pig irons and selected scrap, and it seems that this practice had been growing for some years before 1920. Puddlers' records show that 'Best Yorkshire Iron' plates and bars contained some 15 per cent of scrap by 1915. However, the iron produced after 1920 did not match up to the reputation of that made in former days, and quite soon

after the take-over a large shipment of Yorkshire bars was returned from Canada as not being up to Low Moor quality.
At New Works matters remained well organised. Much of the coking and by-product plant was modern, being run on contract by Simon-Carves until 1924. The furnace slag was utilised for tarmacadam production, and the benzole and sulphate of ammonia from the coke installation found ready sale. There was also a market for low sulphur Better Bed coke. Heath's tried to mix in a certain amount of higher sulphur Black Bed coal, of which there was plenty, and the results were disastrous for Low Moor's reputation. Similar unhappiness existed in the Engineering Department. It appears as though the profitability of whole works was maintained until 1921, but the appearance of a slump in the old heavy industries rapidly affected the picture, and in 1923 Low Moor had to be heavily subsidised from Biddulph. Things became worse in succeeding years; more and more money had to be supplied. Efforts to diversify the nature of the works came too late. Thus, in 1925 the interests of the 'Record' Crude Oil Engine Company were purchased, and much money was spent in trying to develop this semi-diesel unit but without commercial success. The integrated character of the works could no longer be maintained. Although some 34,000,000 tons of Low Moor ironstone remained to be developed, the sinking of new pits was not feasible under the changed conditions. By 1926 the deficit amounted to £249,391, and in 1928 a Receiver was appointed. Although the capital value of the Heath group was £1,837,512 yet the £1shares dropped to 1s. The reason for the collapse apart from the Depression, have been variously attributed to bad management, and to an unsuccessful venture into mild-steel-making, at Biddulph.

This was not the end of the Low Moor story, however. At some time prior to 1928, probably in 1918, Low Moor had acquired the brand name of the Farnley Iron Company, founded in 1846. Later in1923 Heath's joined with the other two members of the old 'Ring" Taylor Bros, and Monkbridge Iron & Steel, of Leeds, to set up a marketing company for Yorkshire iron, known as Best Yorkshire Iron Ltd. Production was concentrated at Low Moor, Kirkstall Forge had retired from the trade in 1920. Now, in 1928, Low Moor was purchased from the Receiver by Thos. W. Ward Ltd, for an undisclosed sum.

Severe rationalisation occurred. All the Low Moor mines at Bradford, Wyke and Leeds were closed. Most were dismantled. The 36 mile miles of Low Moor narrow-gauge railway were dismantled (including a 3ft 1in line serving the New and Old Works), and so were the standing engines. It is remembered that demolition trains were run. Very little now remains of these interesting features.

The coke oven and by-product plant was also dismantled, and Royds Hall was sold. The profit from the estate, though modest, had to keep the Low Moor Company alive for years. The water rights were, and still are, reserved to the works. The blast furnaces were probably stopped for a time, but in 1930 they were acquired by a group known as the Low Moor Iron Company in which the Dudley pig-iron-makers, M. & W. Grazebrook, had an interest. Both the ageing Head-Wrightson blast furnaces were converted to semi-hot-blast working, and as a result, the slag (with its higher lime content) was no longer suited to the making of tarmacadam and that ceased. Ward's had closed the power station at New Works but information received suggests it remained in work till 1936. Old Works, however, got its power from Bradford Corporation. The last pig iron was made at Low Moor in 1936, Ward's re-possessed the New Works site and blew up the furnaces in 1938. It was then found that a leakage of molten iron had formed a deposit soft deep on the site of the furnaces.

It would seem that in 1928 there was still a small market available for good wrought iron, mainly for railways . Two collieries were reopened by independent managements, Coates and Hartshead No 1, only

a mile or two from the works, to supply Better Bed coal, which was used in a somewhat modified furnace. Also, raw materials were strictly controlled. Much good' Best Yorkshire' scrap iron was sought out, and selected pig irons were purchased. Items of Low Moor plant were consumed such as the iron plateways laid around the works, and old structures such as railway bridges. The rolling plant used consisted of a 3-high, 15in cogging mill, a 2-high 16in bar mill, and a 3-high, l0in guide mill, driven by electricity. The best grades were piled three times and hammered before final rolling.

The rationalisation of Low Moor meant that there was a great deal of unoccupied space. After the demolition of the furnaces, New Works remained derelict, except for scrap- operations. Parts of the Old Works were let out to tenant firms, such as English Electric, who carried on engineering work there during the war. Messrs Glover & Woods carried on casting working the old foundry until I957.

An important development, which brought the old ironworks fully up to date with the twentieth century, was the commencement of operations by the Low Moor Alloy Steel works Ltd, This was founded by J. S. Gerber in 1938, and was at that time a tenant in the Old Works. Alloy steel manufacture started using two open-hearth type furnaces. These were gas-fired by producers fed on pulverised coal, and were charged from both ends with scrap and non-ferrous alloys. In this way Low Moor completely by-passed the mild steel stage in its development. Continuous casting operations were started here in 1946, while the plant was one of the first to use tonnage oxygen to speed up the steel-making process. The old pig-boiling process for making wrought iron continued side by side with alloy steel manufacture till well after the war. In 1954 the alloy steel company was bought by the Samuel Osborn Group, along with another firm on the site, known as Low Moor Fine Steels Ltd. The Old Works site was bought outright from Low Moor Best Yorkshire Iron Ltd in 1957. In that year wrought-iron making finally stopped at Low Moor after a run of 156 years. The business of the Low Moor Best Yorkshire Iron, and the Low Moor brand name was transferred to the Midland Iron Co of Rotherham, part of the Ward Group. In 1957 the works finally ceased to use rail haulage.

The new owners of Low Moor discontinued the open-hearth process for alloy steel, and introduced the electric arc furnace. This was set up in a new building. There are three furnaces of $2^{1/2}$ tons and one of 6 tons capacity. Each has three electrodes and operates at 210 volts 3-phase AC, at 9,000 amps per phase. This makes it possible to achieve the 1600-2000°C needed to melt-in the chrome, molybdenum tungsten alloys used to make stainless and other alloy, Output runs at about 350 tons per week, of which some 78 per cent is valve steel, of which Low Moor is a very important supplier. At the time writing, ingots were being cast via crane and ladle; some of these were planed and sold, while the rest were bloomed under .3 ton air hammer and rolled down to various sizes of bar.

Also of interest at the new Low Moor is the highly sophisticated Loewy extrusion process, operated by Low Moor Fine Steels Ltd, Here, alloy billets are heated to 1000-3000°C and are forced through a die at enormous pressure to make extrusions of complex- section.

In spite of these modern developments there is much for the industrial archaeologist to see at Low Moor. There is the New Works area, with its devastation, and the remaining houses destroyed in the 1916 explosion, and the old dams which still feed the works with cooling water. Also there are many remains of the old extensive network of mixed gauge railways. Nearby are the remains of Shelf and Bierley works. At the works entrance can be seen the old Low Moor cannon, and the remains of the first workers houses. Inside the security fence there are still many old buildings remains of kilns etc. In the wall of the

canteen can be seen the recess once occupied by the enormous flywheel of the old trip hammers. A feeder to the M62 is soon to be built through the Biererley works area. . It is to be hoped that this road will reduce the isolation of Low Moor from its parent company in Sheffield, and perhaps prevent the further 'rationalisation' that has closed so many other historic works in the past.

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The situation 2012

In 2012 the area has been drastically redeveloped. The M606 opened in 1973 now cuts across the terrian which includes a big industrial estate. . The actual Low Moor site is now occupied by a diversity of buildings in which a variety of trades operate. There are still some small metallurgical firms which represents the remains of what was once a site of national importance.. The fly wheel can still be seen at what was the old entrance.to the works. The district has changed significantly since the Article was written some 40 years ago but the heritage still lives on in the street and road names.