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Excavations at Summerlee Ironworks, Coatbridge, North Lanarkshire

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ABSTRACT

Excavations within Summerlee Heritage Park, Coatbridge in the late 1980s revealed extensive remains of the Summerlee Ironworks, founded in 1836. These included the bases of four furnaces, five heating stoves, an engine house, a boiler house and several underground flues together with numerous ancillary structures and features and elements of a chemical recovery plant. Although most of the excavated remains were associated with various stages of remodelling and upgrading, a significant number appeared to date from the early years of the works.

INTRODUCTION

Summerlee Ironworks dates from 1836 when two furnaces were erected in what was then the small settlement of Coatbridge in Lanarkshire (now in North Lanarkshire). The works ceased production in 1932, nearly a century after its foundation, and its complex of buildings was blown up and the remains buried beneath demolition debris and other materials brought onto the site. Some of those remains were uncovered during a series of excavations carried out during the late 1980s.

Summerlee's success came about because of several factors but primarily because of the extensive local deposits of the raw materials needed to make iron: ore; coal for fuel; and limestone for flux. The proximity of the Monkland Canal was another major factor which led to the town becoming the centre of the iron industry rather than the nearby, older established burgh of Airdrie, even though most of the ironstone was located there (Drummond & Smith 1982, 7).

THE SITE (ILLUS 1, 2)

Summerlee (situated at NGR: NS 729 655) is situated on the north side of the town of Coatbridge in North Lanarkshire. The town, once the centre of an area of heavy industry, lies some 15km east of Glasgow although now the two are almost contiguous. The remains of the ironworks stand within the Summerlee Heritage Park, alongside an offshoot of the defunct Monkland Canal, known as the Gartsherrie, Hornock & Summerlee Branch or simply the 'Gartsherrie Cut'.

Those remains of the ironworks that have been exposed now form an integral part of Summerlee Heritage Park. They consist of a group of structures in an L-shaped arrangement, located at the base of a high masonry wall that once divided the works into two distinct levels. Among other structures on the upper level were the hoists that fed raw materials into the furnaces as well as a reservoir that supplied water to many parts of the works. On the lower level stood the furnaces, the pig beds into which the molten iron ran, heating stoves, engine houses, boilers

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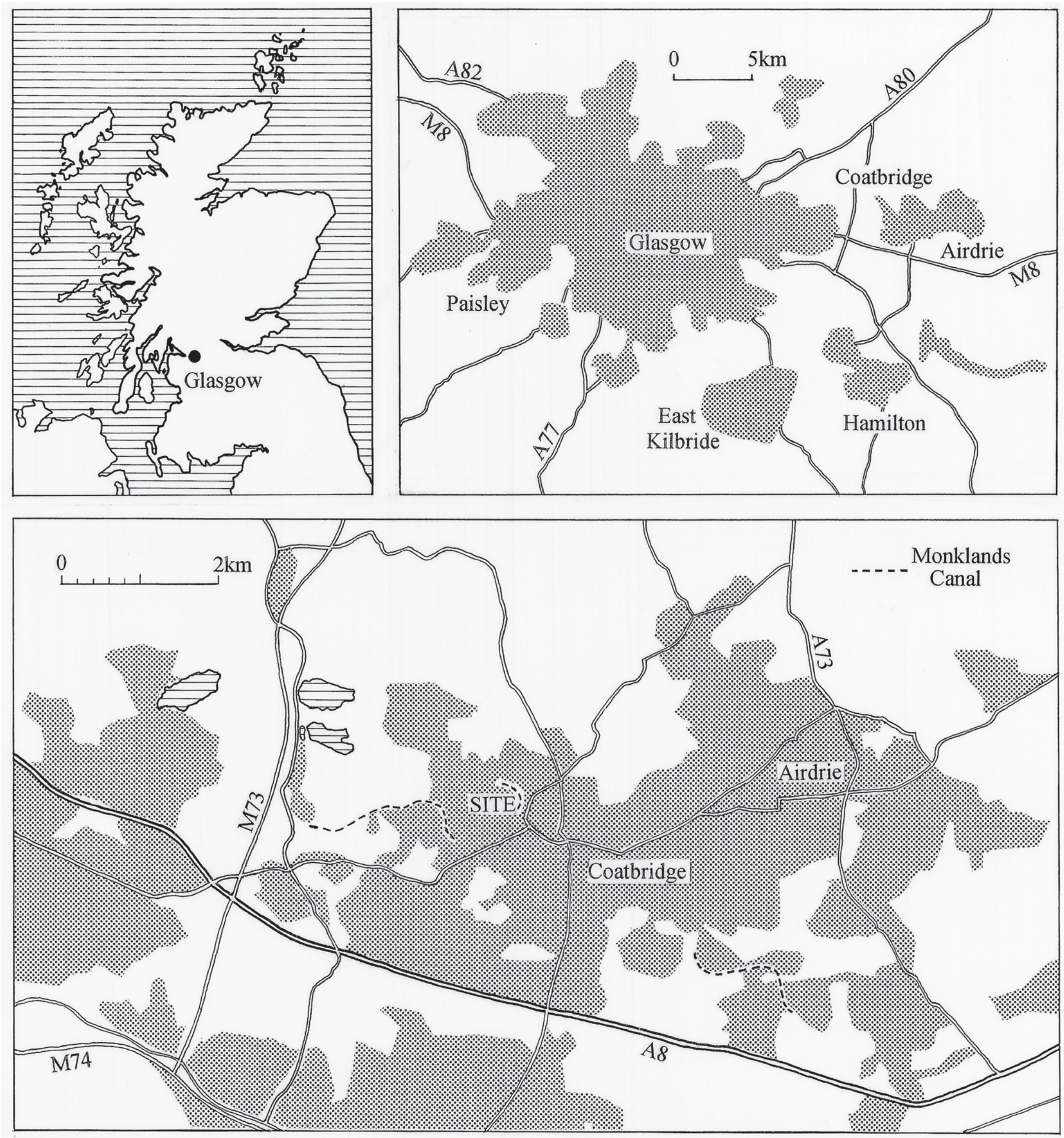
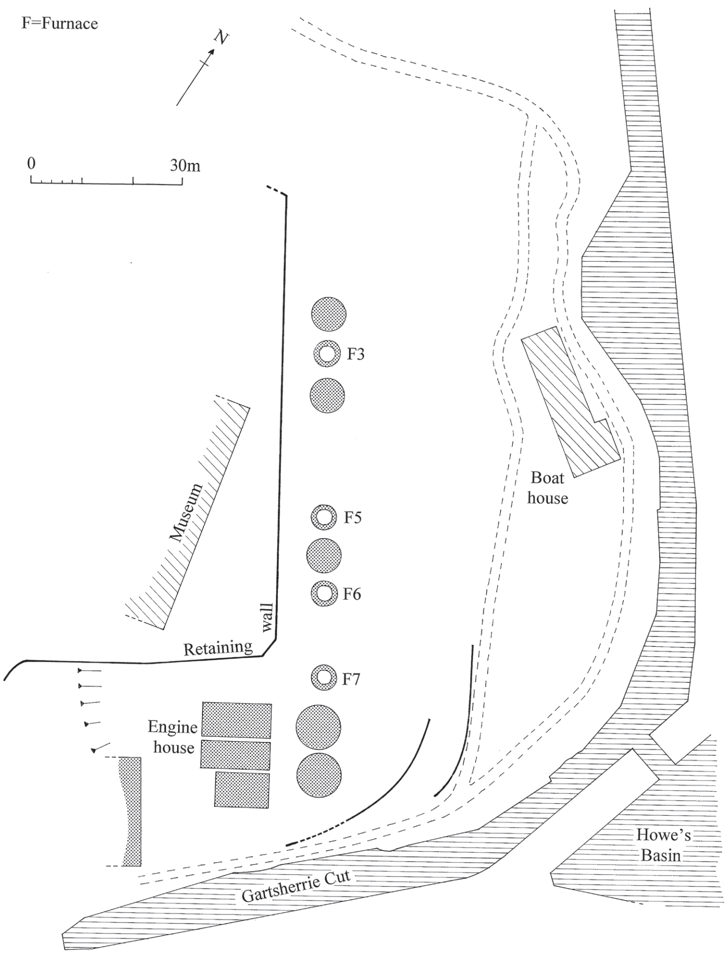


ILLUS 1 Location maps

and ultimately a chemical plant. Many of these structures were identified during the excavations, including the bases of three furnaces and five heating stoves, arranged in a line running north/south a short distance east of the retaining wall that separates the two main levels of the site (see below). At the south end of the site, between the south arm of the retaining wall and the canal, lie the remains of an engine house which probably contained two engines (see below), boiler bases and the chemical plant.

The upper level of the park, where the hoists once stood, now houses the modern exhibition hall of Summerlee Heritage Museum which



Illus 2 The site, showing the locations of its principal features

contains displays and exhibits charting the industrial history of North Lanarkshire.

HISTORICAL BACKGROUND

THE INDUSTRY IN LANARKSHIRE

Northern Lanarkshire, in particular the parish of Old Monkland in which Coatbridge lies, was the centre of Scotland's coal industry from the late 18th century and was the hub of its iron industry from the early 19th century well into the 20th century. Coal had been mined there since medieval times but its extraction was expanded greatly in the late 18th century to supply the domestic and industrial needs of the rapidly developing city of Glasgow.

Before the advent of the Industrial Revolution, Coatbridge was little more than a single cottage on the Edinburgh to Glasgow turnpike road, where it crossed the Gartsherrie Burn. It appears as Cott Brig on Roy's map of 1750 (Drummond & Smith 1982, 7) but it is not shown on Ross's map of 1776. The name 'Summerlee' first appears on William Forrest's 1801 map of Coats Estate (ibid, 12).

Iron had been made in charcoal-fired furnaces in the Highlands during the 17th and 18th centuries (Lewis 1984) but the modern era of manufacture in Scotland is generally recognized as having begun when the Carron Company starting using coke as a fuel at their Falkirk works from 1760 (Lenman 1977, 98). By 1790, blast furnaces had been established in Lanarkshire and Ayrshire, the first in the Coatbridge area being at Calder in 1801, where raw materials were carried along Dixon's Cut, one of the two original branches of the Monkland Canal (Drummond & Smith 1982, 17). Calder Ironworks produced 30,000 tons of iron per year during the Napoleonic Wars but output slumped badly once peace returned and it was well into the 1820s before demand recovered (ibid).

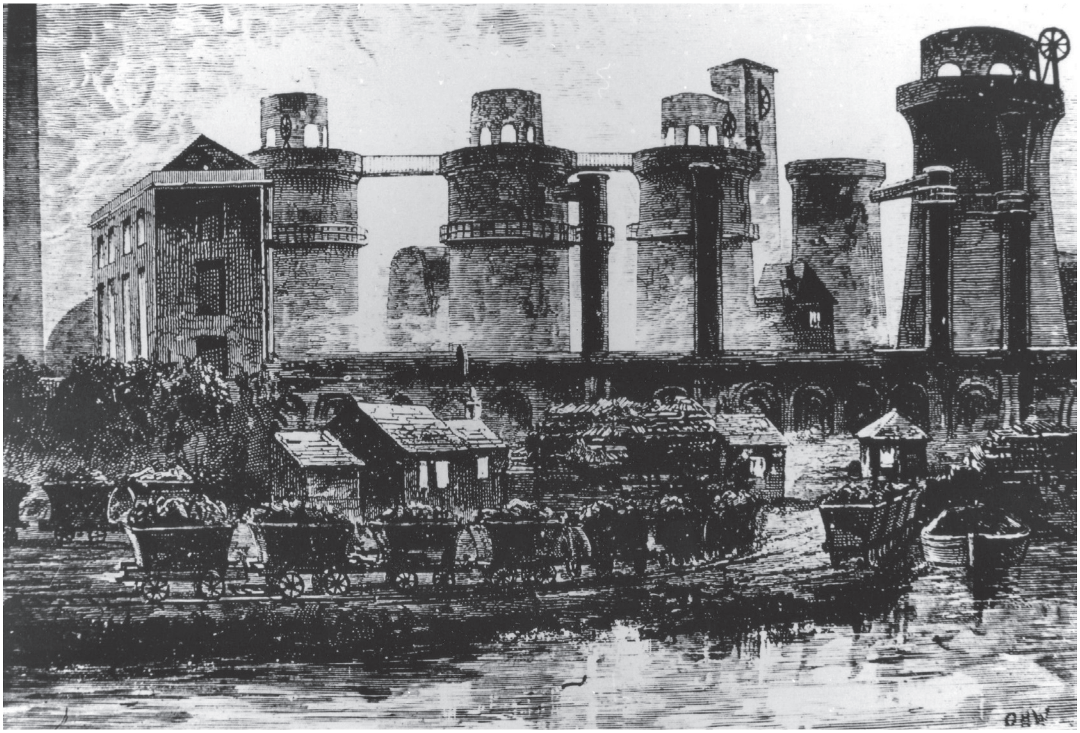
David Mushet, manager at the Calder works, recognized the potential of local blackband ironstone in 1805 (*Engineering* 27 September 1867) but, apart from limited production when mixed with other ores, this valuable resource was not exploited until the late 1820s after the invention of the hot blast process (Drummond & Smith, 17). Until then furnaces had been blown with cold air in the mistaken belief that warm air caused furnaces to explode. The real problem, however, was that the high humidity of warmer months could result in the water-gas reaction which is endothermic and could lead to a reduction in output. A breakthrough came in 1828 when James Beaumont Neilson, an engineer at Glasgow Gas Works, patented the hot-blast process whereby much greater yields could be achieved if the air blown into a furnace was heated beforehand. One significant advantage of this new process was that higher temperatures allowed coal to be used in its raw state rather than having to be converted to coke (*Engineering* 27 September 1867). Another benefit was that local blackband ironstone could be exploited as the principal raw material. This ore consists of iron nodules in a carbonaceous matrix which can be calcined without using additional fuel to produce a heavy, iron-rich material, resembling coke, that needs much less fuel than other ores to process. The industry in North Lanarkshire was built around the ready supply of blackband ore although, as the ironmasters were to find out soon enough, supplies were not limitless (see below).

Neilson's patent was put into practice almost immediately by William and James Baird who effectively stole his idea, resulting in an extended period of litigation which ended in 1843 with the brothers paying Neilson a considerable sum (Miller 1864, 33). By then, however, the Bairds had amassed a considerable fortune and their status in the Coatbridge area was virtually unassailable. The Bairds' success continued over several generations and their hugely profitable Gartsherrie works, which commenced operations in 1830, continued in production until 1967.

Neilson's new process sparked a rapid expansion of the iron industry, especially in the Coatbridge area. By 1840 a total of 34 blast furnaces were in operation between the Calder, Carnbroe, Clyde, Dundyvan, Gartsherrie, Monkland and Summerlee works, Monkland and Dundyvan producing malleable (bar) iron as well as pig iron (*NSA* 1845). An eighth smelting works was added at Langloan in 1841 (Miller 1864, 20). The crucial role played by the Monkland Canal for transporting raw materials and finished goods during the early 19th century is witnessed by the fact that five blast furnace works (Calder, Dundyvan, Gartsherrie, Langloan and Summerlee), together with 12 of the first 14 malleable iron works, were all situated alongside it or one of its branches (Drummond & Smith 1982, 15).

The creation of an extensive railway network during the second quarter of the 19th century signalled the demise of the canal system. However, the Monkland Canal continued transporting heavy goods for several decades, peaking as late as 1863, when 1.5 million tons of goods were carried along it (ibid, 16). The Scottish iron industry reached its highest point in 1871, at which time it employed 40% of the country's adult male workforce (ibid, 17).

The industry and population of Coatbridge expanded during the middle decades of the 19th century thanks to the local abundance of coal and ironstone and the proximity of the canal network. However, as early as 1864 the raw materials were beginning to run out (Miller 1864, 30) and by 1885 most ore and coal was imported (Drummond & Smith 1982, 21). In fact, as early as 1856, the owners of Summerlee leased land for a colliery at Dykehead near Larkhall, several miles from the ironworks (Campbell 1979, 123). The problem was compounded with the introduction of a cheap method of producing steel, which soon replaced cast iron and wrought



ILLUS 3 'Summerlee by night': a mid-19th-century drawing of Summerlee Ironworks

iron as the material of choice of most engineers. One of the new centres of steel-making was Motherwell which quickly toppled Coatbridge from its lofty position as the focal point of Scotland's heavy industry (Drummond & Smith 1982, 21).

Huge fluctuations in the price of pig iron and the trade depressions of the 1890s took their toll on Coatbridge. World War I provided a temporary respite for the iron industry but the majority of the area's blast furnaces were extinguished by 1930. Only Gartsherrie, of the eight works established by 1841, survived for long, eventually closing in 1967. There was a similar situation in malleable iron works. There had once been 17 in the Coatbridge area but ten of them succumbed before 1914 and only five survived until 1950 (ibid, 18).

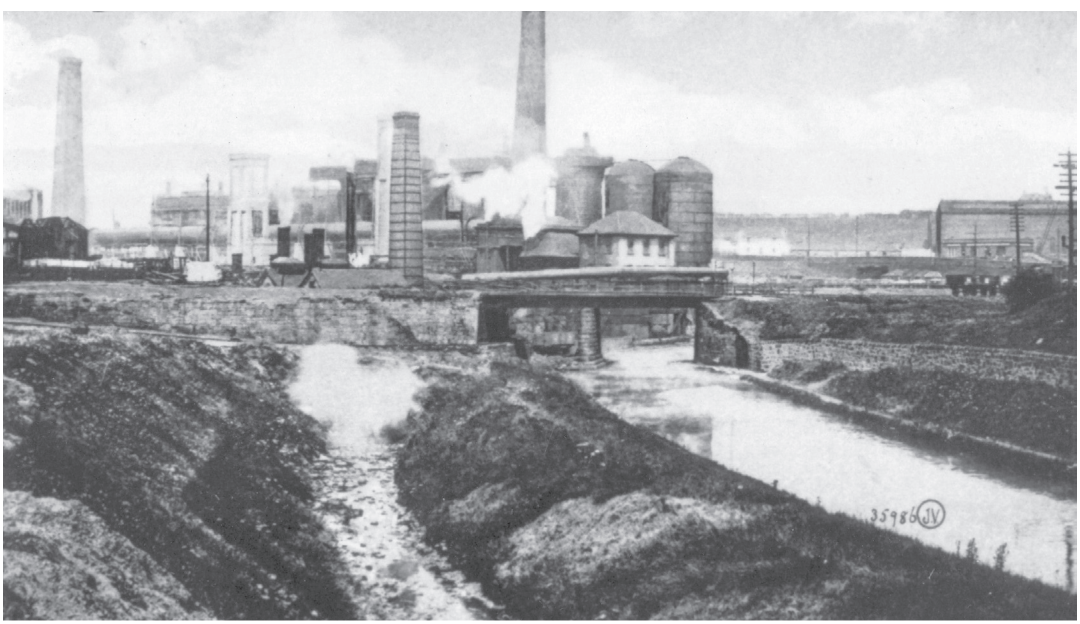
THE HISTORY OF SUMMERLEE

A feu was taken out on 18th December 1835 for an ironworks at Summerlee. The feuars were the brothers John and George Wilson, their cousin Alexander Wilson and John Neilson and his son Walter, the works being set up under the name Wilson & Co. Eight acres were feued, of which 2.5 acres were reserved for the erection of the furnaces (Thomson 1983, 20). The first two furnaces were built by John Neilson, who also had an interest in the Oakbank Foundry and Engine works in Glasgow (*Engineering* 22 August 1879). There is some dispute as to precisely when the first furnaces went into blast although Wilson & Co was described as an iron manufacturer in July 1836, suggesting that the company was in production by then (Thomson 1983, 20). There were certainly six furnaces in blast by 1842 and, according to Miller (1864, 20), a further two were added in 1857–8. The first edition Ordnance Survey (OS) map of 1856 shows only seven furnaces, as does the second edition of 1897. However, Griffiths (1873, 265) confirms that there were indeed eight in 1873, of which only seven were in blast.

John Wilson died in 1856 and the co-partnership ended a year later when the Neilson family assumed complete control and the company's name was changed to The Summerlee Iron Company. The Neilsons had set up a malleable iron works at Mossend in 1839 (Campbell 1979, 209), combining it with Summerlee to form The Summerlee and Mossend Iron and Steel Company in 1886, the steel being made at Mossend. This organization had capital of £400,000 in £1,000 shares, all owned by nine members of the Neilson family (Thomson 1983, 21). In 1896 it became The Summerlee and Mossend Iron and Steel Company Ltd, with capital of £600,000 in £10 shares. Mossend suffered a prolonged strike in 1899 and the works was closed in 1900 and sold to Wm Beardmore & Co in 1906. As a result, Summerlee reverted to being simply The Summerlee Iron Company Ltd, with interests only in pig iron and coal (ibid, 22).

Business appears to have been steady at Summerlee until the 1920s when trading became difficult, especially during the world-wide recession towards the end of the decade. By 1932 Summerlee's blast furnaces were all out of commission and in 1937 the works were sold to James Connell of the Phoenix and Clifton Ironworks, also of Coatbridge (*Airdrie and Coatbridge Advertiser* 6 November 1937). The furnaces were demolished in 1938. The company carried on with its coal interests, however, until the industry was nationalized and finally went into voluntary liquidation on 9 August 1950 (Thomson 1983, 22).

The expansion of the industry during the 19th century saw a simultaneous increase in



Illus 4 Summerlee Ironworks, viewed from the south, *c* 1900

the population of Coatbridge, rising from 741 in 1831 to nearly 37,000 at the turn of the 20th century. This 50-fold increase turned a relatively small village into a major industrial town. Furnace workers and colliers were housed in rows and squares, built and owned by the company and located within close proximity of the furnaces. Little survives now to remind us of how Coatbridge looked in the 19th and early 20th centuries. All the ironworks have been pulled down, the coal mines closed and most of the workers' houses demolished.

THE TECHNOLOGY OF IRON-MAKING

THE EARLY INDUSTRY

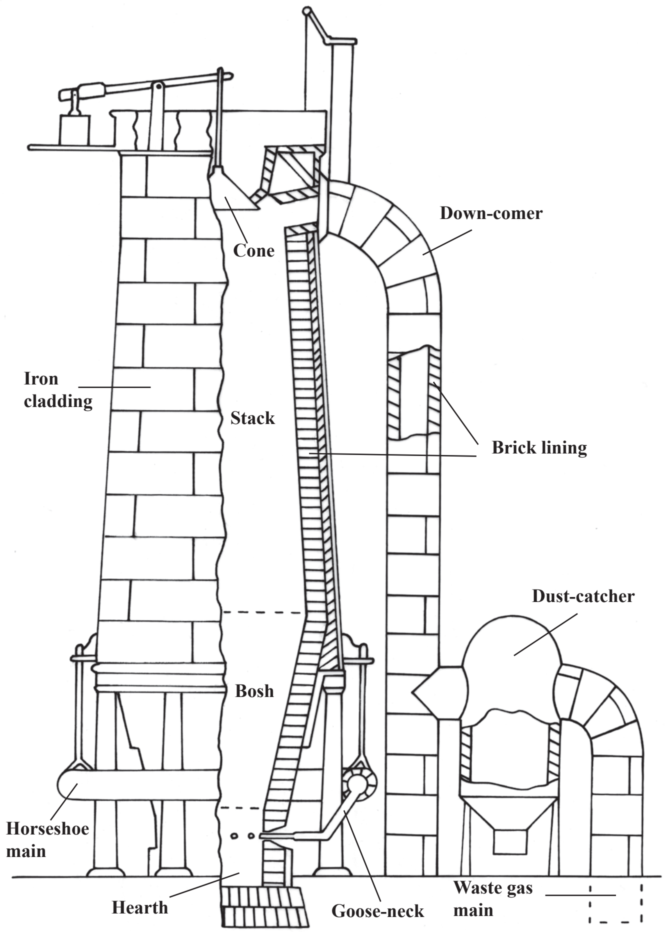
The switch from using charcoal to coal as a fuel for making iron was a long and tortuous process. Blast furnaces were developed in the Low Countries in the 15th century, eventually arriving in Scotland in the early 17th century. An abundance of charcoal for fuel and water for power resulted in the early industry being focused in the Highlands, most of the ore (particularly haematite) being imported from elsewhere, especially by sea from Cumbria. An enormous change overtook the industry once coke was used as a fuel. The change took some time to permeate into Scotland: the first works to use coke as a fuel was at Coalbrookdale in Shropshire in 1709, while the first in Scotland was at Carron, near Falkirk, a half century later. The focus of operations then turned from the heavily wooded areas of the north of Scotland to the coalfields of the central belt.

The next important step in the development of the industry was to use raw coal, rather than coke, as a fuel. This was achieved once Neilson's hot-blast process was put into practice, allowing the central belt's large reserves of blackband ironstone to be exploited. Blackband consists of 50–70% iron but contains enough free coal for the ore to be calcined without the use of additional fuel; furthermore, it can be reduced in a furnace using coal, rather than coke. In addition, the local non-caking splint coal, which could not be coked without significant losses, could be used with blackband ore. Another ore which occurs in seams and bands throughout Scotland's coal measures is clayband, which had been exploited by earlier generations of ironmasters. Clayband, however, contains only 30–40% iron and has to be calcined with coke before it can be smelted. Not only were there huge supplies of ore and fuel in central Scotland, other essential materials were also found among its Carboniferous rocks. Foremost among them were limestone, used as a flux to remove waste during smelting, and fireclay, whose heat-resistant properties made it an ideal material for lining furnaces, heating stoves and flues. Another important resource was building stone, the local sandstone being exploited on a large scale.

The product of a blast furnace was pig iron. It contained up to 5% carbon which rendered the iron molten at temperatures of 1200–1250°C, well below that of pure (wrought) iron (1535°C) thus allowing it to be extracted easily from the furnace. However, to produce wrought (or malleable) iron, the carbon had to be removed. This process was carried out in a reverberatory furnace which, at first, was usually located separately from blast furnaces. From the mid-19th century onwards, however, the two processes were often found in close association, as at many works in Monklands but not at Summerlee.

19TH-CENTURY IRON-MAKING (ILLUS 5)

Much of the following information about the construction and operation of blast furnaces in the late 19th century has been taken from Walter MacFarlane's *The Principals and Properties of Iron and Steel Manufacture*, published in 1906. A slightly earlier (1895) report in the journal *Engineering*, describing the results of a visit by members of the Institution of Mechanical Engineers to Mossend and Summerlee, has also proved valuable, as has *An Outline of the Metallurgy of Iron and Steel* written by A H Sexton and J S G Primrose in about 1912. Most of the *Engineering* report describes working practices at Mossend but it also contains useful information about Summerlee. Some idea of previous methods has been derived from an 1867 issue of the same journal, which gives a fairly detailed account of the ironworks at Gartsherrie, the Bairds' most famous works and a near neighbour of Summerlee, and it would be surprising if basic procedures varied much between these two enterprises.



Illus 5 Cut-away section of a typical 19th-century blast furnace (after MacFarlane)

Early blast furnaces were built of masonry lined with refractory materials. At first, the lining was sandstone but this was replaced by fireclay bricks during the 19th century when fireclay was mined from the same geological levels as the ore, fuel and flux. The lining itself made use of the best firebricks with a layer of lesser quality material behind it. Later furnaces were usually clad with plates of iron or mild steel although sometimes with bricks, as appears to have been the case at Summerlee (illus 17). The superstructure was usually supported by cast-iron columns set on stone or concrete plinths or arches. According to MacFarlane (1906, 195), typical blast furnaces of his day were 24.4m (80ft) high, with diameters of 4.3m (14ft) at the throat, 6.4m (21ft) at the boshes and 3.6m (12ft) at the hearth. A furnace would have had eight to 16 tuyères (the nozzles used to inject air into the furnace), each of them up to 150mm (6in) in diameter. These dimensions can be compared with those recorded for Summerlee a decade earlier when there were seven furnaces in operation, one having been demolished to make way for two new heating stoves (*Engineering* 16 August 1895). At that time, four of the furnaces were 22m (72ft) high, with diameters of 3.6m (12ft) at the throat, 4.9m (16ft) at the boshes and 2.6m (8ft 6in) at the hearth.

The blackband ore was calcined at the mines, in mounds of about 2000 tons which were covered with small material to exclude air. This process took about three weeks to complete and required constant attention although there was no need to add fuel at any stage because of the high concentration of carbon within the ore. The calcined ore was then carefully sorted by hand to remove as many impurities as possible. Blackband was considered the richest ore in use in the mid-19th century, with the result that Gartsherrie No 1 iron was hailed as the aristocrat of pig iron (*Engineering* 4 October 1867). However, there were drawbacks to Scottish pig iron because of its high phosphorus content, a legacy of Carboniferous ore, which made the iron 'cold short', whereby it became quite brittle at low temperatures. About 80% of the phosphorus was removed during puddling, but what remained was sufficient to cause problems and, as a result, the iron was not fully exploited for conversion into its malleable form. Nevertheless, its use for castings was very extensive because the phosphorus rendered the metal very fluid at high temperatures and gave the castings sharply defined edges. By the late 19th century the Lanarkshire seams were exhausted and much of the ore used in Scottish furnaces was Spanish haematite which was also the preferred raw material for steel-making. Most of Summerlee's supply was brought directly to the Clyde in steamers, one of them called 'The Summerlee', which was owned by the company (*Engineering* 24 August 1884).

Around 1870, Scottish blast furnaces required 55cwt of coal to make 1 ton of iron, whereas in Cleveland, north-east England, only 20cwt of fuel was needed to produce the same amount of metal. This disparity was the result of a profligate attitude by many Scottish ironmasters, who operated in the belief that the coal seams would never run out. They tended to use relatively low blast temperatures in rather small furnaces where their throats were open. This allowed the waste gases to escape rather than using them to fuel the hot-blast system (MacFarlane 1906, 188; Campbell 1980, 49).

Two kinds of limestone were used as flux at Gartsherrie, both of them mined locally: pure limestone, of which 6cwt was required to produce 1 ton of iron; and a high alumina variety, which needed 10cwt but which was preferred because it formed 'a surplus of quickly melted slag' (*Engineering* 4 October 1867).

Ore, coal and limestone were brought to the furnaces both by canal and rail. They were transferred to the furnace mouths by hoists, of which there were two at Summerlee in the late 19th century (*Engineering* 16 August 1895) (illus 4 & 16). They stood to the west of the furnaces, on the top of a bank supported by a stone retaining wall which was heightened at some stage and which still stands today. A comparison of the first and second editions OS maps (1856 and 1897) (illus 13 & 14) shows that the original hoists had been replaced with new ones by the late 19th century. The details of how the furnaces were charged in either phase are unknown. Inclined hoists were used at some works, while others preferred vertical hoists, usually contained within towers. In both, the raw materials were transferred along a level gantry to the individual furnaces. Latterly, electrically-operated skips carried the charge along aerial rails to the furnace top (MacFarlane 1906, 202).

By MacFarlane's time, almost all blast furnaces were close-topped, allowing the waste gases to be collected and distilled to extract ammonia and tar. Indeed, Summerlee was one of the first works to reuse the gases, starting in *c* 1849, although it appears that success was limited until about 1867, when waste gases were drawn off two furnaces using the Addenbrooke system (*Engineering* 22 August 1879). The charge was tipped into the furnace using a bell and cone arrangement, the cone returning to the closed position once the raw materials had been dropped.

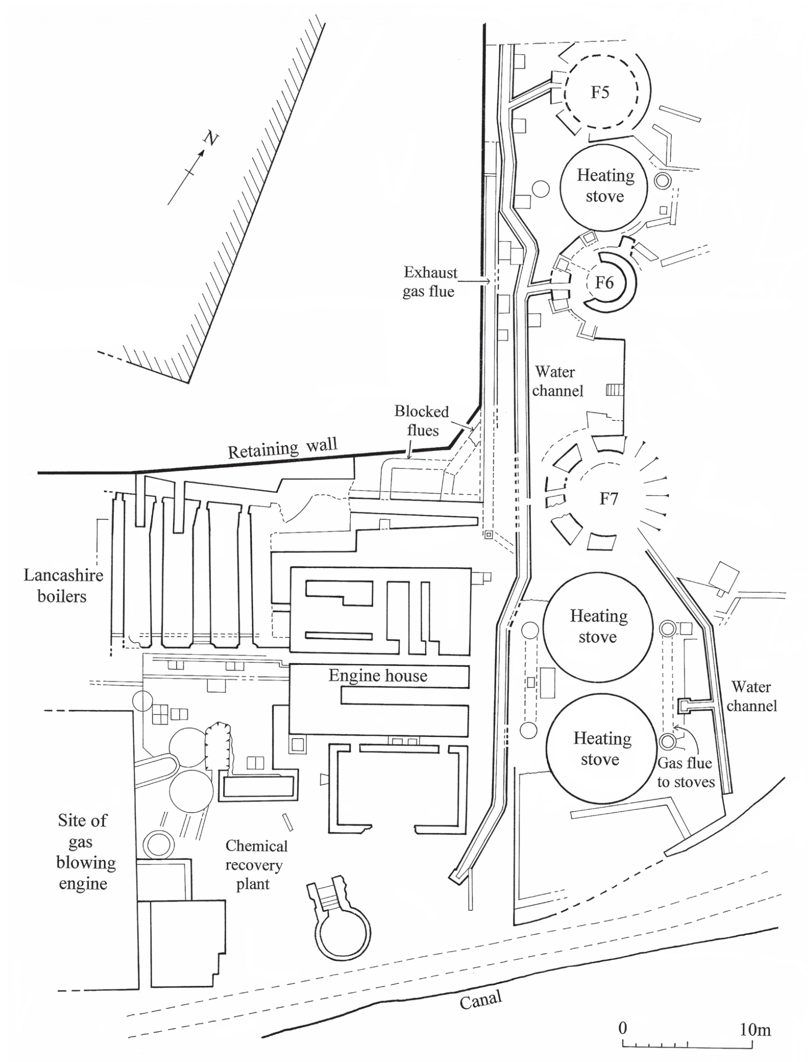
The temperature increased as the charge descended through the furnace stack, which gradually widened to allow the raw materials to expand. It narrowed again in the bosh area, thus slowing the descent of the materials so that the ore was fully reduced. Temperatures of over 1000°C were reached in the boshes, where earthy gangue combined with limestone flux to form slag which floated on top of the iron. Liquefaction of the iron and slag increased in the hearth, where temperatures reached about 1400°C at the tuyères. Condie's tuyères (also known as 'Scotch tuyères'), which were in use during the early years of the coal-fired industry, were made of iron. Moulded onto them were spiral, wrought-iron pipes through which water was passed to lower the temperature and prevent them melting. Later tuyères were made of bronze or other copper alloys (MacFarlane 1906, 195). Iron was tapped in a molten state along a wide channel which divided into a network of smaller channels pressed into the sand of the 'pig beds', in front of the furnaces. When cool, the iron pigs were lifted and loaded, at first onto barges on the Monkland Canal but later onto railway wagons sitting in sidings adjacent to the pig beds (illus 16). Slag was also tapped periodically and deposited away from the furnaces. Much of the slag was used as railway ballast although large amounts were often left wherever there was convenient space around the works.

The tops of early furnaces were open, allowing waste gases to disperse into the atmosphere. However, during the second half of the 19th century, many works started to utilize these gases, principally to fuel the hot blast stoves but also to provide raw materials for chemical plants. In these more advanced works the gases passed from the top of the furnace, along a wide pipe known as a down-comer and through a dust-catcher which filtered out much of the solid material. The gases were then carried to a chemical recovery plant where scrubbers separated ammoniacal liquors and tar, the latter being distilled to produce pitch and oil (*Engineering* 16 August 1895). At times more revenue was gained from the sale of tar and ammonium sulphate than from pig iron. At Summerlee a plant was installed in 1884, at a time when the market for ammonia was beginning to develop (*Engineering* 16 August 1895). Excavation uncovered the remains of what appeared to be a chemical plant towards the south-west corner of the site but it is not clear whether this was the original plant or a new one installed by a Mr Gillespie in 1901 (Turner 1920, 192) (see below).

Early blast furnaces were run by water power, the blast being provided initially by bellows, sometimes operating in pairs, which were eventually replaced by blowing cylinders at many works. The heavier demands of the coke- and coal-fired industry saw the introduction of blowing engines, which were at first driven by steam but later by gas. It appears that a blowing engine installed at Summerlee in 1836 was still fully operational in 1895. It was a beam engine with cylinders of cast iron and moving parts of malleable iron (*Engineering* 16 August 1895).

Air was driven into the heating stoves, which were usually positioned next to the furnaces. Heating stoves were of two main types. In earlier ones air was heated by a coal or gas fire as it passed through a boiler-like arrangement of cast-iron pipes, the temperature rarely exceeding 425°C. A much more efficient system was invented by Edward Cowper, whereby cold air was forced through a matrix of pre-heated firebricks, where it attained temperatures of around 800°C. Cowper stoves (and their variants such as those manufactured by Ford and Moncur and which were used at Summerlee) were heated only by gas, often surplus from the blast furnaces but sometimes produced independently. By the late 19th century these stoves had developed into tall, cylindrical structures with domed roofs and clad with iron or steel plates, as can be seen in several illustrations of Summerlee (illus 4, 16 & 17).

Once the required temperature was reached, the gas and combustion air were turned off and pressurized air from the blowing engines forced through the stove. The heated air was then fed into the hot-blast main (a large iron pipe lined with bricks) and blown to the furnaces, via the horseshoe main, which ran around the circumference of the furnace, a goose-neck



Illus 6 Plan of the south part of the site, showing the principal features uncovered by excavation

pipe and into the tuyères (see illus 5 & 18). The system was a closed one and any loss of pressure caused by leakage was compensated by an increase in pressure resulting from the expansion of gases at high temperatures. Because individual stoves worked on a cycle allowing the bricks within them to be heated up followed by a period when hot air was sent to the furnace, they had to be operated in pairs or even threes to maintain a steady hot blast supply. Cowper-type stoves operated in pairs, one discharging hot air to a furnace while the other was being heated up.

In 1870 the output per furnace in Cleveland was some 500 tons per week, whereas a typical Scottish furnace produced only about 165 tons in the same period, translating to some 8500 tons per annum (Campbell 1980, 49). Lower output was partly the result of the smaller furnaces used in Scotland and partly because coal-fired furnaces were less efficient than those that used coke. Although it is not known how many furnaces were in blast at the time, efficiency appears to have increased at Summerlee by 1884, when the annual output was 85,000 tons (*Engineering* 29 August 1884).

THE BACKGROUND TO THE PROJECT

Summerlee Ironworks ceased production in 1932, the furnaces and ancillary structures being demolished in dramatic fashion, using gelignite, in 1938. Anything worth salvaging was removed from the site. The foundations of the demolished buildings were then covered with up to 6m of demolition debris, supplemented by materials brought in from elsewhere. In due course, other enterprises were set up at Summerlee, one of them being Hydrocon Ltd, which established itself there in the 1950s to manufacture hydraulic cranes. Eventually, these works also declined, leaving the site derelict once more although the main bays of Hydrocon's factory remained and were eventually reused for the exhibition hall of the new museum.

In the early 1980s the decision was made to set up a museum of industry at Summerlee, based around the remains of its former ironworks. The initial stage of this project was managed by Land Use Consultants (LUC), who oversaw the removal of much of the overburden which then covered the site while also initiating a programme of archaeological excavation intended to uncover the remains of at least some of the 19th-century ironworks. In April 1985 a scheme was set up by the Manpower Services Commission to expose the surviving remains of the works, LUC commissioning the first author to provide some measure of archaeological supervision during this project. However, the terms of this commission were such that only occasional site visits were possible and eventually it was decided that a full-time archaeologist should be taken on to direct this work. The author continued to provide some advice during that time. From 1986 to 1987 the excavations were directed by Tom Ward and from then until early 1989 by Mary Clark, née Land.

In April 2000, Glasgow University Archaeology Research Division (GUARD) excavated small trenches at four locations within the area already partially excavated to answer specific questions concerning aspects of the site. In March 2001, Scotia Archaeology carried out a topographic survey of the site and in June of the same year undertook watching briefs during the installation of a walkway from the settings for Lancashire boilers alongside both the south and east arms of the high retaining wall.

Most of the material that had overlain the demolished ironworks since its demolition was removed before there was any archaeological presence on the site. As a result, a stratigraphic approach was adopted only relatively late in the day although, fortunately, little serious damage appears to have been done to the site because of this. The principal surviving features within the excavation area were uncovered within the first main season of excavation although considerably more work was undertaken over succeeding seasons in order to fully expose and interpret those features. The results of the various stages of excavation have been drawn together and presented here according to their geographic and historical status.

Some interim reports were written of the excavation findings and summary reports produced annually for *Discovery & Excavation in Scotland* although a full account of the investigations has not been produced until now. This work has been funded jointly by North Lanarkshire Council and Historic Scotland. It has been compiled partly from the excavation records and partly as a result of several visits to the site by the authors.

THE EXCAVATION RESULTS (ILLUS 6–12)

The principal elements of the ironworks uncovered during the excavations were:

- the bases of four blast furnaces;
- the bases of five circular heating stoves;
- the remains of an engine house;
- the settings for a series of Lancashire boilers;
- numerous flues and other channels, some above and some below ground, that ran between the boilers, stoves and furnaces;
- the retaining wall that separated the charging area from the furnaces;
- several structures and features belonging to a chemical recovery plant; and
- the base of a water tower.

During the excavations, watching briefs were also kept by the archaeological team during building operations within and adjacent to Summerlee Heritage Park. Those developments had little or nothing to do with the iron-making process and are not described here.

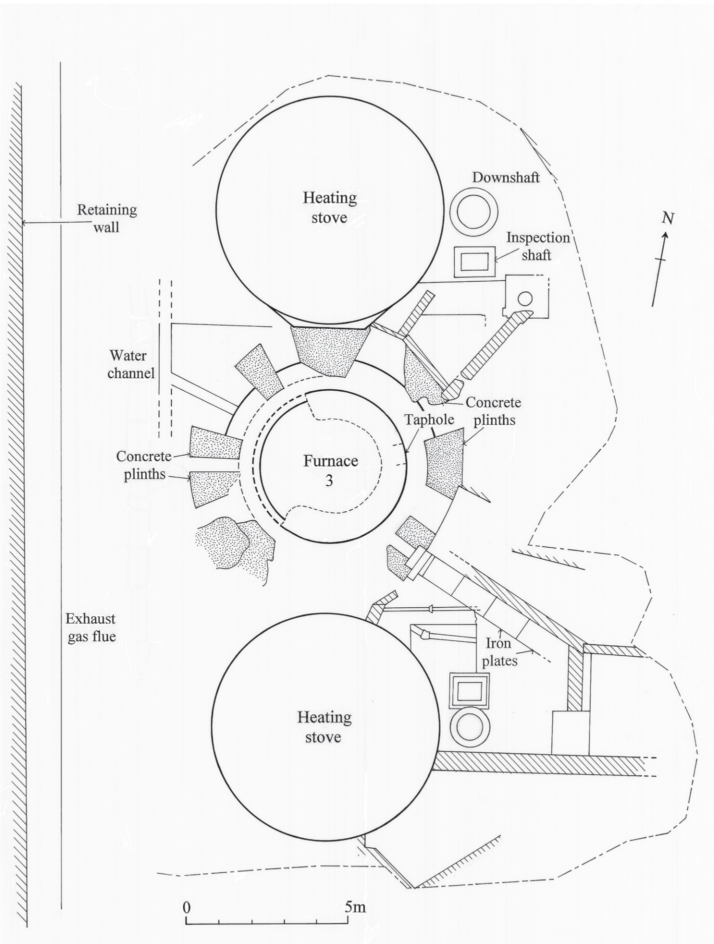
THE HEATING SYSTEM

The system that supplied hot air to the furnaces comprised a series of stoves, heated by waste gases produced by the smelting process, into which air was forced by steam-driven blowing engines powered by independently heated boilers and later (at least in part) by a gas engine. There were engine houses at each end of the line of furnaces at Summerlee although only the one

Illus 7 Cleaning out the Lancashire boilers

at the south end of the site was uncovered during the excavations.

The air flow from the engines to the heating stoves ran through a duct known as the cold blast main while the one taking the hot air from the stoves to the furnaces was the hot blast main.



Illus 8 Plan of Furnace 3 and associated structures and features

The Lancashire boilers (illus 7, 11)

On the evidence of the first edition OS map, the boilers that powered the engines were originally housed within structures integral with the engine houses. No trace of these early structures was uncovered, only the foundations of the building that housed the Lancashire boilers, which were not developed until the mid-1840s. The superstructure of the building measured at least 12m square, although almost certainly it extended further west, beyond the limit of excavation. The building had been demolished to ground level although the dwarf walls that separated the boiler settings, of which four were uncovered, survived more or less intact. These walls were 2m wide and 1m high, including a 0.3m-high scarcement, and were built of sandstone blocks, perhaps reused from earlier structures. They were clad with firebricks which lined the four channels, each about 9m long and 1m wide, over which the boilers would have sat. Lancashire boilers could be fired by coal or gas but, given their length (about 9m), gas was probably used at Summerlee by the time they were installed. Indeed, Sexton and Primrose (1912, 106) state that gas was always used for such boilers.

A photograph of 1925 shows the ends of four of Summerlee's Lancashire boilers, each with twin down-comers from an overhead gas main. The small flue door is open on one of the boilers, allowing burning coal to be inserted to light the gas. When the door was closed vents would have admitted air for combustion. It is possible that this flue allowed coal to be used as an alternative source of fuel. The south ends of the channels had all been blocked which might indicate that working practices had been modified at some stage, possibly when the type of fuel was changed. Water for the boilers would have been supplied by the reservoir some 40m to the north-west (see illus 13–15).

Although coal was in plentiful supply at Summerlee, at least in the early years when there were mines on the site, the works might also have produced its own gas once the chemical recovery plant was in operation after 1884. The remains of a cast-iron pipe uncovered outside the south end of the boiler house might have been part of a gas supply system.

The blowing engines (illus 12)

The excavated engine house, which appears to have comprised two principal chambers, measured 14m east/west by 12.5m north/south overall. In common with most other buildings at Summerlee, it had been demolished to ground level and its original appearance can be gained only from a few early photographs of its exterior (see illus 4 & 16). The foundations of the engine house were exposed to a depth of about 2.6m below present ground level (roughly the same as the principal operating level) and clearly continued downwards for some way beyond that level. Excavation had exposed the tops of stone piers which supported rafts of massive iron beams upon which sat the considerable weight of the engine house. The gaps between the piers allowed access below the floor of the building although substantial amounts of debris will have to be removed before the heights of these underground spaces can be measured. The iron beams continued beyond the south side of the building and a similar raft of beams ran below the brick building to its immediate south. Also running below both structures were two pipes, probably belonging to a water distribution system, supplying the needs of condensers and coolers and for generating steam. Unfortunately,

Illus 9 Furnace 3 viewed from the west in 1988

neither of these pipes is shown on any of the excavation drawings.

The foundations of the south chamber comprised massive squared blocks of coursed sandstone in contrast to the random rubble of most of the north chamber which is thought to be the original part of the building.

Several pits and sockets and numerous hold-down bolts indicated the position of machinery which had been housed in the engine house. In the centre of the south chamber, towards its east end, was a pit, probably for a flywheel, measuring 9.2m long and 1.2m wide and accessed by a flight of steps at its east end. Much of the masonry adjacent to this pit and around various sockets was heavily stained with oil and grease, presumably from lubricating the moving parts of the engines. The narrow (0.6m-wide) gap between the two sections of the engine house may have allowed access for maintenance.

Near the centre of the north chamber was a circular pit, 1.2m in diameter, which was exposed to a depth of 1.8m although it was not bottomed. Within the pit was a pipe of unknown function, leading southwards towards the canal but at a lower level. This pit may have accommodated a condenser although it would have been difficult to access for maintenance. There were two large slots, again probably related to the infrastructure of the engine or blowing cylinder, in the east side of the building although there were no corresponding fixings in the walls. Others were probably maintenance pits. Cut into the outside face of the east wall of this chamber was a curved rebate, perhaps for a blast air receiver or accumulator, a large reservoir vessel which helped maintain a steady air pressure on the blast.

To the immediate south of the engine house were the brick foundations of another structure which, according to photographs, was a very low building (illus 12 & 16), measuring 10.5m by 6.6m with walls 0.6–0.9m wide enclosing two brick platforms. Its purpose remains uncertain although it may have housed an exhauster, machinery which assisted the flow of gas from the furnaces to the chemical recovery plant.

In 1904 a gas-blowing engine was installed at Summerlee, presumably to supplement rather than replace the beam engine(s) which had been in operation since 1836. It is thought to have stood within a brick building located to the immediate west of the chemical recovery plant, in the south-west corner of the site. This building, which is now infilled with debris, still stands to a height spanning the two main levels of the site. On its upper level, where items of heavy plant are now displayed, were several large hold-down bolts, two of them angled, perhaps for the fixings shown on a photograph of this engine (*Engineering* 5 May 1905). Several apertures in the east wall of the building are interpreted as inlets for gas and cooling water. At the base of this wall was a channel thought to be the output route for the blast air from the blowing engine.

The heating stoves

The first edition OS map suggests that the original heating stoves were rectangular pipe stoves. These were relatively small brick chambers containing cast-iron pipes originally heated by coal fires, although gas might have replaced coal eventually. At Summerlee most, if not all, of the pipe stoves were positioned between the furnaces. However, no trace of any of these early structures was uncovered during the excavations, only the bases of circular Ford and Moncur stoves (variants of earlier Cowper stoves) which are shown on later maps. Nothing remained above ground of any of the stoves although a total of five bases were exposed: one each side of Furnace 3; one between Furnaces 5 and 6; and two beyond Furnace 7, where the short-lived Furnace 8 is believed to have stood. The two southernmost stoves were slightly larger (8.2m diameter) than the others (all approximately 7m diameter) and, on the evidence of a photograph by Thomas Annan (illus 16), they were the first of the circular heating stoves to be built.

According to the OS map of 1910, six Ford and Moncur stoves had been built by 1895

ILLUS 10 Furnacemen in front of Furnace 4 in 1919

(*Engineering* 16 August 1895), a further two being added shortly afterwards, one of them between Furnaces 5 and 6. For convenience, the excavated stoves are numbered from north to south.

The walls of Stoves 7 and 8 were only 0.6m wide and built of fireclay blocks, as were their floors. Their foundations were not exposed during the excavations, unlike those either side of Furnace 3. The stove to the immediate north of this furnace had foundations of sandstone, arranged in a hexagonal rather than a circular pattern, suggesting that they had originally formed the base of another structure, whereas the stove to its south was built on foundations of fireclay blocks, many of them impressed with letters and numbers.

THE FURNACES AND ASSOCIATED FEATURES

The furnaces (illus 6, 8, 9)

All of Summerlee's furnaces are presumed to have been increased in height in the later 19th century. For the purposes of this report, they have been numbered from north to south, in the sequence in which they are thought to have been built. Furnace 8, at the south end of the row, was the last to be built and the first to be demolished, being replaced by two Ford and Moncur heating stoves (see above). It should be noted that in the excavation records (and most of the site archive) the furnaces were numbered from south to north.

The only remains thought to date from the original arrangement were the bases of some of the furnace arches (illus 8). However, it is curious that a photograph (illus 10), dated May 1919, of workmen in front of Furnace 4 (now buried beneath overburden) shows a date-plate or stone inscribed '1836' on the furnace. This suggests that either the plate/stone had been reused or that a considerable part of the first phase furnace was still in place at that time.

The remains of four furnaces were uncovered during the excavations. Furnaces 5, 6 and 7 lay within the main excavation area, which also included the south engine house, Lancashire boilers and the chemical recovery plant, while Furnace 3 was located in a separate trench to the north of the main area. Furnace 3 was investigated more thoroughly than the others, probably because it was the best preserved. The other furnaces remain buried. Furnaces 1 and 2 are located beyond the northern limit of investigation, Furnace 4 lies between Furnace 3 and the main area of excavation, while any surviving remains of Furnace 8 lie buried beneath the bases of Stoves 7 and 8.

The furnaces had all been demolished to hearth level or lower. None stood more than about 1.5m above the main level of investigation although the area immediately adjacent to Furnace 3 was excavated to a greater depth. It was difficult to obtain accurate measurements on the furnaces because of the damage inflicted on them. However, on the evidence of the available information, a typical late 19th-century furnace at Summerlee measured approximately 4.6m in diameter internally and 7m externally at hearth level.

Iron was tapped from the east side of the furnaces, the molten metal running into moulds pressed into the sand floor of the pig beds which

Illus 11 View, from the north, of the south-west corner of the site in 2004, showing the bases of the Lancashire boilers on the right of the frame, the engine house in the foreground and the chemical recovery plant behind. The Gartsherrie Cut (a branch of the Monkland Canal) lies beyond the chemical plant

now lie beneath some 2.5m of overburden. The taphole of Furnace 3 was on its east side and measured about 0.6m in diameter although it was completely blocked with iron. Furnaces 5, 6 and 7 had been demolished below this level. On the south-east side of the furnace was the notch from where molten slag was run into a channel and through the pig beds to be removed in bogies.

The furnace bases were built of large fireclay blocks, many of which had been displaced during demolition and also more recently by erosion. Cutting the outer skin of these foundations were concrete pads for the cast-iron columns that would have supported the upper levels of the second phase furnaces, and perhaps other structures such as pipes.

The base of each furnace was filled with iron, slag and partially vitrified lining. In many cases the iron had penetrated into the brickwork, particularly in Furnace 3, forming what was known colloquially as a 'salamander' or 'bear'. This leakage of metal suggests that at least some of the furnaces were in need of repair at the time of their demolition, although it is doubtful if such problems worried the ironmasters at that stage.

Several other features were uncovered around Furnace 3, including sections of masonry and brick walls and pipes (see below). Further investigation would be necessary to interpret these features.

The water cooling system

The tuyères were cooled with water which ran along a network of pipes, usually of iron. No trace of the tuyères or pipes remained at Summerlee although the system for removing waste water from the furnace area was still very much in evidence. It comprised a series of short channels, lined with concrete, leading from the furnaces into larger ones that carried the water either to the Monkland Canal or to the Gartsherrie Burn, which had been diverted underground through the ironworks. A 65m-long stretch of one of these channels, measuring 0.6m wide and 0.6m high, ran between the furnaces and the retaining wall which separated the two main working levels of the site. It dog-legged at a few points, probably to avoid standing structures such as the concrete pads near Furnaces 5 and 6 and the two large heating stoves at the south end of the site. The channel terminated 8m from the canal and, rather than debouching into it, the water had been directed downwards through a small, circular opening and into the culverted Gartsherrie Burn, some 3.2m below. It is not clear why the channel was directed into the burn rather than the canal, which might have seemed the easier option.

Adjacent to Furnace 3 this channel was covered with iron plates although elsewhere along its exposed length the plates had been removed. A feeder channel running south-eastwards from Furnace 3 was similarly capped, although most of the channels had been stripped of their covering. A pipe running eastwards from between Furnace 3 and the heating stove to its south appeared to debouch into this channel, as perhaps did another pipe nearby, although the sources of these pipes remains unclear.

It is interesting to note that feeder channels on the west side of Furnace 3 appeared to be integral with the original masonry of the furnace arch and, on this evidence, dated to the 1830s, continuing in use after the furnace was remodelled.

Furnace 7 appeared to have a discrete drain whose construction and dimensions were identical to those of the main one. It ran eastwards to the rear of the southernmost heating stoves towards the canal, although its full course was not traced.

Directly below the main drainage channel, just outside the engine house, was a cast-iron pipe, 0.15m in diameter, which clearly was not in situ and its original extent remains unknown. Adhering to the west side of the concrete channel were a few bricks, perhaps the remains of a demolished structure against which the channel had been built.

The water for cooling the tuyères and for many other purposes around Summerlee was provided by a reservoir situated on the higher level to the west of the site, intermediate supplies being stored in water towers situated within the works. One such tower, whose base was exposed by excavation, is shown in Annan's photograph (illus 6 & 16).

Other features

To the west of Furnaces 5 and 6 were several large, rectangular concrete blocks of varying sizes although they were typically 1m square in plan. The tops of most of the blocks were level, although some had pronounced slopes. Their arrangement was somewhat irregular, which might point to an accident of survival, or perhaps they did not all have the same function. They were positioned either side of the main waste water channel and were clearly contemporary with it, as well as with the flue located against the retaining wall (see below). There were no fixing bolts, or evidence that there had been any, in these blocks but clearly they were meant to support objects of considerable weight, perhaps the bases for cast-iron columns supporting the down-comers and dust-catchers from the furnaces.

FLUES AND PIPES

The ironworks would have been criss-crossed by numerous flues and pipes: some of metal, often lined with firebricks and usually positioned at relatively high levels; others brick-lined passages at surface level or below ground. Pipes carried steam from the boilers to the engines which sent blast air to the stoves while other pipes took heated air from the stoves to the furnaces. Pipes also took waste gases from the furnaces for processing and back to the stoves while flues removed exhaust gases to chimneys where they were expelled into the atmosphere. The only flues to survive were stretches of subterranean channels running north/south, one each side of the line of furnaces, and a complicated network of brick passages to the north of the engine house, adjacent to the dog-leg in the retaining wall.

At Summerlee very few traces of the metal pipes remained. They would have been removed along with other scrap metal soon after the ironworks was demolished.

The underground flues

The flue to the west of the furnaces was roofless along most of its length, although to the south of the dog-leg in the retaining wall it continued below ground. This passage, which was built of firebricks and originally barrel-vaulted, was 0.75m below ground at its south end and measured 1.14m high and 1m wide. Its route deviated beyond an inspection chamber, some 2.5m north of the engine house, and probably linked with the flue that ran north/south outside Stoves 7 and 8, although this has not been confirmed. In the roof of the passage were circular openings which had probably connected to down-shafts from the stoves. Between the circular openings was a square inspection shaft. The brickwork at the tops of all these shafts was badly eroded by heat, indicating that the gases which had travelled along the flue were very hot. Although this might suggest that the flue was the hot-blast main, it was more likely the route for exhaust combustion gases from the stoves to a nearby chimney.

There is some evidence to suggest that the roofless part of this flue was a secondary feature, replacing its original course a short distance further east. To the immediate west of Stove 6 was a circular opening similar to those adjacent to Stoves 7 and 8 and directly in line with them. Unfortunately, this putative connection has not been examined in detail, but it could form the basis of another programme of investigation at Summerlee.

This passage appeared to continue northwards along the entire range of furnaces, although it had been blocked midway along its length by a flimsy partition wall. The wall might have enabled maintenance to be carried out to one section of the flue or, alternatively, allowed waste gases from Stoves 1–5 to be sent to a chimney at the north end of the site while those from Stoves 6–8 were sent to one at the south end (see illus 16).

Another underground flue, 9.5m long, was exposed to the immediate east of Stoves 7 and 8, 0.2m below present ground level. It terminated in circular openings, 0.8m in diameter, directly in line with similar features outside the other stoves. On this evidence, the flue probably continued along the length of the furnaces, although the debris that filled the passage made this impossible to prove. This flue is thought to have carried gas to fire the stoves, the circular openings accommodating the valve mechanisms while adjacent square openings allowed access for inspection. The brickwork surrounding these openings was stained black, probably by dust in the gas, which would never have been completely clean.

Flues visible above ground

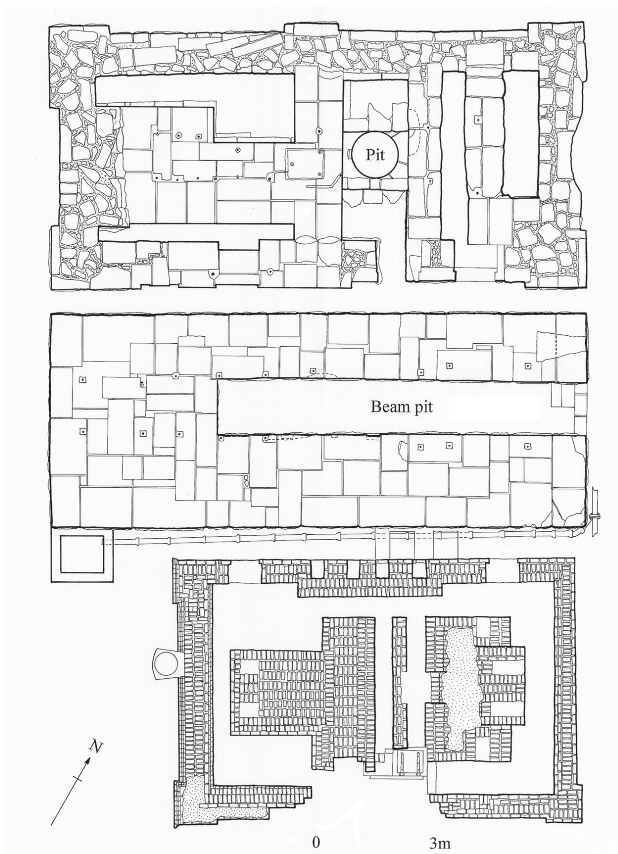
Remnants of a system (or systems) of flues were revealed against the south arm of the high retaining wall, in the angle between the Lancashire boilers and the engine house. These arched passages, all built of firebricks, were difficult to relate to the other surviving elements of the ironworks. The flues themselves were far from complete and some appear to have been rerouted and others blocked, presumably when changes were wrought to the layout of the works' heating and exhaust systems. It is likely that at least some of these flues, which were typically about 1m wide, had connected with the nearby Lancashire boilers, perhaps taking exhaust gases to the chimney although it was not possible to prove this.

One of the passages, which appeared to have linked with the boilers, now forms part of a walkway designed to take visitors through the furnace area.

OTHER STRUCTURES AND FEATURES

The retaining wall

The two principal levels of the works were separated by a stone retaining wall which runs north/south along most of the length of the site before returning westwards at a point just north of the engine house. It is clearly a two-phase structure: its bottom few courses are built of sandstone blocks, measuring typically 0.5m by



ILLUS 12 Plan of the engine house

0.25m, whereas the rest of its height comprises massive blocks, many of them over 1m long. It might be reasonable to assume that this wall was heightened at the same time as the furnaces, presumably in the late 19th century, although it is difficult to prove this.

Excavation revealed two arched openings at the base of the north arm of the retaining wall, one in line with Furnace 5, the other towards the south end of the wall. Each arch was 0.95m wide and exposed for a height of 0.9m above the excavated level although their full dimensions remain unknown. These openings are thought to have connected the exhaust gas flue with a chimney on the upper level. At some stage, perhaps when the wall was raised, these openings were blocked.

The chemical recovery plant

A plant designed to extract ammonia and other chemicals from the furnace waste gases was installed at Summerlee in 1884 and another built to replace it in 1901 (*Engineering* 16 August 1895; Turner 1920, 192). It is not known whether the new plant was on the same site as the original one, although the need to maintain a continuous process suggests it was probably not. However, if the two plants were at different locations within the works there is nothing to indicate whether the one in the south-west corner of the site was the first, or second, to be built. Furthermore, little that was uncovered has been interpreted with any confidence and consequently is not described here.

FINDS

BRICKS

Examples of bricks from several manufacturers were retained during the excavations and many of them are still stored at Summerlee. An inventory of manufacturers and their wares forms part of the excavation archive.

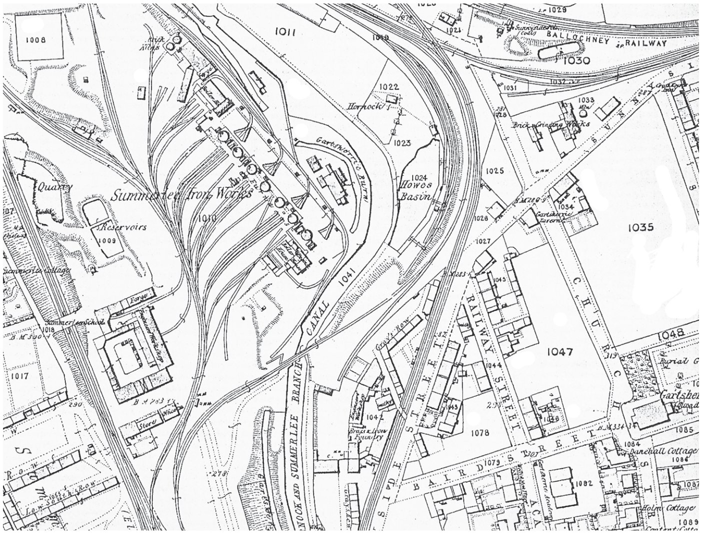
The refractory bricks are of particular interest for the ironworks and were produced in a number of different works throughout west and central Scotland. Those manufacturers represented at Summerlee are:

- Cumbernauld Fireclay Works of Cumbernauld, Lanarkshire
- Garnqueen Fireclay Works of Glenboig, Lanarkshire
- Gartcosh Fireclay Works of Garnkirk, Lanarkshire
- Gartliston Fireclay Works of Glenboig, Lanarkshire
- Glenboig Fireclay Works of Glenboig, Lanarkshire
- Star Fireclay Works of Glenboig, Lanarkshire
- Castlecary Fireclay and Lime Works of Castlecary, Stirlingshire
- Dougall's East Works of Bonnybridge, Stirlingshire
- Dykehead Firebrick Works of Bonnybridge, Stirlingshire
- Glenyards Fireclay Works of Bonnybridge, Stirlingshire
- Atlas Brickworks of Armadale, West Lothian
- Etna Brickworks of Armadale, West Lothian
- Prestongrange Brick, Tile and Fireclay Works of Prestonpans, East Lothian.

Fireclay products come in a variety of forms and have been used (and continue to be used) in a wide range of industries, wherever high temperatures are encountered. They were essential in many locations at ironworks, particularly inside furnaces, heating stoves, boiler bases and flues. Those used within the stove bases, boilers and flues were usually of the same size and shape as standard bricks whereas the dimensions and forms of those in the linings of furnaces and stoves varied enormously.

OTHER ARTEFACTS

Other than bricks, a total of 541 artefacts were retained from the excavations. Most of them comprise a range of iron and steel fixings, fittings and tools, as well as discarded objects expected of a heavy engineering concern. They include a



ILLUS 13 Summerlee Ironworks, as shown on the first edition Ordnance Survey 25-inch map of 1856

few large fragments from riveted objects such as boilers, heating units and furnaces, several of which have been cut by an oxy-acetylene flame, presumably during the recovery of scrap metal following the demolition of the ironworks.

There are many iron tools, particularly chisels and spanners, which would have been used for plant maintenance rather than iron production. Other common objects include nails, nuts and bolts, especially coach bolts, which were probably used for roofing. Heavier bolts would have been associated with metal assemblies. The assemblage also includes several pieces of sheet metal, some apparently unused, and fragments of heavy-gauge cast-iron assemblies of indeterminate purpose. Other cast-iron fragments with ribbed surfaces are presumably from cover plates.

Perhaps the most interesting objects are those associated with the process of iron-making. These include a few fragments of iron pigs, pig-handling tools and sections of small-gauge rail lines and shoes, presumably from Summerlee's internal railway system.

Unfortunately, most of the finds have fared badly since the end of the excavations, many having been reduced to little more than rust. The exceptions are those objects of cast iron which tend to survive better than the purer metal.

GENERAL DISCUSSION (ILLUS 13–18)

Summerlee is one of Scotland's few 19th-century, coal-fired ironworks of which significant remains can now be seen, although much probably survives beneath the ground at some other sites, such as Shotts and Calderbank in Lanarkshire and Dalmellington in Ayrshire. Much of Summerlee still lies buried beneath considerable quantities of overburden; only four of its eight blast furnaces have been exposed,

ILLUS 14 Summerlee Ironworks, as shown on the Ordnance Survey 25-inch map of 1897

Illus 15 Summerlee Ironworks, as shown on the Ordnance Survey 25-inch map of 1910

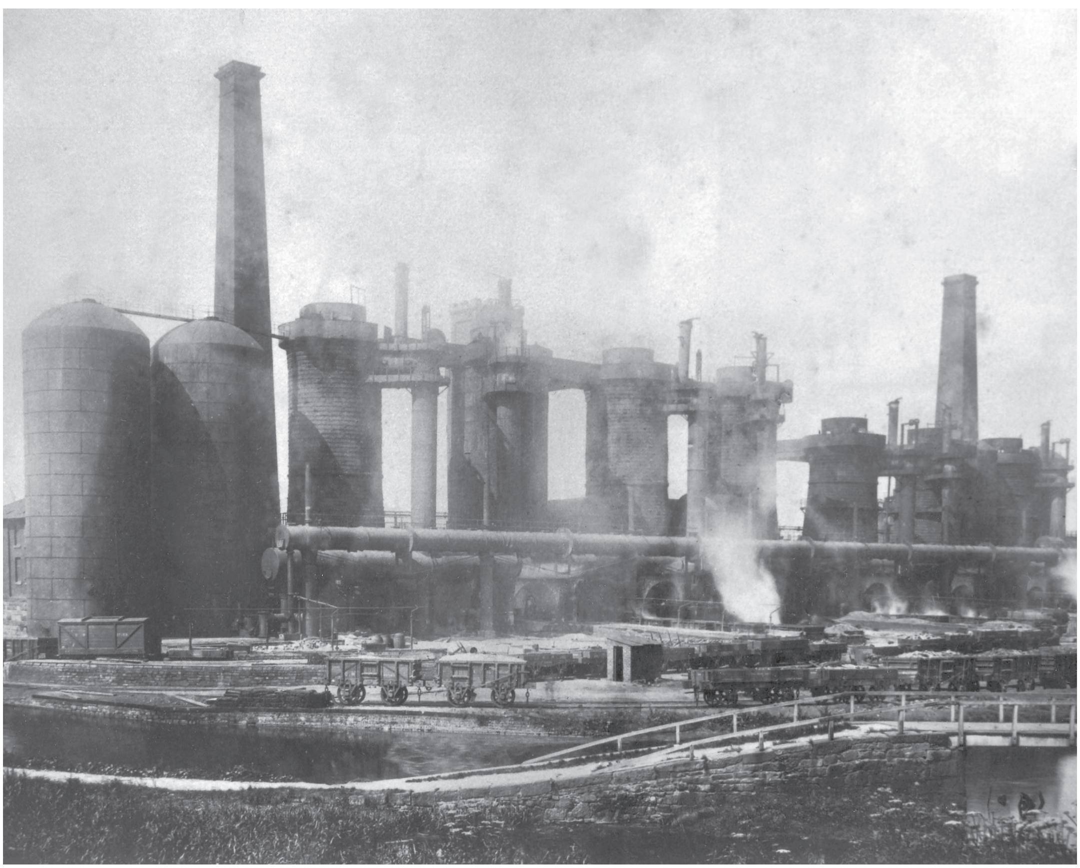
although it is unlikely that much survives of Furnace 8 which was overlain by two circular heating stoves. The bases of three other furnaces are still unexcavated, as are the remains of as many as three heating stoves, the entire casting area, stretches of underground flues, a second engine house, boilers and one of the chemical recovery plants. On a higher level were the hoists and incoming rail-heads, although it is debatable how much survives of those structures and features following the construction and subsequent demolition of the Hydrocon factory. However, while exposing more furnaces and stoves might have its appeal, a more worthwhile approach might be to focus on the underground flues, with a view to understanding how they functioned.

Much of what has been uncovered is relatively easy to interpret. The furnace and heating stove bases are unmistakable and there is little doubt as to the locations of one of the engine houses, one set of boilers and at least one phase of the chemical recovery plant. Furthermore, while there were many variations in the process of making iron in coal-fired blast furnaces, the basic procedure is well understood. Nevertheless, many questions are still unresolved following the excavations. The system of underground flues is not fully understood and the functions of the brick structure to the immediate south of the engine house and the individual elements of the chemical recovery plant remain unclear.

THE FURNACES

While the general form of late 19th century blast furnaces varied little, their dimensions often did. It can be difficult to compare sizes of furnaces from photographs, although the impression is that Summerlee's were somewhat smaller than those at other sites, such as Consett, County Durham and, on the evidence of excavation, their diameters at hearth level were slightly less than those built in the late 19th century at Glengarnock, Ayrshire (Charman 1981, 40). Comparisons of output can also be misleading because the number of furnaces in blast varied considerably, both between different enterprises and within a particular works. Little meaningful information can be gleaned from such an exercise.

In contrast to Glengarnock, where it is known that the original furnaces (built in the early 1840s) were replaced by seven new ones at the end of the 19th century (Charman 1981, 23),

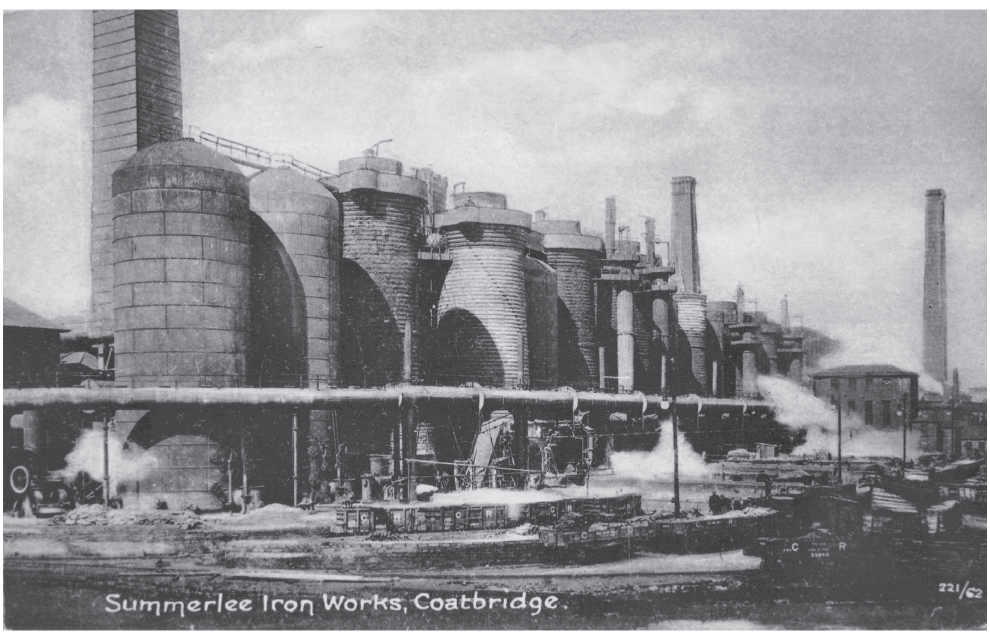


Illus 16 View from the south-east of Summerlee in the late 19th or early 20th century (note the truncated waste gas pipe in front of Stoves 7 and 8 in the left of the frame)

there is no documentary evidence to confirm that Summerlee was remodelled on a similar scale. The OS maps of 1856, 1897 and 1910 indicate that the Summerlee furnaces remained at the same locations over the entire lifetime of the works. Rebuilding a furnace would almost certainly have meant the removal of its entire superstructure and probably its hearth too, although this does not necessarily mean that its position would have had to change. The only material evidence to support a rebuild at Summerlee consists of the concrete pads for the columns which had been built over the foundations of the original Furnace 3. It is worth noting that such slight evidence was more than was uncovered at Glengarnock.

THE HEATING AND EXHAUST SYSTEMS

Perhaps the most interesting questions arising from the excavations concern the network of flues and pipes that carried the cold and hot blasts towards the furnaces and the waste gases to the stoves, chemical plant and chimneys. In most cases, the hot blast main, which carried heated air from the stoves to the furnaces, was an iron pipe lined with firebricks, suspended some distance above ground level. The blast was transferred to the tuyères through a horseshoe main which encircled each furnace, an example of which can be seen in a late 19th-century photograph of furnaces at Glengarnock (illus 18). There were exceptions to this arrangement: for example, at Consett Ironworks where photographs of 1892 show no overhead pipes near the furnaces (Jenkins 1892). However, there were 25 heating stoves, of similar size to those at Summerlee, serving seven furnaces at Consett, compared with a maximum of eight stoves to seven furnaces at the Coatbridge works. As a result, the hot blast at Consett only had to travel short distances and could be accommodated satisfactorily in



Illus 17 Summerlee in the late 19th or early 20th century, viewed from the south-east, showing the waste gas pipe extending south-westwards beyond Stove 8

underground brick flues even though they would have been more difficult to seal and maintain than surface metal pipes. Stoves were operated in units of at least two, one (or more) being heated by waste gases while the other (or others) returned the heat to the hot blast system, which means that at Summerlee the hot blast distribution system must have been radically different from the one at Consett.

The Glengarnock photograph shows an even larger metal pipe, thought to have taken waste gases to a chemical recovery plant, some distance above the horseshoe main. A similar pipe ran the length of the furnaces at Summerlee (illus 16 & 17). Close scrutiny of these photographs shows that at some stage the pipe terminated near Stoves 7 and 8 whereas it appears to have extended around Stove 8 at another stage. One possible explanation is that the original chemical plant, built in 1884, was at the north end of the works and that gases were sent to it from as far away as Furnace 8, which stood in the vicinity of the later Stoves 7 and 8. When a new plant was installed in 1901 the chemical works might have been moved to the opposite end of the site and the pipe carrying the waste gases to it would then have needed to be extended south-westwards beyond its original terminus. Alternatively, the chronology could be reversed with illus 16 showing the site later, rather than earlier, than illus 17. If this is the case, the chemical works uncovered by excavation would be the original one, the scrubbers associated with it perhaps being represented by the large rectangular structure, with internal ribbing, shown on the 1910 map to the north-west of the furnaces.

ILLUS 18 View of some of the furnaces at Glengarnock, Ayrshire in the late 19th century (note the hot blast horseshoe main encircling one of the furnaces and the large exhaust gas pipe at a higher level)

Of course, nothing remained of the overhead system of pipes at Summerlee; the only flues to survive were the short but complicated network of brick flues to the north of the engine house and the two underground passages, one either side of the row of furnaces. The principal purpose of the brick passages standing above ground was probably to carry exhaust gases to the chimney which stood on the higher ground nearby. One source of these gases was probably the Lancashire boilers, although this system of flues associated with it had clearly been altered and at least partially truncated at some stage(s) and interpretation is now all but impossible.

In all probability the circular upshafts on the east sides of Stoves 4, 5, 6, 7 and 8 were all linked to a continuous underground passage, although this is yet to be proved. There was little sign of the heat erosion on the brickwork of this passage that was so evident on the flue to the west of the furnaces, suggesting that it was the gas main to the heating stoves.

The flue running north/south to the west of the furnaces is interpreted as a flue taking exhaust gases to be vented at a chimney. There were chimneys at both ends of the site (illus 16 & 17), through which waste gases from the furnaces, stoves, chemical plant, boilers and perhaps other sources were expelled. The two arched openings, now blocked, at the base of the stone retaining wall were probably outlets from this passage to the southernmost chimney.

The first edition OS map shows that in the 1850s there were engine houses and boilers at each end of the line of furnaces. According to the OS maps, the location and dimensions of the engine house exposed by excavation remained constant throughout the history of the site, indicating that its expansion into two chambers was probably an early development. The Lancashire boilers were clearly not part of the primary arrangement and are assumed to have replaced those shown adjacent to the engine house on the 1856 map. Their full extent is not known (they appear to extend westwards beyond the limit of excavation) but there were at least four boilers, each about 9m long, which is slightly smaller than those at Consett (Jenkins 1892).

There were few clues as to the precise nature of the machinery that stood within the original engine house although there is documentary evidence suggesting that there were two engines within it, presumably one in each chamber (*Engineering* 16 August 1895). In all likelihood, power was provided by beam engines but, most probably, the engines were modified, or at least repaired, on more than one occasion although there is nothing to indicate what such changes might have entailed. The efficiency of the blast system would have increased considerably when a gas blowing engine was installed in 1904. Its location has not been confirmed although it was almost certainly the brick structure which still stands at the south-west corner of the site where there was a radical reorganization between 1897 and 1910 (illus 14 & 15).

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