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Introduction

Introduction

This work is mainly about the charcoal iron industry in the early modern period. Its main concern is history, economic more than of technological. The technology has been described at length elsewhere,[1] but it is difficult to understand anything else without a basic understanding of the technology involved. More strictly, it covers the period from the introduction to Britain of the blast furnace until 1815, a date by which most charcoal ironworks had closed, but its scope will be more precisely defined later in this chapter. It is published in an archaeological series, because it is likely to inform archaeological research, but it is mainly the result of historical (not archaeological) research. However archaeological work is also referred to wherever possible. The subject matter is generally limited to works where artificial power was employed. The artificial power was usually water-power, provided by a waterwheel with a horizontal axle. The use of horsemills and windmills was highly exceptional. From the 1740s water-power was supplemented with steam engines, initially to pump water back over the dam or into a penstock, to power a water wheel. The direct application of steam engines only began in the 1780s, when James Watt's improved steam engine began to be used to provide rotary motion. The main case where water-power was not needed was in certain other capital-intensive works operating on the reverberatory principle, where the fuel is kept separate away from the charge, principally steel furnaces and foundries using air furnaces, but also in the stampering and puddling processes.

The work is structured as a series of regional chapters. These regions are similar to those used by Riden in his *Gazetteer* (which was limited to charcoal and early coke furnaces since 1660),[2] but that only reflects a coincidence of conclusions. The chapters seek to bring together groups of ironworks that have some coherence, rather than being driven by political boundaries. This may involve ironworks having worked together, used similar ore sources, or other considerations, but occasionally mere proximity or lying in an area between other, more clearly defined, groups.

Riden's *Gazetteer* was the culmination of a considerable body of research, towards estimating the output of the British iron industry. This process began with Flinn using of an appendix in Schubert's book on the charcoal iron industry.[3] Flinn countered a longstanding view that the charcoal iron industry had declined in the period before the industrial revolution as charcoal resources were exhausted. The old view goes back to Mushet, who was referring to the Weald.[4] Ashton suggested a decline, but probably only in the period 1720-35,[5] but others sought to generalise their comments.[6] Flinn's work was refined by Hammersley and then Riden.[7] However all these estimates were based on the output of furnaces, but furnaces operate in discontinuous campaigns. I adopted the new approach of estimating bar iron output in forges, on the basis that forges operated fairly continuously.[8] I was thus enabled to use more 18th-century lists and other data. However much of the data, on which my estimates were based, has not been published except as a brief summary of works and dates of operation.[9] An objective of this book is to publish the detail lying behind my 2003-5 estimates. These were the result of over a decade of earlier research, but this *Gazetteer* does not merely reflect what I knew in *c*.2002, but has as far as possible been brought up to date, with the results of further research.

Sources and methodology

The gazetteers here have thus been updated to include new material, from sources that were not readily available (or not discoverable) in 2002, when my thesis was completed: searches of digitised archive catalogues identified additional material;[10] and searchable newspaper archives have added significant detail at the end of the period covered.[11] Further material has been identified from the Discovery catalogue of The National Archives, whose on-line coverage (though still incomplete) has much improved, as the contents of what were manuscript calendars have been incorporated in that database. Nevertheless, the results are inevitably not as comprehensive as may be possible eventually, as I have inevitably had to depend on what archivists have catalogued in whole or in part over many years. If there is a gap in my research, it probably

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1 Schubert 1957; Tylecote 1991; 1992; Gale 1969, 1-39; Hayman 2005; but note also Bayley, Crossley & Ponting 2008; and King 2012. Young & Hart 2018; 2019 and Williams 2019a; 2019b all appeared as I was finishing this work, throwing very substantial new light on the transition from charcoal to coke.
2 Riden 1993.

3 Flinn 1958; Schubert 1957, 366-92.
4 Mushet 1840, 42.
5 Ashton 1924, 13-23 235-8.
6 *E.g.* Deane 1979, 107. She did not clearly indicate what here sources were. Note also Clow 1956 and the response by Flinn (1959b) to this.
7 Hammersley 1973, 594-5; Riden 1977; 1994.
8 King thesis; King 2005.
9 King, thesis appendices: deposited at Archaeological Data Service; and dataset on Economic History Society website.
10 Even *Access to Archives* (A2A) – now incorporated into the TNA Discovery catalogue – came on-line too late for me to make much use of it in my thesis.
11 *The London Gazette;* BL, Burney Collection (via Thomson-Gale); British Newspaper Archive; and Welsh newspapers on-line.

relates to archives that have emerged in recent years, but of whose appearance I have been unaware. In most cases, if I have cited a document, I have examined it myself. However, I have had to draw my research to a close, in order that this book should be completed and published. This has meant that in rare cases, I have had to rely on the description in a record office calendar.

The stories told here have frequently been pieced together from scattered scraps in information. There are a number of significant sources. Obviously the most important sources on any ironworks are the internal records of its own ironmasters, but these often only exist (if at all) for part of its history. Ironworks accounts not only provide information on the ironmaster's own works, but also on his dealings with others. Details recorded of his suppliers and customers provide information on who owned other ironworks, fleshing out what is known from other sources. Records of the sale and purchase of pig iron (also hammers, anvils, and other forge castings) point to both parties being ironmasters. Something similar applies to the purchasers of cordwood (for charcoal) and to the vendors of substantial quantities of bar iron, also cannon, shot, iron ballast, and the like. However, occasionally, the intervention of a merchant as a middleman can be detected. The sources here are mainly accounts, but also the letterbooks and diaries of ironmasters and merchants provide similar information, as do the accounts and other records of the Navy, Ordnance, and Victualling Boards, when they bought the products of ironworks. Details derived from such sources appear in the *Trading* section of gazetteer entries.

A series of contemporary lists of ironworks from the 18th and early 19th centuries (with earlier lists in the Weald) serve to define the breadth of the subject. Research has established that these are largely complete and reliable, though some (particularly the 1717 list) are open to criticism where they deal with areas remote from their Midland compilers. However that bearing the date '1794' seems to be an updated version of a lost 1790 list.[12] Occasionally, it is clear in other cases that such data is slightly anachronistic, the list date is thus sometimes placed in quotation marks. These lists are rarely explicitly cited, but output information attributed to 1717, 1718, 1736, 1750, 1788, 1790 (or 1794), 1805 (or 1806) and 1810 will usually be from such lists. Later statistics usually come from *British Blast Furnace Statistics* (for furnaces) and *Mineral Statistics* (for forges from 1860).[13] Information of a similar nature can be found in travel diaries, of which the most important is *Angerstein's diary*. Material from these is included in the *Size* section of gazetteer entries.

The estate management records kept by landlords are also important: leases to ironmasters, rentals and surveys, rent collection accounts. The property descriptions in the landlord's title deeds can be helpful, though not always for the greater nobility, whose deeds tend to deal with entire manors, but estate correspondence has only been used where it has been indexed. Sometimes taxation records are useful, particularly Land Tax Assessments. A long sequence of them survives in many counties, because duplicates were lodged with the Clerk of the Peace to provide evidence of who was entitled to vote. This is often not an easy source to use and is liable to contain obsolete information, so that other sources are to be preferred where there is a conflict of evidence. Leases and other agreements, quoted in Chancery, Exchequer, or other court proceedings can fill gaps in what is known from other sources. Occasionally this is the only source for the existence of an ironworks or that it existed so early. Finally, it is occasionally necessary to resort to inference. For example, if a certain ironmaster succeeded another in a group of ironworks, but the exact date is only known in one case, it is likely all changed hands together. If an ironworks probably closed at about a certain date, the precise date is likely to be at the expiry of a lease.

Technology

It is very difficult adequately to understand the iron industry, without some knowledge of the processes involved and the organisation of the iron trade.[14] Much of this is now well-understood, though historical intricacies of a few of them are still being worked out. In this section various technical terms are highlighted in bold italics to facilitate its use as a glossary. Certain words may be used loosely by some authors, when in the iron trade they had a precise meaning. Occasionally, it is necessary to take this further: in this book production and manufacture are usually used as antonyms (not synonyms) for different aspects of the iron trade: iron ***manufacture*** consisted of making nails, locks, hinges, edged tools and a host of other finished iron goods out of bar or rod iron or tinplate, a labour-intensive process, employing substantial numbers of nailers, smiths and other artificers. Conversely, making iron in an ***ironworks*** from ore or pig iron is referred to in this book as its ***production*** and not as its manufacture; ***bar iron*** and ***rod iron***, the semi-finished product, might have been described as ***unwrought*** iron distinguishing it from finished iron goods, such as nails, gun barrels, scythes, and awls, which were known collectively, for example to the Customs, as ***wrought iron***. The latter term is today used for fancy metalwork, now usually consisting today of welded mild steel (which is strictly not iron at all) or as a chemical description of commercially-pure iron, irrespective of shape. This is to distinguish it from ***pig iron*** (or ***sow iron***) and ***cast iron*** (with 4-5% carbon) and

[12] Hulme 1928; King 1996b; 2012. There may be omissions from the 1717 list in the Weald and the Northeast.

[13] Riden & Owen 1995; *Mineral Statistics*; later sources on forges include *Wolverhampton Chronicle*, 15 Jul. 1846; Hunt 1852; Griffiths 1873; *Annual Statistical volumes of British Iron Trade Associations* for 1881-1905: see also King 2018b. I have not investigated statistics published in *Mining Journal* in 1841.

[14] The latest contributions to this are Young & Hart 2018; 2019; and Williams 2019a; 2019b. All of these appeared as I was finishing this work. Any statements here that may appear to contradict their views should be read in the light that what I wrote may be an older view.

steel (with rather less carbon). Pig (or sow) iron refers to a commodity needing further processing, whereas cast iron generally means a finished good.

The entrepreneurs of the production stage were called ***ironmasters***. Manufacturing was organised by ***ironmongers***, commonly by putting out iron to skilled artisans. This putting-out system, where the artisans worked in (or at) their own homes has been described as proto-industrialisation. The workers in this used hand tools, without any artificial power. In some periods or areas, the terminology may vary. For example, an entrepreneur specialising in a particular product would be identified by a name related to it. At Sheffield, the term ***hardwaremen*** seems to have been used. Another term used there ***factor*** probably refers to the commercial relationship (as a species of agent) with a distant merchant (often in London). On the other hand, then (as now) most ironmongers were merely retailers of ironware. Relatively little more will be said of ironmongers and of the smiths and others who worked for them, because they did not have any substantial plant and machinery, only warehouses and smiths' hearths respectively, which are beyond the scope of this work.

Bloomery processes

The earliest iron known to man almost certainly came from meteorites and probably had the status of a precious metal. Iron was first smelted probably somewhere in Anatolia shortly before 1000 B.C. The technology spread across Europe and reached Britain in the middle of the last millennium B.C., but remained scarce here until the Roman period. Smelting consisted of the reduction of the ore, iron oxide or iron carbonate, using charcoal at a temperature insufficient to melt iron, for if the iron melted, carbon dissolved in it to produce a brittle material, which we call cast iron. It seems, despite reports to the contrary, that the necessary temperature for efficient reduction could not be achieved in an open bonfire, nor in a confined furnace with merely natural ventilation: it was necessary to confine the raw material in a furnace, known as a ***bloomery***, using a forced draught provided by means of bellows through a hole in the side of the bloomery (a ***tuyere***). Bloomeries were of various designs at various periods, but that need not concern us here. The result of such smelting was a spongy mass of iron and slag, known as a ***bloom***, which was then consolidated into a bar by hammering it. The whole process was thus conducted in the solid state by carbon or carbon monoxide diffusing into the ore. This distinguishes the bloomery process from later indirect processes where iron is intentionally melted.

Because the iron is kept in the solid state, almost any version of the bloomery process must be conducted on a batch basis, the bloomery being allowed to cool between smeltings in order to permit the bloom's removal. This and the limitations of human strength and endurance limited the output of a simple bloomery to a few tons of iron per year. About the 14th century, the power of a waterwheel was applied to the process, enabling production to be increased to 20-30 tons per year, but that was its effective limit of the process. Smelting in powered bloomeries (***bloomsmithies*** or just ***smithies***) persisted in northwest England into the 18th-century, but generally disappeared elsewhere in the late 16th or early 17th century. Because the ironworks involved were also called ***forges***, they fall within the scope of this book, but are dealt with either in a separate section of each gazetteer or are listed among 'other ironworks', according to the size of that section. The coverage of powered bloomery forges in this book is as complete as possible, but it is probable that there were others that I have failed to discover. A significant number of those discovered were first mentioned in the late 1530s in Ministers' Accounts for the estates of dissolved monasteries, but they may be rather older.

Furnaces

At the end of the 15th century, a new process was introduced from the continent (see chapter 2), where a more powerful blast enabled a ***blast furnace*** to heat its charge beyond the melting point of cast iron, so that liquid iron could be tapped from the bottom of the furnace and cast into ingots known as sows or pigs or (less often) into finished cast iron goods.[15] In a preliminary process, the ore (usually known as ***mine***) was ***calcined*** – heated. This was sometimes done in a kiln, something like a limekiln; with the result that iron carbonate (***ironstone***) was converted to the oxide. However, this process was unnecessary where the ore was an oxide, as with the ***limonite*** ($Fe_20_3.xH_2O$) ores of the Forest of Dean and with ***redmine***, the haematite ore (Fe_20_3) of Furness and west Cumberland.

The blast for furnaces (and also forges) came from ***bellows***, operated by a waterwheel. The bellows might have boards 12 feet long, pivoted at the nozzle and with leather closing the angle between the boards. The leather might be from a bull's hide, no doubt chosen for its size. The use of water meant that a furnace could be stopped by drought, so that furnace operation was often seasonal, ceasing in the summer. Instances can be found (though rarely) of men being employed to tread the waterwheel to keep a furnace in blast, in the hope that rain would refill the furnace pond.[16] In the 18th century, steam engines were sometimes provided to pump water back to the furnace pond, so that it could drive the wheel again. Such a returning engine was installed at Coalbrookdale in 1742 to replace a horsemill pump, dating from 1735.[17] However there may have been an earlier case of this as Aston Furnace had 'one of Newcomen and Cawley's engines'. The reference to the latter [John Calley, d.1725] probably points to the period before the steam engine patent expired in 1733.[18] Most of the new Shropshire furnaces of the 1750s had water-

[15] For furnaces generally see Schubert 1957, 232-45; Daff 1973; Tylecote 1991, 209-27; 1992, 95-9.
[16] Crossley & Saville 1991, xviii and no. 267; Jones 1987, 16.
[17] Raistrick 1953, 111-3 139; Mott 1959a, 275.
[18] Dent 1880, 339. John Kanefsky pointed out this reference.

returning engines. Of these, Madeley Wood may have been unusual in that it apparently did not have a pound. The engine seems to have filled a tank, something like a penstock.[19]

Bellows began to be replaced by ***blowing cylinders*** in the mid-18th century. Isaac Wilkinson obtained patents, related to this in 1738 and 1757.[20] The earlier patent is described as for cast-iron smoothing irons, but it also dealt with iron 'bellows', consisting of 'two cylinders of cast iron' with pistons.[21] In 1737, he had cast 'a pair of cast iron cylindrical bellows' for his employers' Backbarrow Forge.[22] Cylinder-blowing is recorded at Swalwell Forge in 1754, having been in use for 7 years.[23] Wilkinson presumably used his system at Bersham Furnace in the 1750s. The 1757 patent relating to adding a trompe, a cylinder partly filled with water, to act as a regulator and smooth the blast.[24] He certainly used cylinders at Dowlais at Merthyr Tydfil (built in 1759), where he was a partner. John Smeaton designed a machine for the Carron ironworks in Scotland with four cylinders operated by two cranks and two beams, but surprisingly, Wilkinson's Plymouth Ironworks at Merthyr apparently used bellows.[25] James Knight of Bringewood had a patent for a machine with cylinders of square cross-section, but this was probably only used there or at Charlcot.[26] The direct application of steam engines to operating blowing machinery began with James Watt designing an engine for John Wilkinson's New Willey Furnace, followed by one for his Snedshill Furnace. The first furnaces in Wales with a Boulton and Watt engine were those at Neath Abbey in 1793.[27]

Throughout the period covered by this work, the blast furnace underwent very little change, except in size. The ***hearth*** may have changed from being square to round. There may have been variations in the angle of the ***bosh***, the part of the furnace that acts as a funnel directing the charge to descend into the hearth.[28] The materials used for the hearth changed from refractory sandstone to firebrick and fireclay, both of which were in use at Coalbrookdale by 1720, though they could have been bought for air furnaces.[29] The initial source of fireclay was near Stourbridge, where it had long been used by local glassmakers for their furnaces. Its use for the hearths of iron furnaces is specifically mentioned in a 1725 mining lease to Humphrey Batchelor, a glassmaker, but not in the preceding lease of 1709.[30] The size of charcoal furnaces, or at least their average output increased from 200 *tpa* of pig iron in 1580-1620 to nearly 400 *tpa* in the early 18th century. Coke furnaces were making about 750 *tpa* from the late 1750s to 1785, rising to over 1000 *tpa* in the late 1790s and over 1300 *tpa* in the early 1810s.[31] This increase was probably the result of an increase in the height of the furnaces and the use of multiple tuyeres. This enabled the furnace to be blown from two or three sides, rather than just one, but this in turn required air-tight joints in the cast iron pipes distributing the blast. Thus Richard Crawshay described Cyfarthfa Furnace in 1791 as 60 foot high and producing 1400 *tpa*.[32] Neath Abbey Furnaces stand 53½ and 63½ foot high and had three tuyeres. The surviving Brymbo Furnace, built in 1796, is similar.[33] However, some of this has to be judged from the remains, which represent the final form of the furnace, as it was last used, and not what was originally built.

Forges and foundries

The ***sow iron*** or ***pig iron*** thus cast using the furnace, containing about 4-5% carbon with some silicon, was taken to a ***finery forge*** to be refined into ***bar iron***, which may be defined as commercially pure iron in the form of bars. In practice, bar iron always contains a small amount of slag as an impurity. Forges for refining iron in Great Britain were (strictly) ***Walloon forges. Osmond iron*** for wiredrawing was produced by a slightly different process, which is described in chapter 29. The alternative (common in Sweden) of a German forge, where a single hearth was used for the whole process, is not found in Britain. Nevertheless, it is possible that some of the smallest British forges (making 50 *tpa* or less) may have used a single hearth for the whole process.

Walloon finery forges contained two kinds of hearths, known as a ***finery*** and one ***chafery***, or often two or three fineries and one chafery, each with a waterwheel to drive the bellows that provided it with a blast, and one or two hammers lifted also by means of waterwheels. In the finery, pig iron was re-melted, the blast providing an oxidising environment to turn the carbon (and silicon) in the iron into oxides. This produced a mass of iron, called a 'loop' or 'loup', which was given a few strokes of the hammer to consolidate it (***shingling***). The ***finer*** then returned the ***bloom*** to the finery, to await the attentions of the ***hammerman***, who drew it out into a bar, the final product of the forge. He reheated it as necessary (often three times in all) in the chafery. Generally, this whole process took place in the same building, but occasional

[19] Trinder 2000, 33-4. The interpretation is mine.
[20] English Patents nos. 565 and 713; for this paragraph see also Tylecote 1992, 227-8.
[21] TNA, SP 36/45/2, f.117; C 66/3599/4. Richard Williams pointed this out to me.
[22] English Patent nos. 565; Cranstone 1991, 88. *ODNB*, 'Isaac Wilkinson', mentions him and his brother John having a mill for grinding smoothing irons. This was probably derived from Janet Butler's research (see Butler notes and thesis).
[23] McNeil 1989, 103; *Angerstein's Diary*, 260.
[24] English Patent no. 713.
[25] Ince 1989; Stewart 2017, 214-5.
[26] English Patent, no. 783; Ince 1991b, 25-6 (citing Herefs RO, T74/407, inventory and T. Daff, 'Introduction of cylinder blowing', *Steel Times* 201(5) (May 1973), 401).
[27] Dickinson & Jenkins 1927. 111-2 244-6; Arnott & Sayer 1978; Ince 1992.
[28] Tylecote 1991, 220-2; 1992, 97-9.
[29] CBD a/c.
[30] Dudley Archives, DE/4/3/8/74-78; *cf*. Guttery 1956, 32-43; King, thesis, 55-6.
[31] King 2005, 13-15; thesis, 201.
[32] Evans 1990a, nos 329 385.
[33] King thesis, 57.

references can be found to blooms being sold or carried from one forge to another.[34]

The ***hammer*** was, for most of the period considered, mounted on a wooden helve and lifted at its belly (between the head and the pivot); hence called a ***belly helve*** hammer. The hammer typically weighed 5 *cwt*. and had a cast iron ***anvil*** to match. The pivot consisted of a cast iron ***hurst***, through which the helve passed, sitting on ***boyts*** (gudgeons).[35] These various other cast iron components were collectively known as ***necessaries.*** However in the industrial revolution, heavier hammers with a cast iron helve were introduced, sometimes mounted as a ***nose helve***, where the lift was provided beyond the hammer head. In a third alternative set up, the ***tilt hammer*** (or ***tail helve***), the cams pushed down a helve, pivoted at its middle, at the opposite end to the hammer (its tail). This could produce a faster stroke rate with a lighter hammer. This tended to be used only in plating forges to work smaller pieces of iron, which would cool rapidly. Tilt hammers were not used in finery forges, perhaps because (with the lighter hammer) too much energy was absorbed in elastic deformation, before the desired plastic deformation began.[36] Throughout the fuel used was charcoal (often simply called 'coal'), but mineral coal (known as ***pitcoal***, also as ***seacoal***) could be used in the chafery. ***Braises***, that is charcoal dust, could be used in the chafery, and also for calcining ironstone, reserving larger charcoal for blast furnaces, which would be clogged up by dusty braises.

The resultant ***bar iron*** might be drawn into ***squares*** or ***flat*** iron bars. Flat iron might be ***narrow*** or ***broad***. Bar iron might be ***merchant bar*** (for sale to merchants) or ***mill bar*** for slitting, the latter 2½-3 inches wide and ½ inch thick in bars 13-14 foot long. ***Tyre iron*** or ***strake iron*** was similar, but slightly thicker and exactly 9 foot long (presumably reflecting a standard size for wheels).[37] ***Tin bar*** was also broad flat iron, but of a precise cross-section, as this became that of the resultant 'book' of plates. At one stage, it was 9 inches wide and ⅜ to ⅞ inches thick, usually 15-20 feet long,[38] but these dimensions imply heavier bars than were usually made in the 18th century. ***Short broads*** seem to have been 4-6 inches wide and an inch thick, these bars (for plating) sometimes being only 4 foot long.[39] The Navy Board ordered iron by size, squares ranging from ¾ to 2¼ inch and flat bars from 1¼ to 7 inches wide.[40] Much of this strictly refers to imported Swedish iron, but it probably also reflects English practice.

Bar iron was also classified according to its quality. It might be ***tough*** (also spelt tuf), coldshort, or redshort. Tough iron was suitable for tools, whereas ***coldshort*** iron is brittle when cold, but was apparently good enough for most nails, even preferred for them, because it was more ductile.[41] Being ductile also made it good for wire,[42] but not for horseshoe nails, which needed to be tough.[43] A phosphorus content (derived from the ore) made iron coldshort, though this was probably not known at the time. ***Redshort*** iron was brittle at red-heat, which made it difficult to forge, and thus commercially useless. This was caused by sulphur, normally derived from coal used as fuel. Several pioneering attempts to produce iron with pitcoal failed for this reason. This applied to Thomas Proctor at Shipley in the early 1590s; to William Wood and then his sons at Frizington in 1728-33;[44] and to the Coalbrookdale Company at their Middle Forge in the early 1720s.[45] Pig iron was classified as tough or coldshort according to the kind of bar iron that it would provide. ***Blend*** (or mixed) iron was also made from a combination of tough and coldshort, either by mixing ore, as Robert Morgan did at Carmarthen in 1761 or by using two kinds of pig iron together as in Cheshire in the 1700s.[46] The distinction was known by 1637, when the king erected an Office for Surveying and Marking Iron, according to whether it was tough, blend or coldshort, a project that was repealed in 1639, as ill-advised.[47]

This technology changed little during the period considered here, but from the middle of the 18th century new methods of production using coke began to be introduced. The ability to use mineral coal (or its derivative, coke) in blast furnaces was an ambition of ironmasters from the 1590s, but the continuous use of coke in blast furnaces only began after Abraham Darby arrived at Coalbrookdale in 1709. Nevertheless, Shadrach Fox, his 1690s predecessor at Coalbrookdale, smelted iron with coke as did Abraham's great-grand-uncle Dud Dudley (in the 1620s).[48] Darby's success was followed by others in subsequent decades, but their iron was almost exclusively used to make ***cast iron goods***, such as pots and kettles, either casting direct from the furnace or by re-melting pig iron in an ***air furnace*** in a separate ***foundry***, a variety of work that began to be established in towns from this period.[49] An air furnace is a variety of ***reverberatory furnace***, in which the fuel is kept separate from the charge. Such furnaces were developed in the 1680s for smelting lead and copper and then applied in the 1690s to re-melting pig iron. The lead and copper furnaces are called cupolas,[50] but the ***foundry cupola*** (as

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[34] Schubert 1957, 275-97; den Ouden 1981; 1982; Tylecote 1991, 233-4; 1992, 103-5

[35] Awty & Phillips 1980, 29-31 (discussing Cumbrian powered bloomeries).

[36] As note 34.

[37] Bodleian Library (Oxford), MS Eng. Hist, C.305; Kent 1973, 69; Prankard l/b, 24 Dec. 1729; Spencer l/b, 22 Nov. 1739.

[38] Jenkins 1995, 89.

[39] Prankard l/b, 4 Sep. 1731.

[40] *E.g.* NMM, POR/A/18, 19 Mar. 1756 (for contract of 3 Mar.).

[41] Britannicus 1752.

[42] Goodway 1987; Goodway & Fisher 1988.

[43] The Navy Board required clench nails to be of the best English rod iron called horse nail rod iron: NMM, POR/A/1, 22 Oct. 1696.

[44] Collinson 1996; King 2014b.

[45] King 2011, 145-50; explanation: Williams 2019a; 2019b.

[46] Morgan l/b, 2 Jul. 1761 to Mr Knight; Johnson 1954, 47.

[47] Larkin, *Proclamations*, no.243; *Cal SPD 1636-7*, 304; TNA, PC 2/50, 209.

[48] For details of this see Chapter 18.

[49] Williams (2019a) suggests that Darby operated his Coalbrookdale Furnace at a temperature too low to eliminate sulphur, which would explain why his pig iron (and Dud Dudley's) was not suitable to be forge feedstock.

[50] King 2002a.

used today) is a species of small blast furnace, introduced probably by John Wilkinson (or his brother William) in the 1790s, or possibly a little before.[51] Since air furnaces do not require artificial power, they strictly fall outside the scope of this book, but a selection of significant early foundries is included in the 'other ironworks' sections of some chapters.

In the mid-1750s, Abraham Darby II succeeded in having coke pig iron accepted as feedstock for finery forges, but their fuel continued to be charcoal. Cast iron existed in two forms, grey and white. Charcoal pig iron is generally white, whereas coke pig iron is generally grey. This is partly the result of the silicon content and partly of how fast the molten metal is cooled. Grey pig iron, with its higher silicon content, was (and is) particularly suitable for foundry work, the area in which Abraham Darby I achieved his success at Coalbrookdale a generation earlier. The precise nature of Abraham II's breakthrough remains not wholly clear, but it provided him and his partners at Horsehay and Ketley in Shropshire with a market for the (cheaper) coke pig iron among the (charcoal) finery forges of the area.[52] It may have consisted of running the furnaces with a greater blast, hence hotter, thus eliminating sulphur.[53]

The first effective process for making bar iron without any charcoal was developed by John and Charles Wood. They were building on the experience that they had gained in failed process of their father William Wood for smelting iron with pitcoal in the 1730s.[54] John Wood operated Wednesbury Field Forge recycling scrap iron from *c*.1740 and Charles had a finery forge at Low Mill near Egremont from 1749, where he also recycled scrap. In 1761 and 1763 they patented a process starting with pig iron. This process was improved by Wright & Jesson of West Bromwich in 1772, and this began to be widely used in the 1780s. The process is known to the historians of technology as '***potting and stamping***', but probably to contemporaries as ***stampering*** or making ***stamped iron***. The first stage involved desiliconising the pig iron to make ***finers' metal*** or ***refined iron***. Then the iron was heated in a clay pot or (from the 1780s) on a ceramic tile known as a pile. Contemporaries called part of the plant for this a ***melting finery***. This was a relatively short-lived process, which began to be replaced by puddling in the 1790s.

Puddling consisted of melting the charge in a variety of reverberatory furnace, known as a ***puddling furnace***, the molten iron being stirred. This process was devised by Henry Cort at Funtley Ironworks near Fareham, but only worked if the charge was white cast iron, rather than the grey cast iron that was the usual product of coke furnaces. This problem was solved by Samuel Homfray of Penydarren at Merthyr Tydfil, who found that ***finers' metal*** made in a ***refinery*** or ***running out hearth*** was a suitable charge for the puddling furnace. This may have been similar to a first stage in potting and stamping. Puddling was followed by shingling (as in the charcoal process, but the bars were usually drawn out using a rolling mill, another innovation of Henry Cort. These processes are also described in chapter 18.[55] This description is probably over-simplified. Fuller detail of this transition has very recently been elucidated by Young and Hart as part of their work on Cyfarthfa ironworks.[56] Joseph Firmstone, then a young man connected with John Guest of Dowlais, claimed that he had suggested the idea to Homfray.[57]

Subsequent processing

Bar iron was a saleable product, used as a raw material by cutlers, scythesmiths, blacksmiths and numerous other manufacturers, but for some purposes it was desirable to process it further. A ***plating forge*** might be employed to make a bar into a plate of iron, for example for the blade of a shovel. At Sheffield, some of these were called ***tilts***, because they had a ***tilt hammer*** (or ***tail lift hammer***).[58] ***Slitting mills*** were employed from 1590 to cut bar iron into rod iron of the dimensions suitable for making into nails: most of the iron firms in the north of England region had their own slitting mills, but in the Midlands many 'slit for hire', receiving a fee per ton slit. The process required the iron to be drawn as a flat bar. A piece was cut off this (with powered shears) and passed between flat rolls, making a thick plate. This plate was passed between rolls with interlocking grooves, which sheared it longitudinally into rod iron, of the right dimensions for nail making.[59] Alternatively, the rod could be passed again through flat rolls to produce a hoop (for a barrel).[60]

Tinmills (also called ***tinplate works***) first rolled bar iron into plates of iron, called ***blackplate***, which could then be rolled still thinner and coated with tin to produce ***tinplate***. The first stage (to produce blackplate) involved a series of cycles of rolling and folding to produce a book of plates. These were separated, annealed, and rolled, before pickling in acid and tinning. Because the cross-sections of the bar and of the 'book' of plates (made from it) were the same, the tolerance in the gauge for ***tin bar iron*** was limited.[61] ***Tinplate workers*** were manufacturing artisans who made finished goods out of tinplate, not the workmen in a tinmill.

Wiremills used osmond iron rather than the usual bar iron. The iron was drawn out into rods using a tilt hammer.

[51] King 2015a. These are referred to as 'blast furnaces' in certain 19th century newspaper advertisements for the sale of foundries.
[52] See also chapter 18, where an explanation is offered; and Williams 2015; 2019a; 2019b.
[53] Williams 2019a; 2019b.
[54] For William Wood see King 2014b.
[55] Morton & Mutton 1967; Mott 1977; 1983; Hayman 2004; Evans 2005; King 2012.
[56] Young & Hart 2018; 2019. I am grateful to Tim Young for sight of these in advance of their publication.
[57] *Staffordshire Advertiser*, 30 Jan. 1830, page 3 column 2 (obituary).
[58] There is no good general account of these, but see Schubert 1957, 301 (as osmond hammer) and 302-4 (as battery); Tylecote 1991, 246-7; 1992, 104.
[59] Schubert 1957, 304-12; Tylecote 1991, 248-52; 1992, 105; and see chapter 3.
[60] SML, Weale MSS, 371/4, 298.
[61] Minchinton 1957; Jenkins 1995; Tylecote 1991, 252-4.

They were drawn, using water power, through holes in drawplates that successively reduced its cross-section and increased its length. The workman used tongs attached to a crank turned by the waterwheel, grabbing the wire as the crank pulled the tongs away from the drawplate.[62] More details of this are given in chapter 29. ***Wireworkers*** were artisans who manufactured finished goods from wire, but wire was also the raw material for pins, needles, and wool cards. All these tertiary processes altered the shape of the iron, but not its chemical composition. The fuel employed for most of these processes was pitcoal.

Knives and edged tools were shaped by hand, and had a strip of steel welded along their cutting edges. However, this edge then had to be sharpened, which was done using a grindstone turned by water power, sometimes several in a row on a single axle. In the Midlands and at Newcastle-upon-Tyne these mills were called ***blade mills***, but around Sheffield ***cutlers' wheels, scythesmiths' wheels***, etc. according to user. The tilts and wheels of Sheffield have been the subject of a detailed survey,[63] and the wheels have therefore been excluded from the scope of this work, but tilts, as a variety of forge, are dealt with briefly in gazetteers. I have described the blade mills in the Stour catchment in an article.[64] The blade mills in the Tame catchment are described in somewhat older works, but they may not have adequately elucidated their use of by Birmingham swordmakers.[65] A smaller cluster near Mells in Somerset is included here, but is more fully ascribed a book on the Fussell family, who operated them.[66] These mills were used for processes that followed manufacture, rather than ones preceding it. They are almost ubiquitous in the manufacturing areas around Sheffield and the Black Country. Having been described elsewhere, they are generally not included in the gazetteers, but the few that operated beyond these clusters are noted. Again the coverage may not be comprehensive.

Similarly, ***needle mills***, which used water-power to scour needles in the course of their manufacture, have generally not been included in the gazetteers, and no full survey of them exists. The main cluster of these was around Redditch (Worcs.), but was somewhat more extensive than sometimes is suggested.[67] ***Boring mills***, related to the Birmingham gun trade, have been included in the gazetteer, because they were sometimes called forges: a plating forge was needed to make the skelps from which gun barrels were forged. The completed musket (or pistol) barrel then had to be bored and its exterior ground off. I needed to research these, in order to distinguish forges plating skelps for gunmaking from finery forges. Similarly, plating forges making spades and other edged tools, for example in Cumbria and at Stourbridge, (being forges) are included in the gazetteers.

Today it is convenient to refer to the 'iron and steel industry'; this omnibus description is really only an appropriate one from the introduction of the Bessemer and Open Hearth steelmaking processes after the mid-19th century, which enabled mild steel to be produced direct from pig iron. Before that ***steel*** production was a distinct activity. In the early 16th century (and before) it was no doubt made by a bloomery process, as at Hartfield, Sussex.[68] Sir Henry Sidney and others had a patent in 1565 allowing him to bring in strangers to make iron and steel and established steelworks, perhaps using a finery process (apparently without artificial power) at Robertsbridge and Boxhurst in Sussex.[69] This was probably the process later used by employees of the Earl of Shrewsbury at Linton (Herefs).[70] This process was superseded in the early 17th century by one where steel was produced from bar iron, generally from ***oregrounds iron*** made in the hinterland of the Swedish port of Örgrund.[71] This ultimately came from ore from the Dannemora mine there, though Örgrund was not in fact its port of export. Bars of iron were laid with charcoal dust in a sealed chest (known as a pot or coffin) and heated. This resulted in carbon diffusing into the iron to turn it into ***blister steel***. From the late 17th century, the bars were broken up and made up into ***faggots***, which were forged, often in tilts, and drawn out into thin strips, called ***gad steel***, but even this was not an entirely homogeneous product. In the mid-18th century Benjamin Huntsman succeeded in melting steel and producing small ingots or other castings of ***cast steel***,[72] a very high quality product, whose raw material was blister steel, particularly the ends of bars which had hitherto been good only for scrap. There were steel furnaces and forges near Newcastle and at Sheffield, and also in the Birmingham area, but very few outside these main iron manufacturing areas.[73]

Orthography

The orthography of names presents a challenge. In most cases I have used a modern spelling. Occasionally, I have preferred a contemporary one that occurs consistently in source material. Thus, Mearheath is preferred to Meir Heath, because the latter name is now used for a district straddling the boundary between one end of a former heath and a farm called Stallington, whereas the furnace was about a mile away at the other end of the heath, making the modern spelling misleading. Welsh names present a particular difficulty as anglicised spellings persisted

[62] Schubert 1957, 292-302; Paar & Tucker 1977; Tucker & Wakelin 1981.
[63] Ball *et al*. 2006.
[64] King 2007a.
[65] Dilworth 1976 and *VCH Warks* vii.
[66] Thornes 2010.
[67] Work on the distribution of these remains to be undertaken. Some appear in Booth 1978; Briggs 1981; and Tucker 1982; but I know of no survey of mills on the Bow Brook, southwest of Redditch.
[68] Cleere & Crossley 1995, 115.
[69] *Cal Patent Rolls* 1566-9, no. 1910; Jenkins 1922, 17-18; Schubert 1950b; Crossley 1975a, 33-4 205-31; Barraclough 1984(1), 28.
[70] Barraclough 1984(1), 28n.
[71] Barraclough 1984(1); 1990; King 2003a.
[72] Evans (2008) has questioned Huntsman's primacy on this, pointing to earlier evidence as to steel being melted in crucibles in London. Also Evans & Withey 2012.
[73] Barraclough 1976; 1984(1) and 1984(2); 1990b; 1991.

until about half a century ago, being replaced with an authentically Welsh spelling. I have sometimes preferred the very different spelling, found in contemporary documents. In particular, I have used Kidwelly (not Cydweli) and Dovey (not Dyfi). On the other hand, the town of Llanelli (Carms) is so spelt, in contrast with the village of Llanelly with its charcoal furnace in the Clydach Gorge, in the lordship of Crickhowell (*Welsh* Crûghoel), formerly in Breconshire and later in Gwent. Surnames have commonly (but not invariably) been reproduced as they appear in original documents, but have been placed in quotes where they appear to be an aberrant spelling.

Economics and trade

For much of the period covered, Britain was usually not self-sufficient in iron. Substantially all of Scotland's iron was imported until the industrial revolution. England (and Wales) imported significant amounts of iron from Spain before the Armada. English output seems to have reached a plateau in the 1610s or 1620s,[74] probably reflecting the maximum sustainable output of the country, or rather the rate of the growth of trees (for charcoal) from those woods that were economically available to the industry: wood growing beyond perhaps five miles from an ironworks was not available (or less available) to it, due to the transport costs involved.[75] This might be solved by building another ironworks (often a forge) in a rural area, where there was an unutilised wood resource. Many of the costs of production in wages and so on were fixed, the workers being paid so much per ton, at least in the forge. The main variables in the ironmaster's profit were thus the transport costs and the yield, that is, how much product was obtained from a given amount of raw material, which depended on the skill of the workmen. With iron selling for £14 to £17 per ton for most of the period and land transport costing perhaps 8*d* per ton per mile, transport costs were a key factor in determining the profitability of a given works. Furnaces generally stood close to mines, so that the mine (ore) did not have to be carried far. An ironmaster generally sought not to have to carry charcoal more than five miles, and reduced the price he was prepared to pay for wood according to its distance from his works, but there are of course many exceptions. Early forges were often sited quite close to furnaces. Later it was found advantageous to have them a few miles apart, so as to utilise charcoal from different districts. It was cheaper to take pig iron to the charcoal than *vice versa*. Ideally a forge would be located between its furnace and the eventual market for its products or the head of a navigable river, on which transport was far cheaper than by land, but that was not always feasible, due to the impossibility of moving fixed plant that was already in place.

When imports resumed in the 1620s (after Spanish imports had ceased after the Armada), their main source was Sweden. Initially, much of this arrived as re-exports from Danzig (perhaps also other northern European ports), but following the enactment of the Navigation Acts from 1651 and the series of Dutch Wars, the Dutch were excluded from the carrying trade to England, so that most imports came direct from Sweden. In the 1720s, Swedish iron was joined by Russian iron exported mainly from St Petersburg.[76] These lower-price producers drove the price down at times to a point where some British ironworks were only marginally profitable. The precise reasons for the decline of the Wealden iron industry are debateable, but it is clear that by the 1660s, its iron was unable to compete with imports in the London market.[77] Again in the 1730s and 1740s, Russian iron was being sold at Bristol at prices considerably below the normal price of English iron. This resulted in some forges closing and others only producing the modest amounts required by local blacksmiths in their area. Their production costs, together with the cost of getting their iron to market in a manufacturing area were not covered by the sale price achievable at its destination.[78]

A great deal of the price of a bar of iron was represented by the cost of the wood to make charcoal. As a result a large proportion of the price of iron flowed into the hands of the nobility and gentry, who owned the woods and also mining rights, leaving ironmasters to draw their profit from the added value of their output. The price of the wood thus tended to fluctuate with the price of iron, so that the risk did not fall entirely on ironmasters. Explicit cases of the charcoal price fluctuating with that of iron are rarely found,[79] but the trend can be seen in the west Midlands in the 18th century.[80] Being tied to a fixed price contract, when other cost factors had changed could be devastating. Zachary Downing complained in 1704 of a contract to sell pig iron at a fixed price, when the iron price (and with it that of charcoal) had risen in wartime.[81] Similarly John Churchill's 1768 bankruptcy was attributed by his son to high prices at which he had contracted to buy wood, which he could not use when Ordnance Board orders suddenly ceased at the end of the Seven Years' War.[82]

Charcoal was the least transportable of the commodities involved. This may to some extent be related to its friability. However, with several loads of charcoal (each weighing about a ton) being needed to make a ton of iron, it paid, not to carry charcoal more than a few miles and to bring the other materials to where the trees (from which charcoal came) were growing. Different strategies for controlling the charcoal price were adopted in different times and places. The industry in some areas was monopolised by a few firms, who were each effectively the only available buyer

[74] King 2005.
[75] *Cf.* Hammersley 1973.
[76] For overseas trade see King thesis, 213-48; summarised in King 2005, 16-20; also Evans & Rydén 2007 (which provides a snapshot, related to a short period); Evans *et al.* 2002 (on Bristol).
[77] Åström 1982; and see chapter 3.
[78] King 1996b, 30-3 44-5; and see comments on Mathrafal in chapter 15.
[79] The only explicit examples that I have found are Welsh Bicknor in 1615: TNA, C 115/D24, no. 2077; and Aberavan Forge in 1747: NLW, Penrice and Margam 5082.
[80] King thesis, 110.
[81] TNA, E 112/880/41.
[82] TNA, WO 47/81, 236.

for cordwood, for example in Staffordshire in the early and mid-17th century. Later, as the greatest of these businesses was broken up in the 1670s, adjoining businesses agreed boundaries within which they would respectively buy wood, but this system was inherently unstable, because the agreements were for fixed terms related to the terms of the ironmasters' leases and ultimately expired.[83] This was the context of Downing's complaint, just mentioned.

By the 1710s, a new system had arisen by which the ironmasters met and agreed the prices at which they would sell their iron. The price they could afford to pay for wood flowed from that. Such price-setting took place on the Ironmasters' Quarter Days at Stourbridge and on the eve of the two fairs at Bristol. Such price fixing mechanisms persisted at least until the late 19th century.[84] In southwest Yorkshire, the solution adopted in the early 18th century was for all the ironmasters to run the furnaces through a single super-partnership, dividing the production between them and in the process closing surplus furnace capacity.[85] In Furness, the two firms of ironmasters arranged in 1714 for their wood clerks to operate together buying wood together and selling it on to each firm with a fixed mark-up. The system used in Furness broke down periodically, sometimes due to a rival furnace being built, but the principle of dividing the charcoal equally was revived again. This lasted until 1820 when one of the two remaining firms bought the works of the other.[86]

Much of the period was one of stability. This applied not only to technology, but also to the identity of the ironworks and even in some cases the families of the ironmasters. This stability broke down in the late 18th century, with the introduction of new processes where production was not limited by the amount of cordwood that was economically available to ironmasters. This enabled a great growth in iron production to take place with considerable investment in new plant. The adoption of new technology, particularly in bar iron production, and the subsequent expansion in British iron production constitutes the industrial revolution for the iron industry. Some of this, late in the Napoleonic war, came too late to catch the wartime boom. The end of that war was followed by an economic slump that affected the iron industry to a considerable extent.[87] In some parts of the country this resulted in the closure of most of the ironworks continuing to use the old technology.[88] This therefore provides a convenient finishing point for this study, but the histories of works, particularly long-established ones are traced forward beyond 1815 to their closure. The coverage in this work of charcoal blast furnaces and finery forges is intended to be comprehensive. This also applies to coke blast furnaces, but it is not unlikely that there were more forges with puddling furnaces or using the stampering process than recorded here. Some aspects of the research have been carried forward to *c.*1830 (occasionally later), but ironworks built after 1815 have purposely been excluded from the gazetteers, so that they provide a very incomplete picture of the subsequent period. Information on blast furnaces is reasonably complete, as a result of Riden & Owen's compilation of statistics from contemporary lists.[89] Nevertheless, a great gap in our knowledge of the bar iron sector remains between 1815 and the beginning of the *Mineral Statistics* in 1860.[90]

Scope and organisation

The rest of this work is arranged in regional sections. Each of these sections consists of a number of chapters, often focused on an orefield, but sometimes on a less well characterised area between them. Some orefields were large enough to need further division by river catchments. In defining the boundaries between the areas covered in different chapters, the objective has been to define economic regions, sometimes related to long-term associations between ironworks. Political boundaries (even the Welsh and Scottish borders) have not been allowed a strong influence. This means that the vagaries of boundary alterations can be largely ignored. The South Staffordshire Iron District is split into the Stour and Tame catchments, with the smaller areas of the Penk valley and Cannock Chase. That Iron District (despite its name) includes parts of north Worcestershire and adjacent areas of Warwickshire, as well as Halesowen, then a detached area of Shropshire. This means it has not necessary to decide whether to place Hales Furnace (in Halesowen) in Shropshire – as it was until *c.*1840; Worcestershire – its county until 1974; or West Midlands. It appears in the Stour chapter, as does Kinver, which is still in Staffordshire, though its slitting mills were supplying ironmongers in Stourbridge (Worcs), who put out iron to nailers some of whom may have been in Kingswinford (Staffs), all these (except Kinver) now in Dudley Metropolitan Borough, West Midlands.

As blast furnaces were introduced to the Weald, it is appropriate to start there. This leads on to the iron processing mills of the Thames valley and the very modest iron production of Hampshire. The rest of the industry was northwest of the Jurassic ridge. The north of England, east of the Pennines forms the next major section, working from north to south, ending in the east Midlands. Next comes the northern Midlands, which here also includes Cheshire, southern Denbighshire (around Wrexham),

[83] King 2010a, 389-90; thesis, 105-9; and see chapters 23 and 24.
[84] King thesis, 111-5; Evans 1997, 126-31; Ashton 1924, 162-85; Birch 1967, 104-18; Smith 1978; *cf.* King 1996, 28-31. The system of Quarter Days for settling accounts (and taking orders) goes at least to the 1670s: Foley, E12/VI/KBf/62-71; also the use of Bristol Fairs for that: Foley, E12/VI/DAf/3-15.
[85] King 2011c, 27; and see chapter 8.
[86] See chapter 41; Fell 1908, 135-57.
[87] The boom and slump are not necessarily directly related to war and peace in Europe: the American War of 1812 and the embargo that preceded it may also be significant: King thesis, 281-2. The famine in 1816, the 'year without summer' cannot have helped: Wikipedia, 'Year without a summer' (accessed 27 Feb. 2019).
[88] For output see: King 2005, 6-8: note that figures for charcoal pig iron from 1790 had to be corrected in errata in 2006; Riden 1977, 452-6; King thesis, 192: note the dip in the graph in the late 1810s.
[89] Riden & Owen 1995.
[90] For the period from 1860, see King 2018b.

and east Montgomeryshire, because the industry in those Welsh counties was closely related to that in Shropshire. The need to divide this work into two volumes together with the sheer amount to be written about the West Midlands region has led me to divide it into northern and southern Midlands, with the latter focused on the South Staffordshire Iron District. This includes Birmingham and the Black Country as the most important manufacturing iron area in Britain. The next region had its commercial focus at Bristol, the second most important port in early modern England (after London). This had ironworks on both sides of the Severn estuary, though mostly north of it and the Bristol Channel, including south Wales. Since water transport was so much cheaper than road transport, the Severn estuary (and the river as a whole) served to unite the area, rather than being a barrier to movement, as it is today with our focus on road transport. The next region consists of west and north Wales and the Northwest, where the redmine of Furness and west Cumberland was the major ore source. These were united by the availability of coastal shipping. Except in Furness, most successful ironworks were located close to water navigable by coasters, which brought more and carried away pig iron.

Each part starts with a key map, but this breaks down for the final parts, which cover such a large area that several key maps are needed. West Wales falls into the redmine zone (part VI), but is shown on key map V, as do the Scottish Highlands, shown on key map VII.

Each subsequent chapter consists of an introduction, followed by a gazetteer. The main part of the gazetteer deals with charcoal ironworks: blast furnaces, finery forges, and certain other ironworks (including the earliest coke furnaces), slitting mills, tinplate works and wire mills. This is then followed by gazetteer sections for ‘other ironworks’ and later coke furnaces; in some cases, powered bloomeries, steel furnaces, or other works have been collected into their own sections. The purpose of the introduction is paint a general picture of the industry in the area, providing a picture of that area as a whole, without saying everything that could be said. The main gazetteers aim to provide a full history of each individual ironworks. For those poorly documented, this may be everything that is known, but for well-documented ones, the account is shorter than it could have been. This is in the hope of reflecting their relative contemporary importance, rather than the extent of the surviving archives. In constructing these histories, inferences have drawn from surrounding circumstances. Thus, if a works closed at about a certain date and a lease expired about then, the expiry date is likely to be the closure date.

The gazetteer sections entitled, ‘other ironworks’, are a miscellany of such, including ironworks that have appeared in the published literature but are spurious; works that were proposed but probably never built; plating forges whose popular nomenclature (as ‘forges’) does not distinguish them from finery forges; and forges built after *c.*1794 probably using Cort’s puddling process; as well as bloomeries, steel furnaces, and such like. In the Sheffield area steel furnaces and tilts (a variety of plating forge) have separate gazetteer sections, because they were so numerous there. Near Birmingham, forges making gun barrel skelps and boring and grinding off barrels have been picked out from other plating forges, distinguishing them from those making frying pans, spades, and other things, though the boundary was not a sharp one. On the other hand, the main clusters of blade mills (in the South Staffordshire Iron District) and cutlers’ and scythesmiths’ wheels (near Sheffield) have been excluded,[91] as have needle mills in the Redditch area (from another finishing process).[92] Nevertheless, edged tool works and needle mills distant from these main clusters are included. This section includes all works of these kinds discovered in the course of research, but with no comprehensive statistical lists for them, the completeness cannot be guaranteed. The final gazetteer section concerns coke blast furnaces: this should be comprehensive on account of the numerous statistical lists of them that exist, starting in 1788 and conveniently summarised in Riden & Owen’s *British Blast Furnace Statistics*, a book which is sometimes my sole source for their later history.

Structure of gazetteer entries

Each gazetteer entry consists of a narrative of its history. They give the location of each ironworks. Extensive reliance has been placed on tithe maps, estate maps, and early Ordnance Survey maps, but these are normally only cited if they provide detail on the occupancy of the ironworks in question, not known from other sources. Similarly previous gazetteers of furnaces are not habitually cited: otherwise, citations of Schubert 1957 and Riden 1993 would have appeared on almost every page. I have similarly limited citations of some of my own publications, where their immediate source is actually drafts of the gazetteers in this work.[93] Considerable use has been made of directories where they exist, but they have not generally listed them as sources. The gazetteers do not have an apparatus of footnotes, only a bibliography of sources, but relay also on the material appearing under *size*, *trading*, and *accounts*, as well as *sources*. In the chapter introductions, a limit has had to be placed on the number of footnoted sources for the chapter introductions: ‘*q.v.*’ is intended to refer the reader to the gazetteer entry for the works mentioned.

The ***size*** sections of gazetteers provide whatever information is available as to the scale of production of the ironworks and the plant there. Statistical lists have been

91 Those in the Stour catchment are described in King 2007a; those in the Don catchment in Sheffield are described in Ball *et al.* 2006; those the Tame catchment are included in Dilworth 1976; King 2006; and *VCH Warks* vii.

92 There is no satisfactory general survey of these. The main cluster was centred on Redditch, but with mills scattered in an area around with a radius of some miles, rather greater than sometimes supposed. There is no comprehensive account of these. Warwickshire ones will be included in Booth 1978.

93 As to this, see also the final paragraph of this chapter.

greatly used, but are not normally cited explicitly. The use of the date (without a reference) implies that the source is a list: see under sources and methodology (above) and 'lists' in the bibliography. Dates in quotation marks come from a list, but I consider that the data refers to a slightly different date.

The ***trading*** section concerns the commercial relations of the works with other ironworks; either summarised from their own internal records (accounts or letterbooks) or derived from references in those of other ones, particularly of the sale or purchase of pig iron. These have been a particularly fruitful source of information. Where only the vendor or buyer is named (but not his works), the transaction has then been attributed to one or other of his works, usually with a cross-reference under the other. Similar information has been derived from records of the Navy Board (mainly cast iron ballast), Ordnance Board (cannon, shot, and small arms), and the Victualling Board (iron hoops for barrels). This matter is discussed further under sources, above. Accounts etc. are usually cited using an abbreviated title, details of which will be found in the bibliography. The accounts of the East India and Royal Africa Companies (for bar iron) have been less helpful, as the bar iron recorded was generally a re-export of Swedish or other imported iron. Such issues of overseas trade generally fall beyond the scope of this book. To keep the index within bounds, mentions of such suppliers and customers and their works in the trading section have not been included in it.

The ***accounts*** entry lists any internal records relating to the ironworks, including letterbooks, inventories, and so on.

The list of ***sources*** in gazetteers is usually intended to be comprehensive, but the resources referred to in the three preceding paragraphs also form part of the source material. The only exception to this concerns a few works and persons, who appear in so many publications that listing them all is not useful. This omission concerns only books and articles which appear to be wholly derived from other published works that are cited here and to add nothing significant to them. Thus, the citation of tertiary (or more derivative) works alluding to Abraham Darby, to Coalbrookdale, or to John Wilkinson has purposely been limited.

Historiographic issues

The core of this book inevitably relies heavily on the work of previous scholars, but wherever possible I have been back to the original sources, mostly the title deeds, leases and rentals of landed estates, together with such ironworks accounts as survive. Occasionally I have found previous writers to have misinterpreted their sources: where what I have said in describing a particularly ironworks specifically contradicts what one or more of the published sources listed at the foot of the description of that works, it is normally because I have found reliable primary sources supporting my view. In such cases, the work disagreed with is cited, but usually with a comment as to why it is wrong. More often the consultation of primary sources has revealed details that did not interest earlier researchers, or whose significance they did not appreciate, or which they simply missed: it takes experience to know how to find one's way around in a deed and to know what is significant and what is mere common form, an area where my legal training has been an advantage.

A common error of biographers is to ascribe the erection of a works to their subject, when in fact he began by buying (or leasing) an existing one, which then became the source of his success. On the other hand, historians (usually amateurs) have a tendency to use minor pieces of irrelevant information to suggest that the particular works, which they are describing, was very much older than it actually was or occasionally that it was in use longer. Another occasion where I have differed from an earlier author is where a history is provided, but is attributed to the wrong ironworks. Examples of this are works near Weybridge in Surrey; and Pool Quay and Mathrafal Forges in Montgomeryshire. In the latter case, Davies placed the Duvall family at Pool Quay at a time when it only had a lead smelting works, whereas Powis Estate rentals clearly locate them at Mathrafal and at slightly different dates, as do their probate inventories. Such issues of historiography are noted briefly, often at the end of the sources, to indicate that I know that I am contradicting a previous incorrect view. I hope that this will enable future authors to take a definite position, rather than 'sitting on the fence'.

This study grew from a study of local history in the parishes of Kinver and Wolverley in the west Midlands. I extended my research to cover forges in those parishes and nearby and realised that I was finding details of the history of ironworks not (or not then) published. From this small beginning a very large research project developed. This has constituted a main occupation in the 1990s, and provided the raw data used in my 2003 thesis. After a period when I concentrated on other historical issues, I returned to detailed work on the historical topography of the iron industry in autumn 2015, to investigate newspapers and other material, available on or through on-line resources, with a view to writing up this gazetteer. This process lasted until Spring 2019.

The study has had the fascination of a jigsaw puzzle in that the story has frequently had to be built up from small pieces of information from many sources. The basic techniques for the research of an ironworks (or any other mill) are very similar to those for researching the history of a house, but statistical sources and accounts, for example those of other ironworks, often provide further detail of a kind not available to the historian of a house. Since the rivers and brooks on which ironworks stood were often boundaries, it has often been useful to consider evidence deriving from land both sides of it. Information on small payments relating to the right to fix a dam to land on the other side of a river contributes to the history of a works.

I, of course, remain responsible for errors in this work. In a work of this size, I expect that I have contradicted myself in places, having used new information (from research) in one place and failed to in another. If so, I hope the user of this book will be able to follow up my sources to determine which is right. If a gazetteer entry contradicts a chapter introduction the gazetteer is likely to be better. It has been necessary to draw this research to a close somewhere. In a few cases, I have had to rely on an on-line catalogue entry for a document, rather than my own study of it. In certain cases, the existence of documents that may throw further light on an ironworks is indicated by 'note also' at the end of a list of sources.

Principal Sources for the iron industry and its technology generally: Schubert 1957; Birch 1967; Gale 1966; 1967; 1969; (and *cf*. 1971); Hyde 1977; Harris 1988; Tylecote 1991; Day & Tylecote 1992; Hayman 2005; Evans 2005; King 2012.

Ubiquitous sources rarely cited: I could have cited certain works on almost every page, particularly Schubert 1957 and Riden 1993 (also his preceding 1987 edition). Instead, these are only cited sparingly, usually where they have information that I have not found elsewhere. This also applies to Riden & Owen 1985 as a source for the history of 19th-century coke furnaces. The gazetteer in Cleere & Crossley 1995 (and their 1984 edition) is also rarely cited (except in the chapter introduction), because the gazetteer for the Weald in this work is ultimately a revised edition of theirs, as explained at the start of the next chapter. Their book in its turn depends significantly on Straker 1931a, which is thus also rarely cited.

I have also been relatively sparing in my citations of some of my own works. Sometimes this is because they are derived from the drafts of work published here, rather than *vice versa*. I have however cited my own work, where it contains fuller detail than can be given in this work. Awty 2019 appeared as I was completing this book. I decided that it was too late to alter the chapter on the Weald, where I have only edited an existing text, ultimately derived from Cleere and Crossley 1984 and 1995. Elsewhere, I have incorporated a limited number of references to it, where I considered that it had new information that I had missed. Sometimes this was only additional dates, but it enabled me to add a few more sites. On the other hand, I may sometimes have passed silently over a few cases, where he has made more of the evidence than I consider it will bear. Generally Brian Awty's book is an excellent work that tends to complement this one.