Dud Dudley's contribution to metallurgy

P W King

ABSTRACT: Dud Dudley was the illegitimate son of Lord Dudley and managed certain of his ironworks in the early 1620s. He attempted to smelt iron with mineral coal, but this proved to be a failure, commercially at least. After a series of such failures, his father expelled him from his furnace and coalworks in winter 1630-1. Twenty years later while a fugitive, he attempted to smelt lead (not iron) in a 'belhouse' near Bristol, and advised others who were attempting to smelt iron with mineral coal. In 1665, he published an account of his efforts entitled Metallum Martis. *This was followed by his erection of a horsemill-powered blast furnace at Dudley, using a mixture of charcoal and coke. This furnace subsequently passed through several hands and probably closed by 1681. In the intervening years, it was associated with several forges in the nearby Stour valley and an experiment in making tinplate. Sir Clement Clerke, one of the partners in these enterprises, and later a significant metallurgical innovator, may have been trained by Dud Dudley. If so, Dud Dudley was the progenitor of later coal-based metallurgy, not merely its forerunner.*

Introduction

Dud Dudley has, for many years, interested industrial historians, as he has been seen as a forerunner of the later coke-based iron industry. He is mainly remembered because he wrote a book, *Metallum Martis or iron made with pitcoale seacoale etc*,[1] in which he set out his claim to have made iron, but without specifying precisely how he had done so. His claims have been widely discussed over the past century and more, and the views expressed have ranged from those who believed every word he wrote to the highly sceptical.[2] Evidence has recently been discovered in the Public Record Office that Dud Dudley was concerned in a blast furnace built at Dudley sometime after the Restoration. This became part of a significant (but ultimately unsuccessful) enterprise, certain aspects of which have been described by R G Schafer,[3] but the newly discovered evidence indicates that the business was more complicated than he indicated. Furthermore the partners in this furnace included 'that excellent mineralist' Sir Clement Clerke, who subsequently devised several coke-based metallurgical processes that were successfully introduced in the 1680s and 1690s.[4] Sir Clement may thus be regarded as a parent of coke-based metallurgy. In that case Dud Dudley was its grandparent, and not a mere forerunner of it.

Dud Dudley's forebears

Dud Dudley was the natural son of Edward Lord Dudley, who owned an extensive estate in the Black Country, including the manors of Dudley, Rowley Regis, Kingswinford, Sedgley, and Himley. When he inherited it in 1586 the estate included 'ironworks', apparently 'smithies' (*ie* bloomery forges).[5] These made iron by the direct process, by reducing the ore in the solid state using charcoal. This process produced a 'bloom', a spongy mass of iron, which then had to be consolidated and drawn out into a bar of iron using a hammer. Waterpower had been applied during the medieval period both to powering the bellows and the hammer.[6] It is not known how many smithies Lord Dudley inherited from his father, but in 1585 they included Funsloe or Fundley Smithy in Baggeridge Wood (in Sedgley), the New Smythies in Himley and New Park Smithies (in Dudley New Park). There may also have been one at Cradley, where there was later a Smithy Croft near the forge.[7]

The Dudley estates largely lay on the coal measures, which contain bands of argillaceous ironstone. They included extensive woods, including Pensnett Chase in Kingswinford and Dudley, Ashwood and Chasepool Hays (in Kingswinford and Wombourne), Himley Park and the adjacent Baggeridge and Gornal Woods, Coneygree Park (immediately to the east of Dudley Castle Hill), and Dudley Old, Dudley New, Sedgley, and Ettingshall Parks (all in Sedgley or partly so).[8] Such medieval deer parks consisted of woodland and pasture,[9] and as such would have been important as sources of charcoal for fuel for ironmaking.

The new indirect method of iron making, using the blast furnace and finery forge, had been introduced to the Weald from the continent at the end of the 15th century and had spread to the Midlands in the mid-16th century. The blast furnace was charged from the top with ore and charcoal, and molten iron was tapped at its base. This pig iron contained 4-5% carbon and could not be wrought. The pig iron was therefore fined in a forge, where the iron was remelted in an oxidizing atmosphere in a finery hearth to remove the carbon. The resultant bloom was then forged into a bar using a water-powered hammer, being reheated periodically in a chafery. Forges typically contained two fineries, a chafery and a hammer; each required a waterwheel. Forges therefore required considerable amounts of waterpower. Furnaces needed less water, since only one waterwheel was required (for the bellows), often a large-diameter overshot wheel.[10]

Edward, Lord Dudley, built at least five blast furnaces (see Fig 1) on his estate, at Cradley, Conigree Park, Himley, Gornal Wood, and probably Ettingshall, but there were few powerful rivers on these lands, so the forges were mostly outside his estate. Cradley Forge (actually in Rowley Regis) was on the boundary, but Greens Forge (in Swindon) and Bromford Forge were on other men's land. He probably operated these ironworks in partnership with his brother John Dudley, in whose name Greens Forge (previously a corn mill) was leased in 1600. Their interest in Bromford Forge is known only from a deed by which John Dudley was secured against liability for the works, after he ended his partnership with his brother there in 1601.[11]

Perhaps also associated with this enterprise was Compton Furnace in Kinver, which was built adjoining a park by Thomas Greene and Geoffrey Mason of Wombourne. Greens Forge probably took its name from a substantial adjacent property called Greens Lodge (now Chasepool Lodge Farm and then recently part of

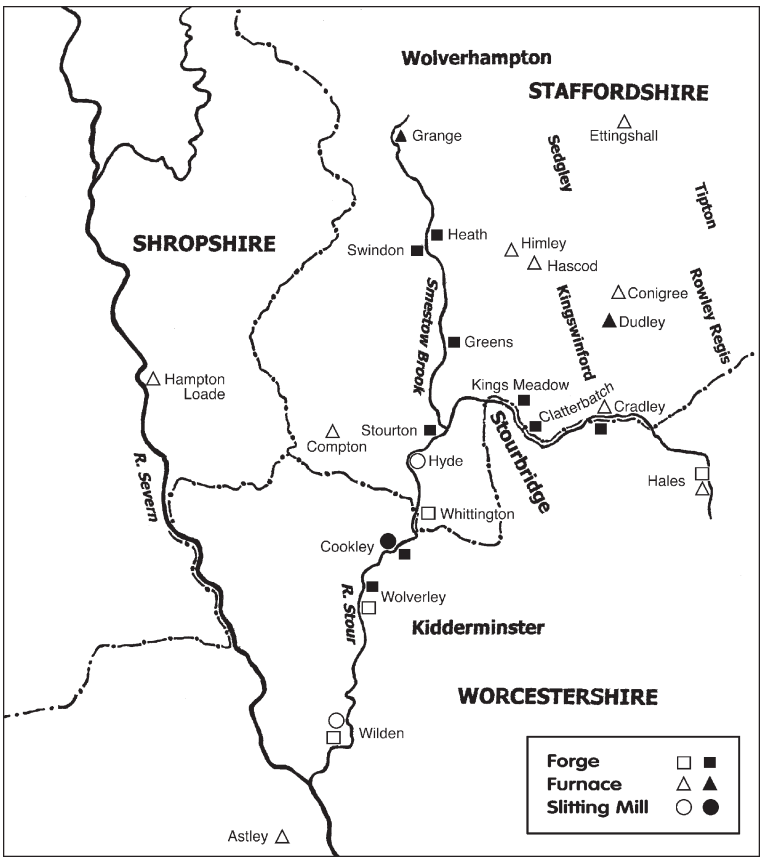

Figure 1: Seventeenth-century ironworks mentioned in the text. The works belonging to Clerke and Forth in the 1670s have a solid symbol.

Chasepool Hay), which was probably in turn named after one of his family, perhaps his father.[12]

Dud Dudley's early life

Dud Dudley's mother was Lord Dudley's long-term mistress, Elizabeth Tomlinson. Lord Dudley treated his illegitimate family well, providing for each of them as if they were legitimate younger children of a peer. For example, he gave a substantial freehold farm at Netherton in Dudley to the eldest of them, Robert Dudley alias Tomlinson. He also gave Elizabeth a lease for life of Greens Lodge, which she subsequently gave to Dud Dudley.[13] Dud Dudley was sent to Balliol College Oxford, but was probably home in the Midlands each summer when the annual blast at his father's furnaces was coming to an end.

He seems to have suggested substituting mineral coal (then known as pitcoal or seacoal) for charcoal. He later referred to this being done because of 'wood and charcole growing then scant and pit-coles ... abounding'. Older authors, such as David Mushet, interpreted this phrase as referring to a general dearth of charcoal, leading some older writers to believe that iron production declined in the latter part of the charcoal era.[14] However this is to misunderstand the nature of charcoal, which is a renewable resource. It was obtained from coppices cropped on a cycle of (usually) 14 to 18 years, so that a short period of heavy exploitation did no damage. The woods would recover, provided that they were allowed to regrow.[15]

This was by no means the first attempt to smelt iron with pitcoal, for which John Robinson held a patent at the time. Lord Dudley first obtained a licence from Robinson in 1619, and then renewed the patent for 21 years in his own name in 1622, a patent whose validity was specifically preserved by a proviso to the Statute of Monopolies 1623.[16]

At this point Dud Dudley was brought back from university to manage his father's ironworks at Cradley, but his management did not prove an unqualified success. Firstly the works were destroyed by flood on May Day 1623, quite probably as a result of a dam bursting. After they were rebuilt and despite a favourable trial of his iron at the Tower of London, he 'was outed of his works and inventions ... by the charcoal ironmasters and others, overlong to relate'. Smiles suggested this was due to resistance from charcoal ironmasters and to lawsuits,[17] but there is no direct evidence. As has been shown elsewhere, the charcoal iron industry in the area had already been consolidated into a very small number of large businesses, and it is far more likely that the Cradley Works were let to one of them, most probably Richard Foley, who certainly had Cradley by 1636.[18] Indeed Richard Foley was so dominant locally that he (and perhaps a partner Thomas Nye) may well have been the sole persons meant by the vague description, 'the charcoal ironmasters'. However in 1665 Dudley was perhaps not willing to criticize explicitly a member of such a prominent (and probably respected) family.

Next Dud moved to Himley Furnace, but, lacking a forge, had no outlet for his pig iron, as the unnamed 'charcoal ironmasters ... did him much prejudice, not onley in detaining his stock but also disparaging the iron'. Presumably they said his pig iron was bad iron and they would not pay for it. The result was that Himley Furnace was 'rented out to the charcoal ironmasters'. In this case what happened is clear, as the lease survives. It is dated 30 June 1625 and was from Lord Dudley (not Dud Dudley) to Richard Foley.[19]

Dud Dudley then erected a new larger furnace at Hasco Bridge (now Askew Bridge, Gornal), perhaps on the site of his father's Gornal Wood Furnace.[20] This time he was 'by force thrown out of' the mines that supplied the furnace and its 'bellows [were] by riotous persons cut in pieces'. Horsecroft or Hascod Furnace had in January 1626 been leased to John Smallman of Swinford (ie Kingswinford), presumably Dud's financier.[21] In November 1627 Dud had let it to Roger Hill, who assigned it to Richard Foley. Foley used it for nine months, but then heard that Lord Dudley was claiming the furnace and 'durst not bring any stock of coals or ironstone to the furnace [which] stood still unwrought'. Nevertheless, Foley still paid the rent until February 1630/1, when Lord Dudley 'entered' (thus forfeiting the lease). Dud and Foley also had an oral agreement for Foley to get 1000 'blooms' of ironstone from Dud's mines. However Lord Dudley 'discharged the workmen and caused the horses that carried it to be stopped' until Foley paid Lord Dudley for it, so that Foley had to pay twice. Dud and Foley also agreed a partnership in mining coal and some £40 was spent making a sough (for draining the mine), but about 4 December 1630 Lord Dudley claimed the coalworks.[22]

Samuel Smiles claimed the riot at Hascod was instigated by the charcoal ironmasters, but the account of Foley (the main charcoal ironmaster locally) makes it clear that the instigator was Dud's own father. He was not encouraging a riot, but exercising his legal rights as the

landowner.[23] Lord Dudley's assertion was that Dud had never had any title to the furnace except in trust for Lord Dudley, though in view of Smallman's lease, this is questionable. However the issue had become mixed up with a larger one.

Lord Dudley was severely in debt throughout the 1620s and several parts of his estates were in the hands of creditors. In October 1622, in order to keep the manor of Himley from his creditors, Lord Dudley had enfeoffed that manor to Thomas Dudley and William Cox, who then (by direction of Lord Dudley) enfeoffed Dud of it that December. Subsequently relations between Dud and his father evidently deteriorated. No doubt Dud's deprivation first of the Cradley Works and then of Himley Furnace was not unconnected with this, but Lord Dudley had also begun to take an interest in his one legitimate grandchild, Frances. He married her to William Ward, the son of Humble Ward, a London goldsmith, and William Ward paid off Lord Dudley's debts. At this point Dud chose to set up a claim to the manor of Himley on the basis that the 1622 feoffment had been a genuine gift. However Lord Dudley's continued receipt of the rents implies that it was not. Nevertheless in doing this, Dud was asserting a title that was inconsistent with his claim to the Hascod Furnace. However any title he could set up (whether under the 1622 feoffment or the Smallman lease) was later than a mortgage of about 1620, which had been bought in by Ward and hence that title was not binding on Ward. As a result, Dud lost the claim to the manor, which he brought against Ward in 1635, leading ultimately to Dud being imprisoned for contempt of court. Finally a settlement was reached by which Dud was confirmed in those properties (such as Greens Lodge) to which he had a genuine title, and disclaimed everything else, including the manor of Himley and the furnace.[24]

While Dud Dudley's use of pitcoal was innovative and forward looking, other aspects of the business were not. Iron production by furnace and forge had been established in the Midlands mainly by aristocrats, such as the Earls of Shrewsbury and Leicester and Lords Paget and Dudley. Lord Dudley was the last of the aristocrats to withdraw from producing iron by means of employed managers, rather than letting their ironworks to professional ironmasters. Dud Dudley was his father's last ironworks manager.[25]

For the next half-century the iron industry in and around the Black Country was dominated by the Foley family, first Richard Foley, who was certainly one of the charcoal ironmasters whom Dud Dudley blamed for his troubles, then his son Thomas, who began taking over ironworks from his father when he came of age in 1637, and finally Thomas' younger son Philip, who bought his father's Midland ironworks business in 1668 and 1669 for £60,000. Thomas expanded his activities in the 1650s and 1660s by taking over ironworks in the Forest of Dean and most of these were passed to his second son Paul.[26]

The Civil War and beyond

There is no reason to suppose that Dud Dudley was involved in the iron industry in any way in the period after he lost Hasco Furnace. With various others he did obtain a new patent in 1638 for smelting metals with pitcoal, but there is no sign that anything was done at that stage to exploit it.

Dud Dudley served in the Bishops War against the Scots and then in the Royalist army throughout the Civil War, rising to the rank of colonel. In 1648 he and others were captured by Andrew Yarranton, then a Parliamentary Captain, after a skirmish in Boscobel woods, where they had gathered with the aim of seizing Dawley Castle in Shropshire. As a result of this, Dud Dudley was sentenced to death for treason. However he escaped from the Gatehouse (at Westminster) during 'sermon time', shortly before he was due to be executed.[27]

He then made his way to Bristol, where he masqueraded as a medical doctor, Dr Hunt. In 1651 he joined with the husband and a kinsman of one of his medical patients, Walter Stephens and John Stone, in seeking to exploit the 1638 patent. This venture has generally been assumed also to have been concerned with iron, but Chancery Proceedings he instituted against Bridget Stephens make it clear that the target was lead. Bridget stated that they used 'an old belhouse for the bloomery', presumably a bell foundry. The business evidently did not prosper, as Bridget Stephens was sued on a bond her late husband had guaranteed for Dudley, and she naturally sued him on his bond of indemnity, leading to the Chancery proceedings mentioned.

This business, which I have discussed elsewhere, represents the first known occasion when a cupiloe or reverberatory furnace was used for smelting lead with pitcoal. Such furnaces were designed so that only the flames (rather than the fuel itself) came into contact with the ore, thus preventing sulphur in the fuel from contaminating the metal.[28] This was followed by a similar enterprise in the names of John and Arthur Scratchfield at Stockleigh Slade (now Nightingale

valley) on the opposite side of the river Avon. That was in turn the location of a lead-smelting cupola, which was built in 1678 by Sir Clement Clerke of Launde Abbey in Leicestershire and was operated successfully by his son Talbot in the 1680s.[29]

In the ensuing years, a group led by Captain Buck tried to make iron with pitcoal in wind-furnaces (*ie* reverbatory 'air' furnaces) and also using glass house clay (*ie* fireclay) pots in the Forest of Dean. Dud Dudley was asked to assist, but became convinced that this was hopeless and they gave up in 1655. The following year Captain John Copley tried something similar at coalworks near Kingswood (outside Bristol), using bellows operated by 'engines' that failed to work. Dudley got the bellows to blow 'without those engines', but told Copley that he 'feared [Copley] could not make iron with pit-cole or seacole'.[30] These were evidently novel kinds of furnace (at least for iron), whereas Dudley's furnaces were essentially ordinary blast furnaces, though used with a different fuel. This is apparent both from the previous and subsequent use of Cradley and Himley Furnaces with charcoal and also from the way Dudley described furnaces in *Metallum Martis*.[31] His failure to get Buck's and Copley's furnaces to work is thus hardly surprising.

Dud Dudley had suffered sequestration of his estates as a result of his loyalty to the king. He failed to compound for his delinquency, with the result that the estates were sold.[32] This failure, together with the purchasers' failure to persuade him to confirm their title, meant that the estates reverted to Dudley at the Restoration. This was because the purchasers traced their title solely through a Parliamentary Ordinance, declared void in 1660 by the Act for Confirming Judicial Proceedings.[33] Dud was among the many people who petitioned for some recompense for their sufferings in the Royalist cause, in his case unsuccessfully seeking a place at court as sergeant-at-arms. He and one William Chamberlaine did however obtain a patent for their invention of 'plating steel and tinning plates' (the latter presumably meaning making tinplate). Nevertheless there is little reason to believe that they exploited it. Indeed according to Andrew Yarranton they did not know how to.[34] It is nevertheless conceivable that William Chamberlaine was connected with John Chamberlaine, who operated the Earl of Southampton's ironworks at Titchfield (Hants.) and elsewhere in the 1630s. The Earl's works in the 1620s included a tinplate mill at Wickham, which operated as a 'plate mill' until at least 1720, though possibly only making blackplate (that is untinned plate).[35]

Dudley and the partners in Dudley Furnace

A horse-mill-powered blast furnace

It was against this background that Dud Dudley, by then an old man, wrote his book *Metallum Martis or iron made with pitcoale seacoale etc* (1665), setting out that he had made iron with pitcoal, and its advantages. It is the existence of this book that has caused Dudley to be remembered. The book should however not merely be seen as an autobiography, but more in the nature of an advertisement or prospectus, and it seems to have been successful as such, for according to Sir Clement Clerke in 1675:[36]

> 'Dud Dudley did heretofore build a furnace for making iron or melting ironstone with charcoal made of wood and pitcoal together to be blown or set on work by the strength of men and horses without the help of water.'

Later Sir Clement also claimed that he himself was:[37]

> 'experienced in melting down ironstone into sow mettle with charcole and pitcole by the strength of men and horses without water ...'

This furnace was at Dudley, probably near Queens Cross, where the existence of a furnace is recalled by the street name, Furnace Road (see Fig 2). This adjoins land formerly belonging to Tandy's Charity known as Furnace Piece.[38] This places the furnace on high ground just to the south of Dudley town centre, in a place where there cannot have been any water-supply sufficient to power the bellows of a blast furnace blown in the usual way using a waterwheel. This horse-mill-powered furnace is thus most unusual, and indeed probably unique. John Tandy, the charity's founder, died in 1709 and was the son of another John Tandy (died 1704), who lived at Dudley Castle as a servant of Lord Dudley and Ward. Despite the description of 'servant' he was actually mining coal in the estates of Lord Dudley and Ward at Dudley New Park, Conigree Park, Gornal Wood, and elsewhere, often in partnership with Lord Dudley and Ward or others. The Tandys also had other mines including at Brettell in Kingswinford and in Greystone Field, Dudley.[39] Unfortunately it is not clear which (if any) of the surviving deeds relate to Furnace Piece, nor is any further light thrown on the subject by the deeds of the adjoining property, formerly the Queens Cross Ironworks, or by any other source.[40]

Dud Dudley's failure to mention this furnace in *Metallum Martis* suggests that it was built after the book was published in 1665. However he had apparently

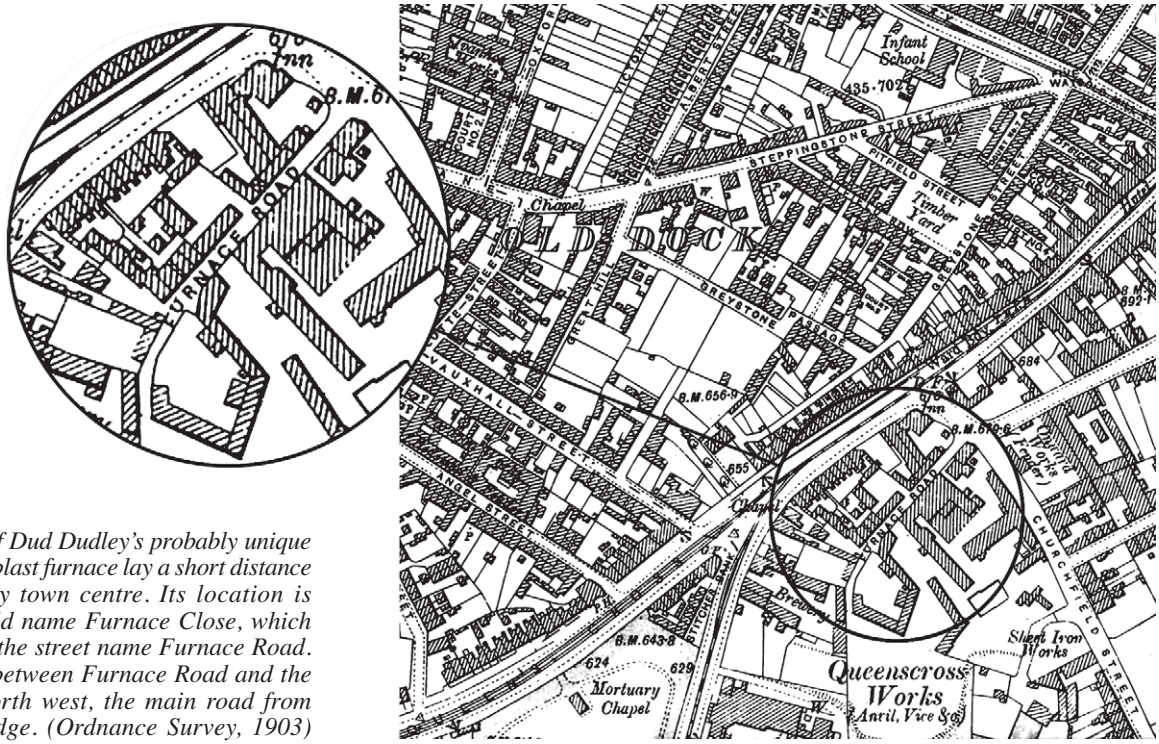

Figure 2: The site of Dud Dudley's probably unique horse-mill-powered blast furnace lay a short distance southwest of Dudley town centre. Its location is indicated by the field name Furnace Close, which in turn gave rise to the street name Furnace Road. Furnace Close lay between Furnace Road and the next road to the north west, the main road from Dudley to Stourbridge. (Ordnance Survey, 1903)

ceased to have any interest in it by 1674 when the partners in the furnace were John Finch and Sir Clement Clerke; Edward Nightingale (perhaps Dudley's neighbour at Tipton) also had some interest, possibly being a former partner.[41] Sir Clement and his wife had an estate at Rudge (in east Shropshire), near enough to Dudley's home at Tipton for them to have met socially. Dud Dudley was certainly not rich and it seems most unlikely that he would not have extracted from this business all the value that he could, including that of his metallurgical know-how. It is therefore suggested that Sir Clement Clerke was introduced to metallurgy by Dud. However one cannot know whether this took the form of formal lessons or merely discussions over supper of the kind that Dud described in connection with Buck's enterprise in the Forest of Dean a decade earlier. This probably related not only to the smelting of iron in blast furnaces, but also of lead in reverberatory furnaces. As indicated above, the latter was a field that Sir Clement and his son later made their own, after experimentation in a furnace at Sir Clement's house at Channel Row, Westminster.[42]

John Finch as an ironmaster and in tinplate

John Finch, the other 1674 partner in Dudley Furnace, was a member of a prominent family long established at Dudley as ironmongers. In that business, iron was bought from ironmasters and then put out to workmen to make into nails and other ironware. Henry Finch, John's father, had in 1644 employed 100 men in iron manufacture, but during the Civil War was prevented from going about his business by a Parliamentary colonel. He had 'hitherto vented his commodities in the associated counties of Norfolk and Suffolk and the like' and had taken there 'such wares as are useful for Parliament forces as bits, stirrups, spurs, and other necessaries ... and upon his return bringing hops and barrels of soap.' [43] John Finch had leased Stourton Mill (in Kinver) in 1670 and converted it to a forge.(44) Not long after, he took over the mill at Cookley, and converted that to a forge.[45] He also had forges, probably plating forges, at Kings Meadow and Clatterbatch in Stourbridge (see Fig 1),[46] but Stourton and Cookley were finery forges and were almost certainly supplied with pig iron from Dudley Furnace. These forges certainly did not receive pig iron from Philip Foley, who owned the rest of the local ironworks in succession to his grandfather Richard and father Thomas, nor apparently from the Forest of Dean furnaces of Philip's father and brothers.[47] However they could have been supplied from Sudley or Shudley Furnace, near Sudeley Castle at Winchcombe where the partners included Andrew Yarranton,[48] the man responsible for Dud Dudley's arrest at Boscobel in 1648, an affair that may well have rankled still.

There was another point of conflict between Dudley and Yarranton. Finch had become one of the sponsors of a tinplate project when it was established in March 1666/7, paying his ten pounds towards the expenses of a journey

by Andrew Yarranton and Ambrose Crowley to Saxony to discover how tinplate was made.[49] Experiments were conducted in 1667 and 1668 in plating iron at Kings Meadow Forge, probably before Finch took it over, and in rolling iron in the slitting mill at the Foleys' Wilden Forge.[50] However two of the other sponsors, Philip Foley and Joshua Newborough (a Stourbridge ironmonger), did go ahead, by building Wolverley Lower Forge as a slitting (or rolling) mill and forge. They began making tinplate, but had to stop when William Chamberlaine (without Dud Dudley) obtained a renewal, of questionable validity, of their 1661 patent. Attempts were made to bring together the entrepreneurs who knew how to make tinplate, and the patentee, who according to Yarranton did not. However this proved unsuccessful and tinplate production ceased.[51] Nevertheless the rolling technology was taken up at Pontypool in the 1690s, when the son of the slitter at Wolverley moved there.[52] This mill probably only made untinned blackplate (rather than tinplate) until about 1725, the date when tinplate begins to appear in the Gloucester Port Books as a commodity shipped up the river Severn.[53]

At one stage there was a partnership between Finch and Sir Clement Clerke at Dudley, under which 'for better carrying on of the furnace without the trouble of mixture of accounts', Finch (with two shares) should have two blasts, and Sir Clement (with one share) should have the third. However before Sir Clement entered for his blast, they agreed that Finch should have two thirds of the profit of the third blast and Sir Clement one third or that Finch should deposit wood, coal, and mine to the value £1200 and Sir Clement £600 in money, stone, and so on. Finch was to take all the iron, allowing Sir Clement for it, 'after the best price Mr Foley or any other should sell that sort of iron for'. However this was replaced by another agreement.[54]

The last years of Dudley Furnace

Being neighbouring ironmasters, Finch and Foley were in competition over the purchase of wood, and this was evidently forcing up the price. On the other hand Yarranton wanted to sell his share in Sudley Furnace, probably to help pay for his work on the Stour Navigation, a troubled enterprise that cannot be discussed in detail here. He met Finch at Winchcombe and prevailed 'with him to give me a paper to Ambros [Crowley] to (authorise) him to agree with Mr Foley.' Yarranton and Ambros then went 'to Prestwood, where Mr Foley agreed frankly unto every title and this day they sealed and all is at peace and to the infinite advantage of both and most of Mr Foleys clerks were present where much joy was on both sides. ... After 12 bottels and all cheeringly merry we parted.'

The incentive for the agreement had been a provisional agreement between Finch and Sir W Child (of Kinlet, Shrops) for Finch to lease Child's woods for a fine of £1500 and £300 per year rent but with the right to cancel the agreement in 14 days.[55] The initial proposal was for the demolition of Dudley Furnace and Stourton Forge, that forge having become a point of contention between them after Foley had bought the manor of Kinver and so become its landlord.[56] However the final agreement provided for Wolverley Old Forge and Stourton to be exchanged, and for all iron 'made with charcoal or partly so' to be sold to two of Foley's managers at the unrealistic price of £4 per ton. There were similar provisions for the sale of bar iron made by Finch other than at Stourton, Cookley, and Wolverley Forges and as to charcoal and wood.[57] Though this latter agreement is expressed as a sale agreement, the prices agreed were so low that the intention must have been that neither party would buy or make anything that would be saleable under its terms. It would have been open to Finch to use Dudley Furnace with pitcoal only, but it is more probable that he did not intend that it should be used at all. A month later Yarranton was treating with Colonel Archer (of Umberslade, in Warwickshire) and Mr Finch for the sale of his share of Sudley Furnace, but he said he would have preferred Philip Foley to have it.[58] It is probable that something came of this negotiation, as, not long after, Sudley was in Finch's hands and Thomas Archer built Clifford Forge near the mouth of the Warwickshire Stour.[59]

Finch did not long retain his ironworks, for in April 1674 he sold them all to Alderman John Forth and Sir Clement Clerke, that is Cookley, Wolverley, Stourbridge (*ie* Kings Meadow), Clatterbatch, Sudley and part of Dudley Furnace (presumably the part that Clerke did not already own).[60] The point of contact between Clerke and Forth was probably George Skippe of Ledbury. Skippe was Forth's partner in farming (that is leasing the right to collect) the excise duties of Somerset (and perhaps other counties) and, like Sir Clement, he owned a half share of the manor of Notgrove in Gloucestershire.[61] Clerke and Forth had recently bought wood being sold (on behalf of the Crown) in Lea Bayley, which is part of the Forest of Dean, but found that Paul Foley (Philip's brother), who owned ironworks in that area, had recently bought (for demolition) the materials of the Kings Ironworks in the Forest.[62] In consequence Clerke and Forth had to build their own furnace, which they did at

Burton Mill in Linton near the Herefordshire border.[63] The following November they agreed to take over from Philip Foley further ironworks, Grange Furnace and Heath, Swindon, Greens, and Cradley Forges, and (most unusually) to make a payment of £2000 for goodwill. To increase the business' capital to £30,000, several new partners were brought in, including John Forth's brother Dannett and George Skippe. Unfortunately at this point things went wrong. Sir Clement Clerke was found to have mortgaged his share in the previous partnership to two goldsmiths, and Dannett found it necessary to pay off this mortgage in order to preserve his own investment. Furthermore the second £1000 due to Philip Foley remained to be paid.[64] To complicate matters further, Clerke and Forth had agreed to take over Yarranton's share in the Stour Navigation.[65] While at a meeting at the house of Robert Chelsham, the ironworks manager, at Wollaston (near Stourbridge), Sir Clement Clerke was arrested for debt at the suit of Dannett Forth and had to send for George Skippe to bail him out. The ensuing litigation was ultimately settled in 1676 by the sale to another group of Londoners of the whole business, including Dudley, Sudley, and Linton Furnaces. The share of the Navigation was excluded from this sale and Skippe replaced John Forth in that affair.[66]

The purchasers were Henry Cornish, John Langworth, and John Sergeant, though Henry Ashurst, a connection of the Foleys, seems also to have had an interest. They continued to employ Robert Chelsham to run the business, but did little better. Ultimately in 1681 they gave Philip Foley notice to quit in respect of the works he had sold to Forth and Clerke. At that point many of the works passed to Richard Avenant and John Wheeler, who as Foley's managers had joined in the agreements with Finch in 1673. They operated the works for their own benefit.[67] Linton Furnace was sold to Paul Foley, but was closed in about 1692, because whatever profit was made at the nearby Elmbridge Furnace (at Newent) was lost by Linton.[68] However neither Dudley nor Sudley Furnace is mentioned again. Each no doubt closed about 1681, if not before.

Conclusion

By this stage, Sir Clement Clerke was ruined financially; he was outlawed for debt in October 1676 and his (or rather his wife's) estate at Rudge was foreclosed,[69] but he was by no means a spent force. As has been shown elsewhere,[70] Sir Clement Clerke was responsible for the introduction of the reverberatory furnace (or cupola) for smelting lead and copper and also (in this case usually called 'air furnaces') for re-melting pig iron for foundry work.[71] His son Talbot went on to float three chartered companies: The Company for Smelting Down Lead with pitcoal (later called the London Lead Company), the English Copper Company, and the Company for Running Iron with pitcoal, founded on these three innovations. The iron company also made use of Thomas Addison's patent for smelting iron with pitcoal and had in the 1690s a foundry at Vauxhall in Lambeth, a blast furnace at Cleator, and some connection with the use of pitcoal at Coalbrookdale. These matters have been described at length elsewhere.[72] Dud Dudley was not involved in these matters, but behind them lay whatever foundation in metallurgy he had given to Sir Clement.

Dud Dudley was already an old man even when Dudley Furnace was set up, having probably been born in spring 1600.[73] He probably retired to Worcester, where in 1678 he had a house with five hearths in Friar Street (now 44 Friar Street).[74] He had owned this since before the Civil War, and it had been used for 'his late sacred majesties armorors to woork in from [16]42 to 1646'.[75] When his wife died he erected an elaborate memorial to her (or rather to himself) in St Helens Church in Worcester, but, when he died in October 1684, no one added the date of his passing to it. His house was sold sometime in the following 30 or so years by 'one Dudda Dudley and Anne his wife'. The vendor was presumably Dud's son.[76]

Dudley's last link with the metal industry nevertheless comes from his final years. He applied to the Company of Mineral and Battery Works, of which he had been an Assistant (*ie* Director) between 1663 and 1670, for a lease of their mining rights to Mines Royal. In December 1683 he first proposed an area within three miles of Dudley Town Hall, but was told that the diameter of grants was only one mile. The following February he applied for a similar grant for the whole Malvern Hills. He wrote that 'being 85 yeres of age and having a sonne of his olde age [he was] willing to leave him some of his experiments in mines and minerals'. Nothing came of this, no lease being granted.[77] However, his achievements have lived on in the later coal-based metallurgical processes, of which he and Sir Clement Clerke were the technological ancestors.

References

1. Dud Dudley, *Metallum Martis or Iron Made with Pitcoale Seacoale etc* (London 1665; reprinted ed John N Bagnall of West Bromwich, 1854; London 1858); *J Iron & Steel Inst* 1872(2), 215–36 and (in part) Joan Thirsk & J P Cooper (eds), *Seventeenth Century Economic Documents* (Oxford 1972), 277–84.
2. D Mushet, *Papers on Iron and Steel* (London 1840), 402–3;

H Scrivenor, *A Comprehensive History of the Iron Trade...* (London 1841), 36–55; S Smiles, *Industrial Biography* (London 1863), 43–59 reprinted (with comment) as 'Dud Dudley, iron-smelter 1599-1684' *Industrial Archaeology* 12(3) 1977, 252–64; A A Rollason, 'The seamy side of Dud Dudley and his father' (reprinted from *The Dudley Herald,* 1921); R A Mott, 'Dud Dudley and the early coal-iron industry' *Trans Newcomen Society* 15 (1934–5), 17–37; A Bedford-Smith, 'Dudonius Dudley' (typescript in Birmingham Central Library, class L78. 1); H R Schubert, 'The truth about Dud Dudley' *J Iron & Steel Inst* 166 (1950), 184; W K V Gale, *The Black Country Iron Industry: a Technical History* (London 1966), 16–20; G R Morton & M D G Wanklyn, 'Dud Dudley: a new appraisal' *J West Midlands Stud* 1 (1967), 48–65; P W King, 'Dud Dudley and pit-coal iron' *The Blackcountryman* 29 (3) (1996), 23–24; D E A Evans, 'Did Dud do it?' *The Blackcountryman* 30 (1) (winter 1996/7), 17–18; P W King, 'The development of the iron industry in south Staffordshire in the 17th century: history and myth' *Trans Staffs Archaeological & Historical Society* 38 (1999 for 1996–7), 61–2.

3. R G Schafer, 'Genesis and structure of the Foley "Ironworks In Partnership" of 1692' *Business History* 13 (1) (1971), 19–38.
4. P W King, 'The Cupola near Bristol' *Somerset Archaeology and Natural History* 140 (1999 for 1996), 37–51; P W King, 'Sir Clement Clerke and the adoption of coal in metallurgy' *Trans Newcomen Society* (forthcoming); *cf* J Day, 'Introduction' in J Day & R F Tylecote, *The Industrial Revolution in Metals* (London 1991), 13–17.
5. A A Rollason, 'The seamy side' (as note 2), 1; Dudley Archives, DE4/3, Himley leases, 4 Jul 1585.
6. For this technology see R F Tylecote, *A History of Metallurgy* (2 edn, London 1992), 75–6; H R Schubert, *History of the British Iron and Steel Industry from c 450 BC to AD 1775* (London 1957). 146–53.
7. Dudley Archives, DE4/3, Himley leases, 4 Jul 1585; Worcs RO [Record Office is hereafter 'RO'], 705:658 BA 5462/146, deed of 1775 mentions a Smithy Croft, belonging to Thomas Biggs of Homer Hill in Cradley. Fundley Mill was a corn mill by 1640: Dudley archives DE4/3, Sedgley leases, 20 Oct 1640.
8. Dudley archives, DE2/142–6; T J Raybould, *The Economic Emergence of the Black Country: a Study of the Dudley Estate* (Newton Abbot 1973), ch 1.
9. S Lasdun, *The English Park: Royal, Private and Public* (New York 1992), 13–14.
10. H R Schubert, *History* (as note 6), 157–291 *passim*; R F Tylecote, *History* (as note 6), 95–104.
11. H R Schubert, *History* (as note 6), 375–77; Public Record Office [hereafter PRO], Exchequer Proceedings, E112/244/11; Dudley Archives, DE2/31; *Victoria County History, Staffordshire* [hereafter '*VCH Staffs*'] ii (1967), 372–77 *passim*. Schubert was wrong in saying that the furnace at Gornal Wood was let in 1591: in fact, it was excepted from a lease of adjoining land.
12. *VCH Staffs*, xx (1984), 208–9; Herefs RO, E12/V1/KY/1; Dudley Archives, DE4/3, Swindon leases, 11 Jun 1600. I am most grateful to Mr A T Foley for permission to consult his family archive in Herefs RO.
13. 'Heraldic Visitation of Staffordshire 1663', frontispiece to D Dudley, *Metallum Martis* (1854 edn); Greens Lodge: PRO, Chancery Proceedings, C2/Chas1W84/53, answer of Dud Dudley *alias* Tomlinson; Dudley Archives, DE2/l42; DE4/3, Sedgley leases 1591; Netherton: PRO, C 2/F2/17. It is not clear whether the Bromford Forge in question was that at Oldbury or Erdington.
14. Eg H Scrivenor, *History* (as note 2), 36; T S Ashton, *Iron and Steel in the Industrial Revolution* (Manchester 1924), 13; M W Flinn in 'The growth of the English iron industry 1660–1760' *Economic History Review* Ser II, 11 (1958), 144–53 gives several other examples of similar statements. Flinn's work has led to a great deal of research to estimate the production of pig iron, including, most recently, Philip Riden, 'The final phase of charcoal iron-smelting in Britain, 1660–1800' *Historical Metallurgy* 28 (1) (1994), 14–26.
15. As to charcoal generally see G Hammersley, 'The charcoal iron industry and its fuel 1540–1750' *Economic History Review* Ser II, 26 (1973), 593–613. Possibly, Dud meant that, as all available wood was already being used, production could only be expanded by the adoption of a more abundant fuel. The surname 'Robinson' has often been misread as 'Rovenson'.
16. Dudley Archives, D/DE/V/I, agreements, 1619; H R Schubert, 'The Truth' (as note 2), 183; D Dudley, *Metallum Martis* (1854 edn), 2–3.
17. D Dudley, *Metallum Martis* (1854 edn), 11–12; S Smiles, *Industrial Biography* (as note 2), 57.
18. P W King, 'Development' (as note 2), 59–76.
19. D Dudley *Metallum Martis* (1854 edn), 11–12; Dudley Archives, DE4/3, Himley leases, 30 Jun 1625.
20. D Dudley, *Metallum Martis* (1854 edn), 12.
21. PRO, C2/Chas.I/D42/9.
22. PRO, C2/Chas.I/D24/70. A bloom of ironstone seems to have been identical with a load (that is a wain load) or dozen. The yield of ironstone at Grange Furnace (Staffs) in 1698–1703 was calculated in the units 'blum s. p.' The latter are probably a strike (*ie* level bushel of 8 gallons) and peck (of 2 gallons). The arithmetic implies that the 'blum' was 12 strikes: Herefs. RO, E12/VI/KL/12. 'bl.' and strikes were used at Wombridge (Salop) in 1669: R G Schafer (ed), *A Selection from the Records of Philip Foley's Stour Valley Iron Works 1668–74 part i* (Worcestershire Historical Society, ns, 9, 1978), 86. A report of 1590 on ironworks on Cannock Chase (Staffs) refers to 'every waine [having] 12 bushels or strikes': A C Jones and C J Harrison, 'The Cannock Chase Ironworks 1590' *Eng Hist Rev* 93 (1978), 799.
23. PRO, C2/Chas.I/D24/70; D Dudley, *Metallum Martis* (1854 edn), 12; S Smiles, *Industrial Biography (as note 2), 51; R A Mott, 'Dud Dudley' (as note 2), 24–5*.
24. PRO, C2/Chas.I/W87/3; C2/Chas.I/W84/53; C2/Chas.I/D36/8; C2/Chas.I/D49/33. Dudley Archives, DE2/142–7. The conveyance to Dud Dudley was strictly a feoffment with livery of seisin.
25. P W King, 'Development' (as note 2), 59–60; P W King, 'Wealden Ironmasters in the Midlands' *Wealden Iron* 2 Ser 21 (2001), 21–2, 25–6.
26. P W King, 'Development' (as note 2); R G Schafer, 'Introduction' in *A Selection .. i (as* note 22).
27. PRO, State Papers, SP24/11/54(i); S Smiles, *Industrial Biography* (as note 2), 52–56; A Bedford-Smith 'Dudonius Dudley' (as note 2), 60–79. Certain contemporary sources refer to the object of the rising as seizing Doyley Castle in Herefordshire, but there is no such place, nor is any part of Herefordshire close to 'Bosco Bello', presumably Boscobel, where the meeting took place. Yarranton was rewarded by Parliament for this: *cf Journal of the House of Commons* v, 642.
28. PRO, C6/191/40; P W King, 'Cupola', 44; P W King, 'Sir Clement Clerke' *cf* J Day, 'Introduction' in J Day & R F Tylecote, *The Industrial Revolution in Metals* (London 1991), 13–17. This business is mentioned by D Dudley, *(Metallum Martis* (1854 edn), 16), by S Smiles *(Industrial Biography* (as note 2), 56–7), and

by R A Mott ('Dud Dudley' (as note 2), 56–7), but they assumed it concerned iron. The fact that it was concerned with lead only appears from the Chancery proceedings.

29. P W King, 'Cupola' (as note 4); P W King, 'Sir Clement Clerke' (as note 4).
30. D Dudley, *Metallum Martis* (1854 edn), 18–20.
31. *Ibid*, 32.
32. 'Royalist Composition Papers for Staffordshire', William Salt Library (Stafford), Salt ms 393(ii), 27–43 (transcript of documents in PRO).
33. Statute, 12 Chas II c. 12; J Thirsk 'The Restoration land settlement' in J Thirsk *The Rural Economy of England: Collected Essays* (1984), 109–27. Many purchasers of forfeited property secured their position by obtaining a confirmation of their title from the deprived owner or his heir, thus providing them with a title not dependent on the acts of 'usurping powers' that were declared void at the Restoration. Dud had attempted to buy back his estate in 1653, but nothing came of this: PRO, C5/420/77.
34. F W Gibbs, 'Early tinplate manufacture to *1700' Annals of Science* 7 (1951), 34–5; P J Brown, 'Andrew Yarranton and the British tinplate industry' *Historical Metallurgy* 22 (1) (1988), 43–44; P W King, 'Wolverley Lower Mill and the beginnings of the tinplate industry' *Historical Metallurgy 22 (2)* (1988), 109.
35. W E Minchinton, *The British Tinplate Industry: a History* (Oxford 1957), 4–6 249; A Bartlet, 'The ironworks at Sowley in the manor of Beaulieu *c* 1600–1820 (typescript in Hants RO, TOP Beaulieu 3/1–2), from PRO, C3/397/58-9; Hants RO, 5M53/511–2; wills, 1720 A96 (John Smith of Wickham). I am grateful to Jeremy Greenwood for a useful discussion concerning the iron industry in Hampshire.
36. PRO, Exchequer proceedings, E112/538/94.
37. PRO, E112/502/70.
38. *Ibid*; *VCH Worcs* iii (1913), 104.
39. Herefs RO, E12/VI/NC; Dudley Archives, DE4/3, Tipton leases, 1687 to 1701; DE4/3, Dudley leases, 6 Feb 1678, 26 Sep 1683 and 11 Oct 1690. The younger Tandy's executor was John Hodgetts of Shut End in Kingswinford, whose descendant Eliza Maria Foley Hodgetts of Prestwood married the Hon Edward Foley in 1790, with the result that certain Tandy deeds form part of the Foley archive.
40. Information from the Dudley Borough Archaeologist from the deeds of Claughton House and the public baths, held by the Legal Department of Dudley Metropolitan Borough Council.
41. There is an inventory for a John Nightingale of Tipton (PRO, PROB4/1330). If Edward Nightingale was a third partner in the furnace (with Clerke and Finch), the new partnership agreement may have been the result of his withdrawal.
42. See P W King, 'Cupola' (as note 4) and P W King, 'Sir Clement Clerke' (as note 4); *cf* D Dudley, *Metallum Martis* (1854 edn), 18–19.
43. M B Rowlands, *Masters and Men in the West Midlands Metalware Trades before the Industrial Revolution* (Manchester 1975), 78 95 quoting *Historical Manuscripts Commission: Denbigh MSS, app 5, 79*.
44. *VCH Staffs* xx (1984), 145; Herefs RO, E12/V1/KE/28; R G Schafer, 'Genesis...' (as note 3), 29.
45. There had been a slitting mill at Cookley from about 1639; this was managed by the Winchurst family (Stourbridge ironmongers) until at least 1669. However no forge is mentioned until the early 1670s, when there was an agreement (whose precise terms are not known) between Finch and the Stour Navigation proprietors about making a lock there: PRO, C8/192/54; Staffs RO, D(W)1788/P61/B7(b), 26 Apr 1678; R G Schafer (ed), *Philip Foley's Accounts* i, (as note 22), 97; Herefs RO, E12/V1/KE/31 50 (discussed page 7 below).
46. R G Schafer, 'Genesis ...' (as note 3); P W King, 'Wolverley Lower Mill' (as note 34), 110. The Kings Meadow Forge was however built by Joshua Newborough in 1666 and was not an early slitting mill as I suggested there: Staffs RO, D(W) 1788/P59/B3, 6 Dec 1666.
47. Herefs RO, E12/VI/KBf/1–19 (parts of which are published as *Philip Foley's Accounts:* as note 22); E12/VI/Af DBf and DCf, *passim*.
48. The location of this furnace is indicated by the places from which wood was available to it, including 'Doudswell' and 'Farmcot': Staffs RO, D(W) 1788/P6l/B5, 21 Oct 1673.
49. P J Brown, 'Andrew Yarranton' (as note 34), 42.
50. P W King, 'Wolverley Lower Mill' (as note 34), 108. The accounts imply that some equipment of the 'tinworke', *ie* Kings Meadow Forge, was taken over by Finch at the end of the experiment: Herefs RO, E12/VI/KT/4 7.
51. P J Brown, 'Andrew Yarranton' (as note 34), 43–44; F W Gibbs, 'Early tinplate' (as note 34) 34–35.
52. P W King, 'Wolverley Lower Mill' (as note 34), 109. The Kings Meadow Forge was however built by Joshua Newborough in 1666 and was not an early slitting mill as I suggested there: Staffs RO, D(W) 1788/P59/B3, 6 Dec 1666.
53. *Gloucester Port Books Database,* ed D Hussey, N C Cox, and G J Milne (CD ROM, Adam Matthew 1998). Iron plates appear regularly as a minor commodity from 1704, usually being sent from Bristol, 1 cwt of tinplate was carried from Gloucester to Bristol in 1723 and modest amounts from 1725, usually from Bristol.
54. PRO E112/538/94.
55. Staffs RO, D(W) 1788/P61/B5, 21 Oct 1673 and 12 Nov 1673; Herefs RO, E12/IV/31, nd 'Capt Yarranton about John Finch'. This furnace is also mentioned as at Winchcombe in the diary of George Skippe [hereafter Skippe's diary] (Hereford City Library, LC Mss (oversize), class W/920 Skyppe (sic), 6 Sep 1674. There is as yet no good published account of this navigation, but see J H Parker Oxspring, 'Andrew Yarranton, "Worcestershire Worthy" 1619-84**:** his life and work with special reference to... river Stour' (Typescript, 2 vols, Worcester City Lib, class WQB/YAR), and the paper cited in the next note.
56. Herefs RO, EI2/IV/31, nd 'Capt Yarranton about John Finch'; VCH Staffs xx (1984), 131–2.
57. Herefs RO, E12/VI/KE/3l 50; R G Schafer, 'Genesis ...' (as note 3), 30.
58. Staffs RO, D(W) 1788/P61/B5, 12 Nov 1673.
59. Sudley: PRO, 12/502/70; Clifford: *VCH Warws*, iii (1945), 269; Shakespeare Birthplace Trust Library (Stratford), DR37/2647.
60. PRO, E112/502/70.
61. Skippe's diary, 16 Dec 1668, 21 Apr 1671 and *passim*.
62. *Cal Treasury Books* iv 1672–5, 489, 496–7.
63. Herefs RO, E12/II, Herefs Misc, Linton. The furnace was also called 'Burton Furnace' and said to have been built by 'Sir CC'. It is possible there was also an earlier furnace there.
64. PRO, E112/502/70.
65. Staffs RO, D(W) 1788/P59/B3, 6 May 1674; P37/B8, 25 Jul 1674 and 11 Dec 1674; P61/B5, 11 Dec 1674; P61/B7, 10 and 22 May 1675.
66. Herefs RO, B38/130–1; Skippe's diary, 29 Aug 1675.
67. R G Schafer, 'Genesis ...'(as note 3), 31; Herefs R O, E12/VI/KD/57–8; E12/VT/KH/31–35.
68. EI2/VI/DCc/2 21; E12/VI/DDc/15.
69. PRO C10/2l9/27, answer; Shrops RO, 6000/14273; *cf* 6000/14263–14290. 'Foreclosed' is used in its technical legal sense.
70. P W King, 'Cupola' (as note 4) and P W King, 'Sir Clement Clerke' (as note 4).

71. These are not to be confused with the foundry cupola (as used to this day), which was a late-18th-century invention.
72. See note 70.
73. Dudley's own statements as to his age imply that he must have been born between January and May 1600: A Bedford-Smith (as note 2), 9.
74. *The Hearth Tax Collectors' Book for Worcester 1678–80* ed C A F Meekings, S Porter and I Roy (Worcestershire Historical Society ns 11, 1953), 89; P Hughes and N Molyneux, *Worcester Streets: Friar Street* (Worcester 1984), 22.
75. PRO, State Papers domestic, SP 29/11/54(i).
76. Worcs RO, 705:477 BA 4925/2(i), deed of 29 Jun 1745.
77. British Library, Minutes of Company of Mineral and Battery Works, Loan Mss, 16/2 ff 201 204 *cf* ff 128–58.

The author

Peter King is by training a chemist and a solicitor, but has spent most of his time in recent years researching the history of the iron industry. He hopes this year to complete a doctorate in economic history on 'The Iron Trade in England and Wales 1500-1815: The charcoal iron industry and its transition to coke'. He has been a member of the Historical Metallurgy Society for about 20 years and has published a number of articles, principally on metallurgical history.