

CHAPTER 4

THE SMELTING OF COPPER

The first written account of the processes of smelting and refining of copper is to be found in the 12th century.¹

On smelting:

Copper is engendered in the earth. When a vein of which is found, it is acquired with the greatest labour by digging and breaking. It is a stone of a green colour and most hard, and naturally mixed with lead. This stone, dug up in abundance, is placed upon a pile, and burned after the manner of chalk, nor does it change colour, but yet loses its hardness, so that it can be broken up. Then, being bruised small, it is placed in the furnace; coals and the bellows being applied, it is incessantly forged by day and night.

On refining:

Of the purification of copper. Take an iron dish of the size you wish, and line it inside and out with clay strongly beaten and mixed, and it is carefully dried. Then place it before a forge upon the coals, so that when the bellows acts upon it the wind may issue partly within and partly above it, and not below it. And very small coals being placed around it equally, and add over it a heap of coals. When, by blowing a long time, this has become melted, uncover it and cast immediately fine ashes over it, and stir it with a thin and dry piece of wood as if mixing it, and you will directly see the burnt lead adhere to these ashes like a glue. Which being cast out again superpose coals, and blowing for a long time, as at first, again uncover it, and then do as you did before. You do this until at length, by cooking it, you can withdraw the lead entirely. Then pour it over a mould which you have prepared for this, and you will thus prove if it is pure. Hold it with pincers, glowing as it is, before it has become cold, and strike it with a large hammer strongly over the anvil,

and if it be broken or split you must liquefy it anew as before.

Reference to coal in the above descriptions is to charcoal. Charcoal burnt with a clean flame, and did not introduce any contaminants. It could therefore be in intimate contact with the ore. As the demand for copper and other metals grew, so there was an ever increasing demand for charcoal. This increase led to calls for controls in its use, resulting from shortages in the supply of timber to other industries, especially shipbuilding. Peat was tried, mixed with charcoal, with only partial success. Coal had been tried, both mixed with charcoal, and on its own, yet it did not have the clean burning properties of charcoal. It was not until the introduction of the reverberatory furnace that the use of coal in copper smelting and refining became universal. In this furnace the coal and ore mix were segregated, and the heat from the fire directed to flow over the ore on its passage to the flue. The establishment of a smelter required considerable capital investment. Percy estimated:

... that works on the smallest scale to afford any prospect of success should be capable of making 1,100 tons of fine copper per annum from a good mixture of ores yielding, say on an average, 10 per cent. Such works would contain about 18 furnaces (say six calciners and twelve others) with all the necessary accompaniments, and may be estimated at a cost of £9,500, or £10,000. The calciners may be estimated at £240, and the melting furnaces at £200 each, exclusive of workmen's tools, &c. The additional capital needed to carry on the concern in an independent manner should be £35,000, making a total of £45,000. If such works were judiciously constructed with a view to future extension, their capacity might be doubled at an outlay of about 50 per cent of the original cost.²

A number of locational factors determined growth in the copper smelting industry: access to copper ore, fuel, the consumer, and an efficient transport infrastructure. Prior to the dominance of the smelting companies of South Wales, copper smelters were erected at a number of locations throughout England and Wales. Before embarking on an examination of the resources in South Wales, these locations will be reviewed to determine the reasons for their success or otherwise.

A plentiful supply of coal was essential. Typical quantities varied from three tons for each ton of ore during the first half of the eighteenth century, reducing to one or two by the beginning of the nineteenth century; this was certainly one justification for the concentration of smelting in South Wales. But it was rarely the case that the consumer, and also the source of ore would be found in proximity with the requisite amounts of fuel. With these three factors being decentralised an efficient transport system became essential. Throughout the eighteenth century the most cost effective means for the bulk transport of commodities like coal and copper ore was carriage by sea or canal, a further constraint on the location of an economically efficient smelter. Between the mines and the ports conveyance was on the backs of horses and mules.

Concurrently in the closing decade of the seventeenth century and the first half of the eighteenth, smelters were erected in Bristol, Gloucestershire, South Wales and Cornwall. As the industry prospered and output of ore rose, so further smelters were established in Lancashire, Anglesey and Staffordshire. However, by the end of the eighteenth century and throughout the nineteenth the industry became concentrated in South Wales.

SMELTING IN BRISTOL AND GLOUCESTERSHIRE

For much of the eighteenth century Bristol was not only England's second most important city and port after London, it was also a pioneer in the development of the copper and brass industry in Britain. With a ready market for its output, proximity to supplies of coal, and copper ore from Cornwall, the three essential criteria for the effective smelting of copper were satisfied.

In the 1670s, Sir Clement Clerke and his son Talbot, following a dispute in the use of a patent for employing the reverberatory furnace in the smelting of lead, shifted their efforts to the smelting of copper. Only by the use of these furnaces, with coal as fuel,

could the requirement for high temperatures in copper smelting be satisfied. In this endeavour they were probably assisted by John Coster and Gabriel Wayne, two men who were to figure prominently in the early history of the industry. By 1688 they were offering copper for sale from their works in Stockley Vale, Hotwells, Bristol.³ In 1680 a second smelter was erected at Upper Redbrook in the Forest of Dean by John Coster. His partner was William Dockwra, who probably obtained his copper from these works for use in his brass foundry at Esher in Surrey. In 1691 a further smelter in the Forest was erected at Lower Redbrook, the premises of the English Copper Company. Amongst the technical staff was Gabriel Wayne.⁴

The industry was also expanding in Bristol. In 1698 during a visit to England on behalf of the Swedish authorities, Thomas Cletscher visited the copper smelter situated on the banks of the River Avon at Conham, to the east of Bristol. This facility had been built by Abraham Elton, and had probably been in existence for at least two years prior to his visit, ore being shipped from Truro for his use in 1696.⁵ As well as receiving ore from Cornwall, Elton also acquired ore from the mines of North Molton, Devon. This ore was of a much higher yield than that obtained from Cornwall, and may be a further indication of the advantage derived from mixing ore.

Sometime prior to 1702, Abraham Darby, with other Quaker partners, founded a brass foundry at Baptist Mills in the north east of the city, using calamine. This, an ore of zinc, was found in the Mendip Hills, not 20 miles from Bristol.⁶ A second mill was in use by 1708 at Keynsham, midway between Bristol and Bath. By this time Darby's interests had changed to the working of iron, and in 1709 he moved to Coalbrookdale. In the same year the Bristol firm merged with one at Esher, the combined company becoming known as the 'General Joint United Stock of the Societies of Bristol and Esher for making Brass, Battery and Brass Wire.'⁷ Copper output from these Bristol based smelters was by this time in excess of 400 tons per annum,⁸ due in part to a second smelter being erected at Crew's

Hole for the Brass Warehouse Company, about half a mile down stream from Conham.⁹

Four smelters were now in production in Bristol and Gloucestershire, obtaining the bulk of their ore from Cornwall. In 1719 the Bristol firms began to directly involve themselves in the county, both with a view to guarding their own interests, and increasing output. John Coster, jnr (son of John Coster of Redbrook), Gabriel Wayne and others were managing mines in the county. This is confirmed in the 1724 diary of Henric Kalmeter, a Swedish mining expert. He wrote on 4 December that "The second work is called Metal Work and is carried on by Mr Coster or the Bristol Company... The third work is called Pittslooarn or Wheal Busy, and is run by the same company, together with other adventurers, such as Sir Abraham Milton (*sic*, Elton) and Mr Wayne, the part owners of a smelting works near Bristol."¹⁰ John Coster was also working a tin mine at Polgooth, near St Austell, no doubt for the subsequent manufacture of bell metal, an alloy of tin and copper.¹¹ His brother, Thomas was in partnership with William Champion of Bristol and others in running a tin smelter at Calenick, Truro, where it was likely the tin ore raised by his brother at Polgooth would have been smelted.¹² Kalmeter also associates him with the tin smelter at Angarrack.¹³ There is little doubt the proprietors of the Bristol companies, and in particular the Coster brothers, had a strong influence in the mines of Cornwall.

This grouping dominated by John Coster was the first of a number of copper cartels which were to plague the Cornish mine owners over the coming years. Coster was buying on behalf of the Upper Redbrook Works, the English Copper Company at Lower Redbrook, the Elton and Wayne Company at Conham and the Bristol Brass Company at Crew's Hole. John Coster continued to act for these companies 'confederated to serve their own interests without limit or controul' until his death in 1731.¹⁴

Following the deaths of John Coster, jnr in 1734, his brothers Robert in 1735

and Thomas in 1739, control of their business was transferred to Thomas' daughter, Jane, who after a number of years sold her interest to a partner, Joseph Percival. He changed the name of the company to Joseph Percival & Copper Company, transferring the smelting branch of the business to South Wales. Frances Coster succeeded to the management of the Upper Redbrook works on the death of his father, John. Frances remained in control at Upper Redbrook, until the business was transferred to Neath.¹⁵ The Lower Redbrook works continued in operation until 1790, in which year the English Copper Company, having previously moved their smelting facilities to South Wales, sold it to David and William Tanner of Monmouth.¹⁶

Following the departure of Abraham Darby in 1709, control of the Baptist Mills works was assumed by Nehemiah Champion. In 1738, after some eight years of experimentation, his son William perfected the technique for smelting zinc from its ore, calamine. Following opposition to a smelter he had erected in the centre of Bristol, William moved to Warmley on the eastern edge of the city. There he erected a new facility for the purposes of smelting copper and zinc, and the production of brass and allied goods.¹⁷ The company expanded rapidly, such that by 1761 it was equipped with five furnaces for the production of spelter, 22 copper furnaces, 15 brass furnaces, a wire mill, two rolling mills, five water battery mills complete with 12 hammers, and a 24 inch cylinder Newcomen steam engine, in addition to the usual administrative facilities and warehouses. For the workforce there were 25 houses and tenements.¹⁸ A new company was constituted in 1761, and named The Warmley Company. In the same year, through advantageous partnerships, Champion obtained exclusive access to the nearby Kingswood coal mines, giving him a guaranteed supply of fuel. New copper furnaces were constructed on or adjacent to the coal mines. The result was overcapacity with output exceeding demand. It also became clear the Warmley Company had overextended itself financially, not all the new shares had been taken up, nor had the new shareholders met their liabilities. Large loans had been entered into which could only be met with an increase in

the share capital, which required the approval of Parliament. Opposition from local and national interests was such that in 1768 the firm was advised a Charter of Incorporation would be refused, and the matter was dropped. A month later Champion was removed from the board, and a year later the company declared bankrupt. It was bought by the Bristol Brass Company,¹⁹ making it for the next two decades the foremost copper and brass business in Bristol, yet coming under ever greater competition from firms without the city. The growth in power of the South Wales producers, a consortium of brass makers, the rise in the Birmingham trade, and ultimately the business empire of Thomas Williams together forced the closure of the Bristol Brass Company. In 1787 it was advertised for sale, and within a few days was sold to a partnership of the original management, who in 1788 reconstituted it under the name of Harfords & Bristol Brass & Copper Company. In 1790 Harfords transferred their smelting facilities to works in South Wales.

One of the principal objectors to the formation of the Warmley Company was John Freeman & Copper Company. This company was formed in 1742 as successor to the John Percival company. They had retained brass making facilities in Bristol and other locations nearby, but smelted all their copper ore at White Rock, Swansea, the works of their predecessors, John Percival.²⁰

A short lived attempt at copper smelting was made by the firm of Issac Elton and Thomas Tyndall, and named Tyndall & Company, alias Elton & Company.²¹ Founded in the 1770s it was buying copper ore from Roe & Company of Macclesfield, but it never figured in the Cornish ore sales. The Macclesfield company's records would appear to indicate the firm specialised in the manufacture of japanned copper. It was possible it was located at one or both of the old Brass Company's sites at Conham and Crew's Hole. These had been vacated following the take over of the Warmley works. Tyndall & Company ceased trading sometime in the 1790s, bringing to an end the smelting of copper by Bristol

based firms in the city and its environs.

Between 1765 and 1770 the Bristol companies were producing in excess of 1,000 tons of copper per annum. Assuming the majority of this was consumed in Bristol, it made the city one of the biggest producers of copper and brass wares in the country, placing them on a par with Birmingham, where such consumption was not achieved until later in the century.²²

SMELTING IN CORNWALL

Whilst much of the literature concentrates on the developments in copper smelting in Bristol and South Wales during the early decades of the eighteenth century, there were a number of attempts to smelt copper ore in Cornwall. With one exception these all came to naught for a variety of reasons.

The earliest was a partnership of local people and the Bristol merchants and manufacturers, Sir Clement Clerke, or Clark, and his son Talbot. In the late 1690s they built a smelter at Polrudden, near St Austell. It was apparently, to a degree, successful for it remained in existence for about four years, notwithstanding its distance from the coal ports and copper mines. Its failure was attributed to poor management and an untrustworthy workforce.²³ Contemporaneously with the attempt at Polrudden, John Pollard of Redruth, in partnership with Thomas Worth of St Ives, established another short lived smelter in St Ives sometime around 1700, on which Celia Fiennes may have remarked during her tour of Cornwall that 'Indeed, at St Ives they do melt a little, but nothing that is considerable.'²⁴ Its failure was ascribed to poor siting and a lack of understanding of the processes involved.²⁵

It was not until 1710 that it could be said that some success was achieved,

following the erection of a smelter at Penpol in the parish of Phillack by Gideon Cosier. Penpol was situated close to the quays at Hayle where coal was unloaded, and the mines of Camborne and Redruth; it was therefore well sited, unlike the previous attempts. Cosier died shortly after a successful start, the business being taken over by Sir William Pendarves, land owner and adventurer in mines, and Robert Corker, his son-in-law. It remained in operation until 1735, ceasing as a result of the death of the partners.²⁶ In 1721 a small smelter was erected at Lenobrey in the parish of St Agnes but the inability to obtain an appropriate mix of ores forced its closure after only a few months.

The most successful of the early Cornish smelting ventures was that erected at Carn Entral to the north of Camborne on the Dolcoath sett in 1750. The driving force was Sampson Swaine, who had previously experimented in the calcining and smelting of copper ore. A partnership was formed to manage the operation, comprising Swaine, John Vivian, a Camborne merchant, the Rev John Trevenen, curate of the same town, and others. Their success met with fierce opposition from the smelting companies of South Wales and Bristol. This was rebuffed following the injection of fresh capital by Christopher Hawkins of Trewinnard, a wealthy landowner with considerable interests in the Cornish mines. It soon became apparent that the business could never be fully effective due to the cost of transporting coal up to Carn Entral from Hayle, and copper back down again. In 1756 the furnaces were relocated to Copperhouse, east of Hayle, where there was easy access to the sea.

Concurrently the partnership was reconstituted in the name of the Cornish Copper Company, remaining in business as a copper smelter until 1819.²⁷ Hitchens and Drew provide a very complete description of the smelting process at the new Copperhouse smelter.²⁸ It was almost identical to the 'Welsh Process', but charcoal was used in preference to anthracite at the final refining stage. Copper manufactured included: tough cake and brass ingots, japan copper, shot copper, bell metal (copper and tin), and pot

metal (copper and lead). The cake and ingots were used in the nearby battery and rolling mill to manufacture plate, bolts and furnace bottoms. The mill had a maximum capacity of 700 tons per annum, although it usually produced less than 450 tons. The Cornish Copper Company faced stiff opposition from the smelting companies of South Wales. Pryce wrote:

The author very well remembers the combinations which were formed to overthrow this laudable effort. The companies left no method unsought to traduce the credit, and stab the vitals of this undertaking. Threats and remonstrances were equally used to oblige or cajole the owners of the Mines to abandon or suppress the new company at Hayle. The opponents of this association using every expedient to mortify the spirit of this arduous undertaking, alternately raised the price of Copper Ores, and lowered the value of fine Copper, to the great loss of the contending parties; which will ever be the case where monopolies are disturbed, and the almighty power of opulence can prevail. But happening to have men of fortune and capacity at their head, they were founded in prudence, and withstood the shocks of power and artifice.¹²⁹

This was amongst the earliest references to the methods employed by the South Wales operators in their attempts to defeat any opposition resulting from the formation of new companies.

The argument for smelting in South Wales would seem irrefutable. In a letter to Sir William Pendarvis in 1726 Robert Morris calculated 'that in copper making he could do as much for £100 at Swansea as in Hayle for £160.¹³⁰ It was generally argued that the cost of shipping coal to Cornwall was the main reason for it being uncompetitive to smelt copper ore in Cornwall. In the 1730s it was estimated that to produce one ton of copper required ten tons of ore and five and one half weys of coal, that is approximately 30 tons.³¹ Thus transport costs would appear to be three times greater by smelting the ore in Cornwall. Furthermore, there would be no return cargo of ore. Whilst this was less than the coal shipments, it could possibly inflate the factor of three times to nearer four, if all ships returned in ballast. A counter to this argument was the success of the Cornish Copper Company. It operated profitably for the best part of 63 years, albeit at time marginally.

Newell, whilst acknowledging the increase in coal shipments to Cornwall, argued it was still possible to make a significant profit by smelting the ore locally.³²

By the time the Cornish Copper Company became a viable entity, there was adequate smelting capacity elsewhere, this being a more likely reason for the lack of any additional growth in the county. There would, however, seem to have been a similar opportunity to employ the methods Thomas Williams used on Anglesey, whereby some initial processing was undertaken locally, such as the initial calcining and first melting to make regulus.³³

SMELTING IN LANCASHIRE, CHESHIRE AND STAFFORDSHIRE

Lancashire in particular was an attractive proposition for the establishment of copper smelting, with its coalfield close at hand, and the Liverpool slave traders ready consumers for the products of the manufacturers. The first company to be set up was Patten & Company, who established a smelter at the Bank Quay Copper Works, Warrington and a brass foundry at Cheadle in Staffordshire in 1717.³⁴ In 1755, the Warrington Company, was founded with much the same partnership.³⁵ Whilst it never appeared amongst the buyers of Cornish ore it did smelt the Anglesey ore of Sir Nicholas Bayly, and latterly the ore of the Parys Mine. The Patten Company was buying Cornish ore as late as 1784, and may well have been buying on behalf of both firms. Between 1729 and 1784 Patten & Company purchased 19,495 tons of ore at the Cornish ore sales.³⁶ Patten also obtained ore from the Ecton mine, probably smelting it at Cheadle.³⁷ In 1772 the Warrington Company opened a new smelter at Stanley, giving it direct access to the coal wharfs of the Sankey Canal, and a preferential contract for coal shipped from the coalfields of Ashton and Garwood.³⁸

In 1757 Roe and Company was founded and commenced building a copper smelter and brass foundry at Macclesfield in Cheshire. Initially the company worked the

Alderley Edge mine, but following their lease of the Parys Mountain mine concentrated their mining activities in Anglesey.³⁹ In 1764 a further smelter was erected in Liverpool in 1767 for the conversion of these ores. Between 1765 and 1781 they purchased 4,308 tons of ore at the Cornish sales.⁴⁰ Following later difficulties in purchasing ore, combined with the end of their lease in Anglesey, the company turned to Ireland for their ore supplies.⁴¹

In 1779 Williams leased a site from John Mackay for the construction of a smelter on the Ravenhead branch of the Sankey Canal, close to Mackay's coal mines. This became known as the Ravenhead Works, and was situated at St Helens.⁴² It was of significant benefit to Williams, for this freed him from the intrigues of the South Wales smelting companies, who had been doing everything possible to force him out of business. Williams could not have been in a better location; on the coalfield with a very advantageous contract for its supply, smelting his own ores, and on the doorstep of his customers in Liverpool. Following the formation of the Mona Mining Company in 1785, Williams opened another company, the Stanley Smelting Company. It was located at Stanley near St Helens, resulting from the take over the Warrington Company.⁴³

Williams' success can be gauged following a visit in 1784 of French armaments experts. They estimated these companies were smelting 12,000 tons of ore per annum, yielding 11 per cent copper, and returning a profit of £29,000 prior to the deduction of labour costs.⁴⁴ By 1815, some 13 years after Williams' death the two copper producers were closed down as a result of the decline in output from the two Anglesey mines, and competition with South Wales.⁴⁵ The two undertakings of Thomas Williams were the only ones to come close to fulfilling all three smelting criteria of close proximity to ore, coal and consumer.

SMELTING IN ANGLESEY

Williams was aware at an early stage in the growth of his business activities of

the opposition he faced from the association of South Wales companies. As early as 1775 he perceived the advantages to be gained by partially smelting the Parys Mountain copper ore locally. However, this could not be fully realised until the duty which had to be paid on sea borne coal was lifted. He petitioned Parliament in 1776, 1782 and 1783, but was unsuccessful on each occasion. He had to wait until 1786 for the successful passage of a bill through Parliament, leading to 'An Act for allowing a drawback on duties upon coal used in smelting copper and lead ores and in fire engines for drawing water out of the copper and lead mines within the Isle of Anglesey ...'⁴⁶ It was during these years he commenced smelting copper ore in Lancashire and South Wales, pending the relief on the coal duties, and avoiding the pressure exerted on him by the cartel of smelting companies.

In the first instance a considerable amount of processing was undertaken at the mines over and above the mandatory dressing of the ore. Reference has already been made to precipitation; in addition low grade ore was calcined at the mine. This greatly reduced the quantity of ore to be shipped to the nearest port of Amlwch, and from there onwards. At the same time it increased its yield, as well as producing a worthwhile by-product, sulphur. A contemporary description paints a graphic picture of what must have been an impressive process:

It (ore) is quarried out of the beds in vast masses, is broken into small pieces, and the most pure part is sold raw, at the rate of about (£)3 l. to (£)6 l. per ton, or sent to the smelting-houses of the respective companies to be melted into metal.

The more impure ore is also broken into the size of hens eggs; but, in order to clear it from the quantity of sulphur with which it abounds, as well as other adventitious matter, it must undergo the operation of burning. For that purpose it is placed between two parallel walls of vast length; some kilns are twenty, others forty and fifty yards in length; some ten, others twenty feet wide; and above four feet in height. The space between is not only filled, but the ore is piled many feet higher, in a convex form, from end to end. The whole is then covered with flat stones, closely lined with clay; and above is, placed a general integument of clay, and small rubbish of the work, in order to prevent any of the

fumes from evaporating. Of late, some kilns have been constructed with brick arches over the ore, which is found to be the best method of burning; and within these few years attempts have been made to preserve the sulphur from flying away, which is done by flues made of brick, whose tops are in form of a Gothic arch, many scores of feet in length. One end of these opens into the beds of copper which are to be burnt: these beds are set on fire by a very small quantity of coal, for all the rest is effected by its own phlogiston. The volatile part is confined, and directed to the flues; in its course the sulphurous particles strike against their roofs, and fall to the bottom in form of the finest brimstone; which is collected and carried to adjacent houses, where it is melted into what is called in the shops stone brimstone.

The beds of copper, thus piled for burning, are of vast extent. Some contain 400 tons of ore, others 2000. The first require four months to be completely burnt, the last near ten. Thus burnt, it is carried to proper places to be dressed, or washed, and made merchantable. By this process the ore is reduced to a fourth part in quantity, but considerably improved in quality; and by this means the water is strongly or richly impregnated with copper, which is dissolved by the acid quality of the sulphur; and is collected or precipitated again by iron in the above-described pits. The iron is all dissolved.⁴⁷

By 1786 a number of smelting houses had been erected in the port of Amlwch close to the quay side. In these houses were installed 31 reverberatory furnaces, used for processing the poorer ores raised on Parys Mountain. Output was of the order of $1\frac{1}{2}$ cwt of 50 per cent copper, or regulus, from 12 cwt of ore every five hours, a yield of some 4 per cent. Coal for smelting was obtained from Lancashire and South Wales. Although coal in considerable quantities, some 30,000 tons per annum, had to be brought to Anglesey, it was offset by the greatly reduced quantity of ore that had to be shipped to the smelters. In addition to the export of regulus, the richer roasted copper ore, dried precipitate of copper from the vitriol pits on the mountain, refined sulphur, ochre, alum, and green vitriol were also shipped for further smelting, processing or sale elsewhere.⁴⁸ The complete process, to include the final refining, on Anglesey was never contemplated for the low yield of the Anglesey ores would have necessitated the supply of between 30 and 40 tons of coal for each ton of fine copper.⁴⁹ One estimate of the yield was something in the order of seven and one half per cent, producing 3,000 tons of copper in 1784.⁵⁰

SMELTING IN BIRMINGHAM

In the years up to 1780 the manufacturers in Birmingham, and the towns in its immediate vicinity, were major buyers of brass produced in Bristol and Cheadle. From this they manufactured a range of small articles such as buttons, buckles and domestic hardware. This limitation was primarily imposed by an inadequate transport infrastructure. Roads were in a dilapidated condition, in many cases the result of the extensive movement of coal. Even so these remained the sole means of moving raw material and finished goods into and out of the town for most of the eighteenth century. Even as late as 1783 Hutton wrote: "The road to Walsall, ten miles, is rather below indifferent. That to Wolverhampton, thirteen miles, is much improved since the coal teams left it. The road to Dudley, ten miles, is despicable beyond description...⁵¹". He continued in a similar vein with his description of the roads to Coleshill, Lichfield, Halesowen, Bromsgrove, Alcester, Stratford and Warwick. Prior to 1767 the nearest waterway was the River Severn at Bewdley. In the same year Parliamentary approval was granted for a canal to be built from Birmingham to Wednesbury, which was later extended to connect with the Staffordshire Canal between Wolverhampton and Tettenhall.⁵² In 1783 this canal was further extended to provide a link with the Coventry Canal and thence to London, and in the 1790s the town was linked to Stourport and Worcester by canal.⁵³

This greatly improved transport system, coupled with the advent of steam power, and the Welsh smelter's cartel, encouraged the brass consumers of Birmingham to look to their own resources. Throughout 1780 meetings were held and proposals made, culminating in November in an agreement for the formation of a company to erect smelting, brass founding and spelter works. Boulton was approached, and made the counterproposal to use an existing copper smelter, and concentrate on the manufacture of brass and spelter. Initially accepted by the interested parties, it failed to come to

fruition because of the insistence of the management committee of undertaking the copper smelting in Birmingham, rather than Swansea. This combined with other disagreements with the committee induced Boulton to withdraw. The company, known as The Birmingham Metal Company, came into being on 11 April 1781, with a capital of £20,000, divided into 200 shares.⁵⁴ The proposal to smelt copper would appear to have been dropped at this time, and never resuscitated.

Despite opposition from local metal dealers and the smelting companies, the new entrant flourished, both to the benefit of the shareholders, many of whom were manufacturers, and its Birmingham customers. Throughout the 1780s copper prices continued to rise which, combined with the success of the Birmingham Metal Company, and the perceived monopoly of Thomas Williams, produced moves for the establishment of a second Birmingham based company, one which would undertake its own copper smelting. Attempts to form a consortium of adventurers, smelting companies and manufacturers came to naught, yet this lack of success failed to dampen the enthusiasm for the formation of another company. Ultimately in 1791 The Birmingham Mining and Copper Company was founded. It was constituted as a co-operative, with shareholders committed to purchasing annually a specific quantity of copper, commensurate with their shareholding. With a capital of £50,000 divided into 500 shares, it embraced many of the constitutional characteristics of the Metal Company, but with the major difference of owning its own smelting works in South Wales. These were to the north of Swansea, on the western bank of the River Tawe.⁵⁵

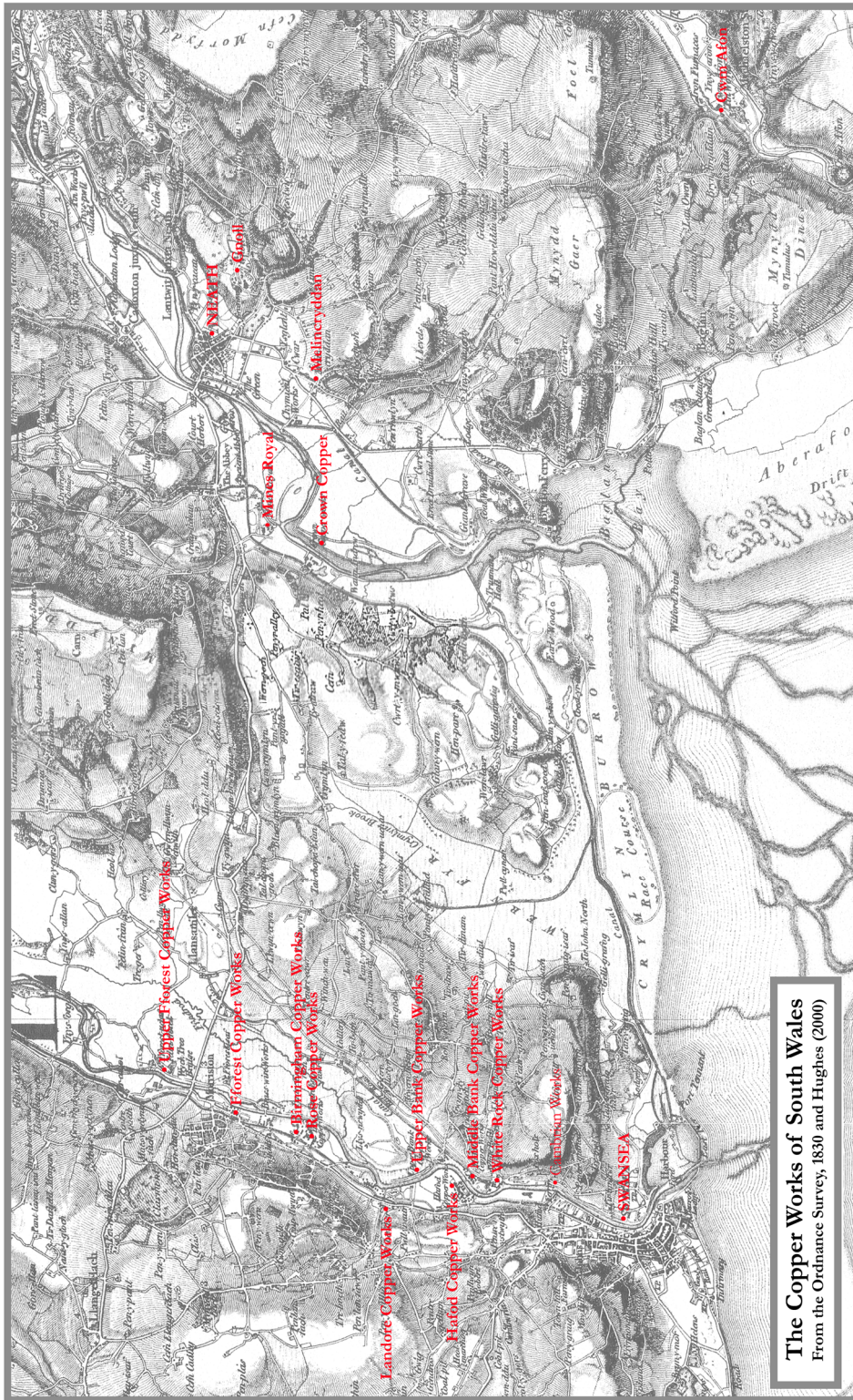
Less is known about the later Birmingham companies. In 1792 a third company was formed by Birmingham businessmen, the Rose Copper Company.⁵⁶ Initially it obtained its copper from the Mines Royal Company,⁵⁷ subsequently shifting to Fenton & Company, whose smelting works, next to those of the Birmingham Mining and Copper Company, were bought by the Rose company in 1797.⁵⁸ Like the earlier companies it

probably also manufactured brass, and possibly spelter. Matthew Boulton was a prominent shareholder and instrumental in arranging the merger with Fenton. It was through the Rose company that he obtained much of his supply of copper for his coinage contracts. The final copper company to emerge from within the Birmingham business sector was the Crown Copper Company. This company was floated in 1803, and smelted its ores at Neath Abbey, the former premises of the Mines Royal Company.

The three Birmingham companies together were able in the closing years of the eighteenth century to restrict the hold on the industry that had been imposed by the smelting companies of South Wales, and Thomas Williams. In so doing they ensured a supply of copper for the manufacturers of the city that was unfettered by economic and political constraint. Hamilton wrote: "The independent spirit of the Birmingham people had triumphed, and the town was able to take first place in the brass and copper industries."⁵⁹

DOMINATION OF THE SOUTH WALES SMELTING COMPANIES

From the time of Elizabeth I, South Wales had been associated with the smelting of copper, although its domination was nowhere near complete until the second half of the eighteenth century. It had significant advantages over the locations discussed above, such that it induced even those seen as rivals by the original Welsh companies to open smelting works in the valleys of the Rivers Tawe and Neath. (Plate VI) This was not surprising given its unrivalled access to suitable coal and limestone in the West Glamorgan coalfield, and access to the sea at Swansea, with tidal waters up to many of the smelters. It was the closest location to the mines of Cornwall, although this could never be considered a comfortable passage for small sailing vessels employed in the shipment of coal and ore to and from Cornwall.⁶⁰ An indication in the growth in traffic is given by the number of vessels using the port:



The Copper Works of South Wales
From the Ordnance Survey, 1830 and Hughes (2000)

| | | | | | |
|----------|------|-------|-------|-------|-------|
| Year: | 1768 | 1790 | 1791 | 1792 | 1793 |
| Vessels: | 694 | 1,697 | 1,803 | 1,828 | 2,028 |

This represented a near threefold increase in 25 years, of which perhaps half would be in the ore and coal trades. Over the same period the tonnage increased from 30,631 tons burthen to 120,828 tons, an increase of the order of 33 per cent in the size of the vessels using the port.⁶¹ In 1768 the smelting companies of South Wales bought 14,243 tons of ore at the Cornish sales. Calculations based on the figures supplied above suggest this would have required some 300 voyages. In the 1790s, John Vivian estimated that between 8,000 and 10,000 tons of shipping was in constant use.⁶²

Between 1729 and 1784 annual sales of copper ore in the Cornish market rose on average by just under 8.5% per annum, of which more than 65% per annum was purchased by the South Wales companies. Over this period the number of their agents attending these sales did not change significantly, increasing from seven in 1729 to a maximum of 12 in 1783. What was significant was the increase in the number of smelters located in South Wales, from three in 1729 to seven in 1784. These seven companies were purchasing in excess of 72% of the ore offered for sale.⁶³

The evolution of these smelting companies was a complex process, with not infrequent change of ownership, and companies being identified by a range of names.⁶⁴ Initially copper smelting was concentrated in the Vale of Neath in the vicinity of Neath and Neath Abbey. For most of the seventeenth century the coal measures in the vicinity of Neath had been in the hands of one family, the Evans. On the death of Herbert in 1686, the control of the property passed, through marriage, to a London member of the legal profession, Sir Robert Mackworth. Thereafter the business was conducted in the name of The Mine Adventurers of England, and as part of its reconstruction, copper smelting furnaces were erected at Melincryddan in 1695. By 1708, Mackworth was converting lead, silver and copper ores, employing a total of 22 furnaces. In 1713 it

became known as The Mineral Manufacturers of Neath. In 1731 the Melincryddan works was taken over by John Coster following the move from Upper Redbrook. They remained at this site until 1739 when they moved to a newly erected smelter at Taibach near Port Talbot. The Melincryddan site was next occupied by the English Copper Company, originally of Lower Redbrook from 1742 to 1763. From then until 1779 it would appear to have been disused, but in that same year it was taken over by the Gnoll Copper Company, who continued to occupy it up to 1796. Copper smelting finally ceased with the site's closure in 1804.

In 1710 a second copper works were erected at Neath Abbey by Dr John Lane of Bristol and John Pollard, both of whom had interests in Cornish mining. In 1717 they moved to Llangyfelach in the parish of Landore to take advantage of the improved access to the sea and coal. There they remained until circa 1726, when the works were taken over by Richard Lockwood & Company.

Richard Lockwood & Company continued at Llangyfelach until 1748, but increased their facilities by building a new smelter, the Cambrian Works, in 1720. This they occupied until 1745, Following its disposal it was converted into a porcelain factory. In 1748 Lockwoods moved northward up the River Tawe, establishing a new smelter at Upper Fforest and the adjacent industrial village of Morristown. This they occupied until 1790, when they sold the works to the Bristol firm, Harfords & Bristol Brass & Copper Company. Harfords remained there until no later than 1833, at which date the company ceased to be a copper and brass manufacturer. Lockwoods continued to operate the Landore facility until the early nineteenth century. By 1810 they had ceased submitting to the ticketings in Cornwall.

A new smelter, the White Rock works, on the River Tawe was built in 1738. This was the successor to John Coster's facilities at Melincryddan and Upper Redbrook. Within a year, following the deaths of the Coster brothers, the ownership of the White

Rock works was in the hands of Joseph Percival & Copper Company. In 1770 the company underwent a further name change, becoming John Freeman & Company. It continued to smelter copper ore until the third quarter of the nineteenth century.

In 1780 the Leeds based firm, Fenton & Chacewater Company erected a smelter adjacent to Lockwood's Landore works. These were taken over in 1797 by the Rose Copper Company who continued to occupy the works up to 1822. Of the other two Birmingham companies, the Birmingham Mining & Copper Company erected their smelter in 1791 at Ynys Howell between the Rose and Fforest works, where it remained until 1833, and the Crown Copper Company who between 1803 and 1839 occupied the rejuvenated Neath Abbey works.

Two new works, Middle Bank (1755) and Upper Bank (1757), were erected on the east bank of the River Tawe just to the north of the White Rock works. These were owned by the London based company, Chauncey Townsend & Company. This company also owned coalfields in the vicinity, and lead and zinc mines in mid-Wales. The Middle Bank property was a copper smelter. By 1769, following Townsend's death, its ownership had been transferred to George Pengree & Company. In 1787 they were bought out by Thomas Williams, and managed by the Stanley Company on behalf of the Mona Mine Company. Williams retained ownership until his death in 1802.

The Upper Bank works were initially used in the production of lead and zinc, but in 1782 ownership was also transferred to Thomas Williams. He converted it to copper smelting, and operated it on behalf of the Parys Mine Company. Ore was mainly obtained from Cornwall, purchased by his Cornish agent, John Vivian. On his death in 1802 the works were transferred to his son Owen, long time associate Pascoe Grenfell, and Grenfell's brother William. Trading as Williams Grenfell & Company, this firm in various guises continued to smelt copper at these works into the twentieth century.

John Vivian, recognising the benefits to be derived from smelting rather than mining, a lesson he is said to have learnt from his relationship with Thomas Williams, moved in the early nineteenth century to Swansea. In 1792 the Cheadle Company had commenced smelting at Penclawdd, situated to the west of Swansea. In 1800, for reasons of finance and expertise, John Vivian entered into partnership with the company. Whilst a satisfactory arrangement, Vivian in 1808 recognised the benefits to be gained by a move to the Swansea valley, and in 1809 erected a new smelter at Hafod in partnership with his sons, John Henry and Richard Hussey. (Plate VII) The company, John Vivian & Sons, expanded rapidly, rivalling the operations of Grenfell, Williams & Company.⁶⁵

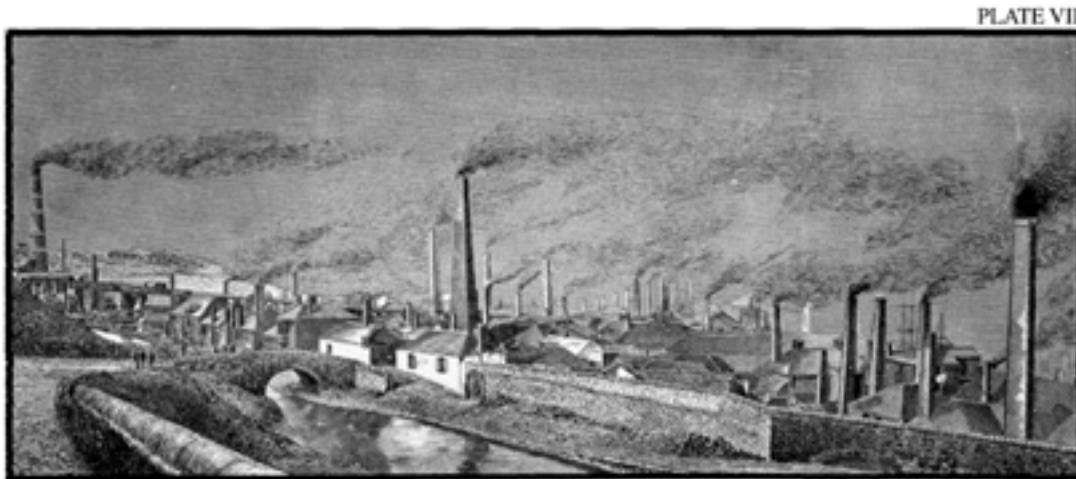


PLATE VII

The Copper Smelting Works of John Vivian & Sons at Hafod, Swansea.

The Mines Royal Company evolved from The Governor and Company of Mines Royal who received their royal charter in 1568. In the 1690s the company lost its Royal Charter and monopoly of copper mining, becoming the Mines Royal Company. In 1694 they established themselves at Neath Abbey where they remained till the third quarter of the nineteenth century, making them the longest serving copper firm in the two valleys. The final firm to be noticed is the Welch Copper Company, also situated in the vicinity of Neath Abbey. Little is known in respect of this company, other than it was founded in 1694 as the Governor and Company of the Copper Mines of the Principality of Wales. It was still in existence in 1756, but had ceased buying at the Cornish ticketings in 1751.

The increase in the number of companies smelting copper in the Tawe and Neath valleys was accompanied by both improvements in technology and capacity. Some indication of the increase in capacity may be gleaned from the following. In 1691 at Coster's Upper Redbrook smelter there were ten reverberatory calciners, plus two further smelting furnaces, prior to the raw copper's refinement in a blast furnace. This hybrid process remained much the same for the next 30 years, in which time the number of furnaces had been increased to 26. The earliest of the South Wales works, such as those at Llangyfelach and Melincryddan, were of similar form.⁶⁶ Productivity was low, smelting in these early years being a time consuming process. In 1729, the smelting companies of South Wales bought 941 tons of ore in Cornwall.⁶⁷ Even allowing for some additional purchases elsewhere, probably quite small, the output of copper would have been of the order of 100 to 150 tons, assuming a yield of ten to 15 per cent. At Lockwood's Fforest copper works in 1775 there were 21 smelting furnaces, 2 refineries and 11 calciners in operation. This installation was capable of producing 473 tons of copper per annum.⁶⁸ At Hafod in 1809, there were a total of 27 furnaces, increased to 36 by 1819. Although roughly similar in number the individual sizes of the various furnaces had increased, allowing for a greater throughput. In 1809 the ore calciner accepted a charge of 40 cwt which required nine hours to treat, by 1823 the charge had risen to 69 cwt and the time had been reduced to 3.5 hours. In 1809 for the second calcining,⁶⁹ the metal calciner accepted a charge of 32 cwt and required 15 hours to complete, in 1823 the charge had risen to 65 cwt with the time reduced to 7.5 hours. Similar improvements were apparent in the smelting and refining processes, clear evidence of the improving efficiency of the 'Welsh Process'.⁷⁰

In the introduction to this chapter it was suggested that the preconditions for the smelting industry were ready access to copper ore, fuel, the consumer, and an efficient transport infrastructure. In general, the locations described fulfil at least two of these

criteria, the sole exception being the Cornish Copper Company. Only one largely satisfied all three, the two smelters in Lancashire operated as part of Williams' consortium. Their locational advantage was further assisted by the calcining of the ore at both the site of the mines on Parys Mountain, and the smelters in the port of Amlwch on Anglesey. Notwithstanding these advantages, Williams still felt it necessary to engage in smelting in South Wales, in common with the Bristol and Birmingham companies. The Bristol companies were amongst the earliest to make such a move, recognising the advantages inherent in the two valleys of the Rivers Tawe and Neath. They were still in reasonable proximity to their customers, closer to the source of ore, and located on a coal field. Harbours at Swansea and Briton Ferry gave access to the necessary transport infrastructure. Increasing concentration also enabled a more rapid growth in the technology of smelting, a result of mobility amongst a skilled workforce, coupled with the opportunity for commercial cooperation. The ascendancy of copper smelting in South Wales was due in no little part to its locational advantages, but a significant contributory factor would be its rapid growth, enabling it to be strong enough to counter any threat from elsewhere. It was this combination of factors which enabled it to be the focus for the smelting industry for the best part of two centuries, not just in Britain, but throughout the world.

NOTES

- ¹ Hendrie, R (ed.), 'An Essay Upon Various Arts', *Three Books by Theophilus*, (John Murray, London; 1847), 305.
- ² Percy, J. (1861), 500.
- ³ Day, J. (1973), 26.
- ⁴ Jenkins, R. 'The Copper Works at Redbrook and at Bristol', *Transactions of the Bristol and Gloucestershire Archaeological Society*, (1942), 150 – 162. Hamilton, H. (1967), 101 – 102, 244 – 45.
- ⁵ Day, J. (1973), 29 – 32. Jenkins, R. (1942), 163 – 64.
- ⁶ Day, J. (1973), 35.
- ⁷ Day, J. (1973), 40.
- ⁸ Day, J. (1973), 44.
- ⁹ Stephens, R A. 'A Short History of Baptist Mills Brass Works, Bristol', Living Easton, September 20th 1999 <www.csm.uwe.ac.uk/~rstephens/livingeaston/local_history/brass1.html> (7 Aug 2002).
- ¹⁰ Brooke, J. (trans.), (2001), 39.
- ¹¹ Brooke, J. (trans.), (2001), 41.
- ¹² Brooke, J. (trans.), (2001), 22.
- ¹³ Brooke, J. (trans.), (2001), 35.
- ¹⁴ Pryce, W. (1778), 287.
- ¹⁵ Jenkins, R. (1942), 156.
- ¹⁶ Jenkins, R. (1942), 158 – 59.
- ¹⁷ Day, J. (1973), 78.
- ¹⁸ Day, J. (1973), 82.
- ¹⁹ Day, J. (1973), 73 – 93. Hamilton, H. (1967), 154 – 56. Jenkins, R. (1942), 165.
- ²⁰ Hamilton, H. (1967), 154.
- ²¹ Day, J. (1973), 125 – 26. Japanned copper was manufactured by immersing the refined metal in hot water, and forming a slight oxidisation on the surface.
- ²² Day, J. (1973), 223.
- ²³ Carew, R. (1811), note q, 21 – 22. Pascoe, W H. *CCC*, (Dyllansow Truran, Redruth; nd), 21. Rowe, J. (1953), 19.
- ²⁴ Fiennes, C. 'Through England on a Side Saddle', Pearse Chope, R.(ed), (1967), 126.
- ²⁵ Carew, R. (1811), note q, 21 – 22. Pascoe, W H.(nd), 21.
- ²⁶ Hitchens, F and Drew, S. (1824), vol 2, 553. Pascoe, W H. (nd), 21.
- ²⁷ Pascoe, W H. (nd), 24– 27.
- ²⁸ Hitchens, F and Drew, S. *The History of Cornwall*, (Penaluna, Helston; 1824), vol 2, 553 – 56.
- ²⁹ Pryce, W. (1778), 279 – 80. See also Vale, E. *The Harveys of Hayle*, (D Bradford Barton, Truro; 1966); 37 – 38.
- ³⁰ Jones, H. (1985), 21.
- ³¹ Jones, H. (1985), note 23. 37. Considerable caution must be exercised in the conversion of weys, a measure of volume, to tons, a measure of weight. The conversion factor varied by location and commodity. Jones cites the conversion as 5.5 tons to a wey at Neath in 1713.
- ³² Newell, E. (1988), 42. He assumed a two to one ratio of coal to ore.
- ³³ See the paragraphs on smelting in Chapter 2.
- ³⁴ Barker, T C and Harris, J R. *A Merseyside Town in the Industrial Revolution – St Helens, 1750 – 1900*, (University Press, Liverpool; 1954), 75. Hamilton, H. (1967), 111.
- ³⁵ Barker, T C and Harris, J R. (1954), 76.
- ³⁶ Roberts, R. 'Copper and Economic Growth in Britain 1729 – 1784', *National Library of Wales Journal*, 10, 1, (1957), 69 – 73.
- ³⁷ Robey, J A and Porter, L. (1972), 67.

- ³⁸ Barker, T C and Harris, J R. (1954), 76.
- ³⁹ Rowlands, J. (1966), 24.
- ⁴⁰ Roberts, R. (1957), 69 – 73.
- ⁴¹ Hamilton, H. (1967), 157.
- ⁴² Barker, T C and Harris, J R. (1954), 78. Harris, J R. (1964), 37.
- ⁴³ Barker, T C and Harris, J R. (1954), 80. Harris, J R. (1964), 52.
- ⁴⁴ Barker, T C and Harris, J R. (1954), 81.
- ⁴⁵ Barker, T C and Harris, J R. (1954), 89.
- ⁴⁶ Cockshutt, E. (1966), 108 – 109. Rowland, J. (1966), 37.
- ⁴⁷ Anon, *Universal British Directory*, vol 5, (London; 1791), 7.
- ⁴⁸ Anon, *Universal British Directory*, vol 5, (London; 1791), 8.
- ⁴⁹ Harris, J R. (1964), 37.
- ⁵⁰ Hunt, R. (1887)122.
- ⁵¹ Hutton, W. (1783), 259 – 65. Anon, *Universal British Directory*, (1791), vol 2. 203 – 04 and 243.
- ⁵² Hutton, W. (1783), 266 – 69.
- ⁵³ Hamilton, H. (1967), 216.
- ⁵⁴ Day, J. (1973),106. Hamilton, H. (1967), 218 – 24.
- ⁵⁵ Hamilton, H. (1967), 234 – 35. Hughes, S. (2000), 112 – 13.
- ⁵⁶ 1799 Report, 667. Harris, J R. (1964), 109.
- ⁵⁷ Grant–Francis, G. (1881), 77.
- ⁵⁸ Hamilton, H. (1967), 236.
- ⁵⁹ Hamilton, H. (1967), 239.
- ⁶⁰ The earliest reference to the transport of copper ore to Wales in the eighteenth century was found in a contemporary copy letter dated 1 Jul 1704: 'We have received the favour of y^{rs} of the 24th past together wth a protection for y^e Two Brothers of Truro w^{ch} proves altogether useless y^e vessel being as we are told already Loaden wth Copper oar for Wales...' Letter Book of the Tin Contract, Truro; 1703 – 10.
- ⁶¹ *Universal British Directory*, vol 4,(1791), 520.
- ⁶² 1799 Report, 657.
- ⁶³ Roberts, R. 'Copper and Economic Growth in Britain 1729 – 1784'. *National Library of Wales Journal*, 10, 1, (1957), 65 – 74.
- ⁶⁴ In this and the remaining paragraphs (bar the conclusion) numerous sources have been consulted in an effort to arrive at a sensible evolution of the various firms with some degree of chronological rigour. References consulted included: Day, J. (1973): Hamilton, H. (1967): Harris, J R. (1964): Grant Francis, G. (1881): Hughes, S. (2000): Hughes, S and Reynolds, P. *A Guide to the Industrial Archaeology of the Swansea Region*, (RCAHMW, Aberystwyth; 1992): Rees, W. *Industry before the Industrial Revolution*, (University of Wales Press, Cardiff; 1968): Roberts, R O. 'The Development and Decline of Copper and other Non–ferrous Metal Industries in South Wales', *Transactions of the Honourable Society of Cymmrodorion*, (1955): Roberts, R. (1957), Toomey, R R. *Vivian and Sons, 1809 – 1924*, (Garland Publishing, New York, USA; 1985).
- ⁶⁵ Toomey, R R. (1979), 8 – 14.
- ⁶⁶ Hughes, S. (2000), 19 – 20.
- ⁶⁷ Roberts, R. (1957).
- ⁶⁸ Percy, J. (1861), 501.
- ⁶⁹ See Chapter 2.
- ⁷⁰ Toomey, R R. (1979), 282.