The Avon Valley Copper and Brass Industry

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Saltford Brass Mill Project

Introduction

From the late 1600s until the early 1900s, the Avon Valley was home to a range of people engaged in the processing of copper, zinc and brass. Early investigations were transformed into an industry which reached its zenith around 1750. The aim of this paper is to provide a short account of that industry, from its inception in the late 1600s, when people first began smelting Cornish copper using Bristol coal on the banks of the River Avon, until around 1750 when the Avon Valley led the world in technical skill and production capacity. Thereafter the focus of the copper industry moved to South Wales, where there were more plentiful supplies of coal, and the brass industry moved to Birmingham where emerging industrial markets came to dominate new demands.

The paper draws heavily upon 'Bristol Brass, a history of the industry', published in 1973, supplemented by new sources which have subsequently emerged, some quire recently.

The industry is complex. The approach adopted in this paper is to describe the evolution of the industry by considering the production process for the manufacture of brass pans, vats and kettles (collectively known as hollow-ware), plus brass wire and sheet, from the raw materials available to the early industrialists; copper ore, coal and calamine (zinc carbonate, the available zinc ore). The process commenced with copper smelting to produce metallic copper for the manufacture of copper vessels, and providing one of the raw materials for brass-making. It then proceeded to calamine mining and processing, also required to enable brass-making. The techniques for brass-making were acquired from continental centres of the industry, along with which were acquired the techniques for brass-manufacturing, including: the use of water-powered battery hammers to produce hollow-ware; later followed by the introduction of water-powered rolling, slitting, and drawing to produce wire; and finally the production of brass sheet by the use of wide bed rolls. Superimposed upon these developments was the requirement to perfect the use of coal as a fuel, in particular overcoming the harmful effects of sulphur, the requirement to master the release of zinc from its ore and the requirement to establish an efficient means of annealing the product to retain its malleable properties.

Copper Smelting

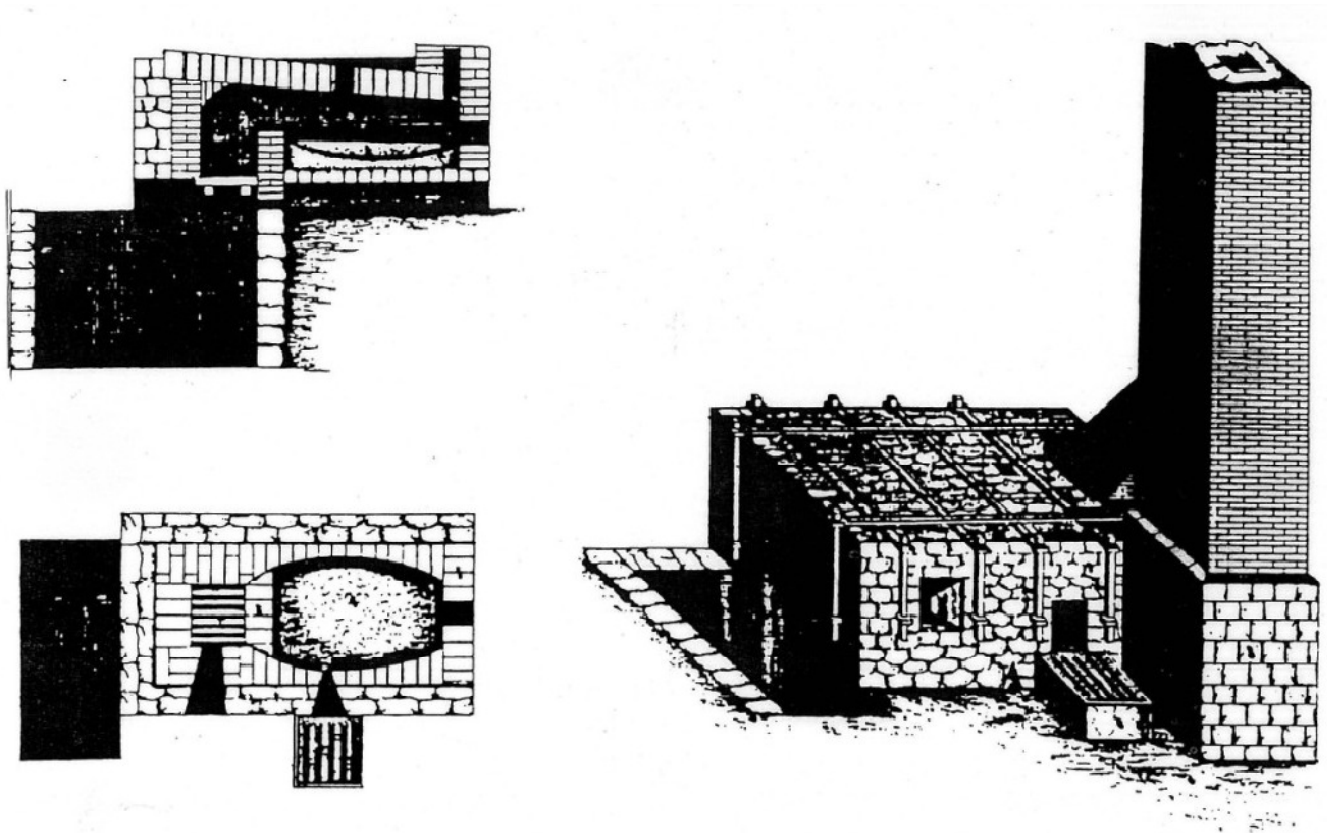
The Avon Valley copper industry originated in the late 1600s. In the late seventeenth century, Government restrictions on the production of copper and brass, aimed at protecting Government monopoly rights, were relaxed, allowing emerging industries to create an indigenous capability for the production of non-ferrous metals and break our reliance on imported materials. Ancient sources of copper ore, such as those once mined in North Wales, had been fairly simple to process, but these had long been worked out. The ores

available in the late 1600s were more complex, the main ore being copper pyrites, $Cu_2S.Fe_2S_2$, or chalcopyrite. The smelting of this ore requiring an involved process of alternatively calcining and smelting to produce reasonable purity copper. Techniques developed on the continent to perfect this process used charcoal as a fuel.

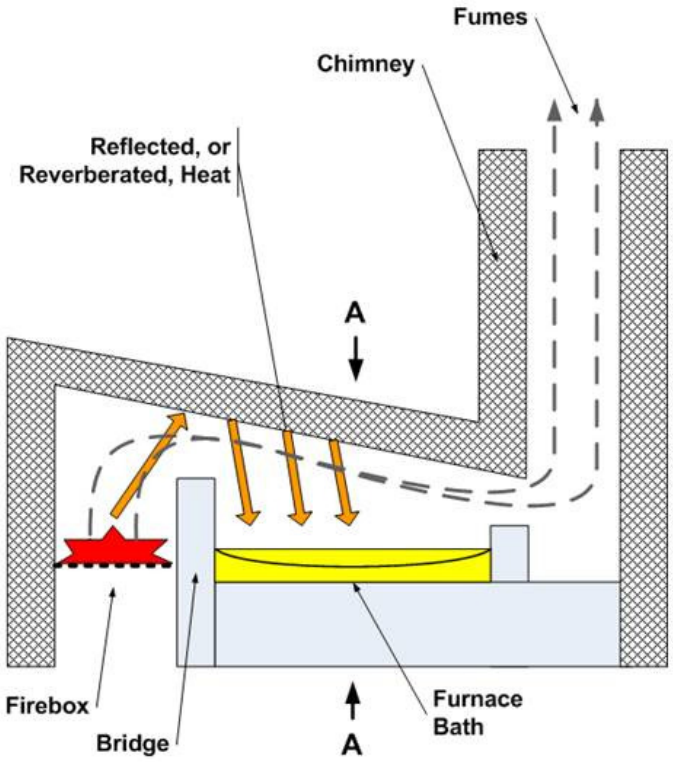
However, such techniques were ruled out in the United Kingdom due to restrictions on the use of charcoal caused by the depletion of woodland and the reserving of home timber for naval and military use. Smelters in the emerging industry were therefore forced to find an alternative fuel, that fuel being coal. But this brought its own problems, in particular the management of sulphur. Innovation overcame those problems, particularly in Bristol, where a new type of coal-fired furnace, the reverberatory furnace, anciently called an air furnace, was developed, which separated the sulphur containing combustion products from the metal being processed (Figure 1). This was to enable the successful coal-fired production of copper.

The key person responsible for establishing the copper industry in the Avon Valley was John Coster, son of an iron smelter from the Forest of Dean, where the introduction of coal-firing had been investigated. Other leaders in the Bristol industry included Gabriel Wayne, a former assistant of Coster in the early years of development, who starting a smelting site besides the River Avon at Conham during the mid-1690s. By the turn of the century small supplies of metallic copper were becoming available, not of the highest quality, and not all of the drawbacks were understood, but there were prospects of better to come. This early progress in copper production roused interest in wider uses of this new local source of the metal.

In 1711, a group of copper manufacturers in various parts of the country combined with leaders of Bristol brass to petition Parliament for protection against imported goods. They included Edward Lloyd, Benjamin Coole, and John Hitchcock, all proprietors of the brass company who claimed, with others, that they were providing employment for many thousands of the country's poor, when, formerly these goods had come from the continent through Holland. London importers were equally anxious to guard their favoured position, as their foreign goods had received protection from some import duties, being formerly the only source of such supplies. Much was written, officially and more widely, and an opportunity was taken for a sly attack against unnamed Quaker producers. London importers were in a strong position and no Government action was taken. In a few years, these attitudes were seen to be changing.



The Reverberatory, or Air Furnace, as recorded by Schlüter 1738



Operation of the Reverberatory Furnace

Figure 1 The Reverberatory or Air Furnace

Brass Production

On 25 July 1700 a group of five Bristol Quakers petitioned the Privy Council for a Charter of Incorporation to manufacture brass; the alloy of copper and zinc. Earlier efforts to produce brass in the United Kingdom, including at Tintern on the River Wye, had ended in failure, but the prospect of locally produced copper provided a great incentive for entrepreneurs in the Avon Valley. Nothing practical appears to have arisen from this original petition, but Edward Lloyd, one of the original group of Quakers, joined a new Quaker partnership two years later.

In 1702, this new company set out to make brass at Baptist Mills, a small community a few miles north of Bristol. Included in their number was Abraham Darby, a Quaker from Dudley in the West Midlands who had moved to Bristol in 1699, having completed an apprenticeship as a malt-mill maker. This may well have involved producing components in brass, possibly from recycled waste or imported alloy from continental sources. Whatever the reason, Darby must have shown leadership qualities quite quickly to be named as the 'active man' in the partnership after just three years in the city.

The newly created company appears to have set out from the start to copy the latest techniques from the continental manufacturers, where a large trade in brass 'hollow-ware' had been built up by producers, supplying experienced Dutch merchants who had established trade routes overseas, especially to parts of Africa and other undeveloped territories. In Bristol, as one of the country's major ports involved in overseas exploration and trade development, there was a strong desire to match these Dutch activities

The prospect of new production techniques must have made it desirable for Abraham Darby, as 'the practical man of the company', to go to the continent in search for men experienced in the latest techniques of brass production. A later account, written by the daughter of one of his employees, described Darby travelling to Holland for this purpose, in around 1704. He must have strayed further into the Low Countries, between the rivers Meuse and Rhine, as is confirmed by the origins of some of the immigrants later known to be working for the company.

On the continent, calamine, the zinc carbonate ore, had been mined to make brass from ancient times between the rivers Rhine and Meuse and the ancient city of Aix-la-Chappelle, where there were also limited sources of copper ores. This area had been ruled by various countries, including France, Holland and later Germany, when the city acquired its modern name of Aachen. There, in the early 1700s, powerful catholic bishops were intent on depriving work from its protestant citizens by means of ancient guilds guarding traditional methods. Many brass workers there had converted to Protestantism by this time, and avoided problems by joining the growing protestant community of workers at nearby Stolberg, just outside the bishops' jurisdiction. Others may have been among those persuaded by Darby to come to Bristol, although it has been impossible to identify precise origins of the earliest immigrants in the first decade of the century.

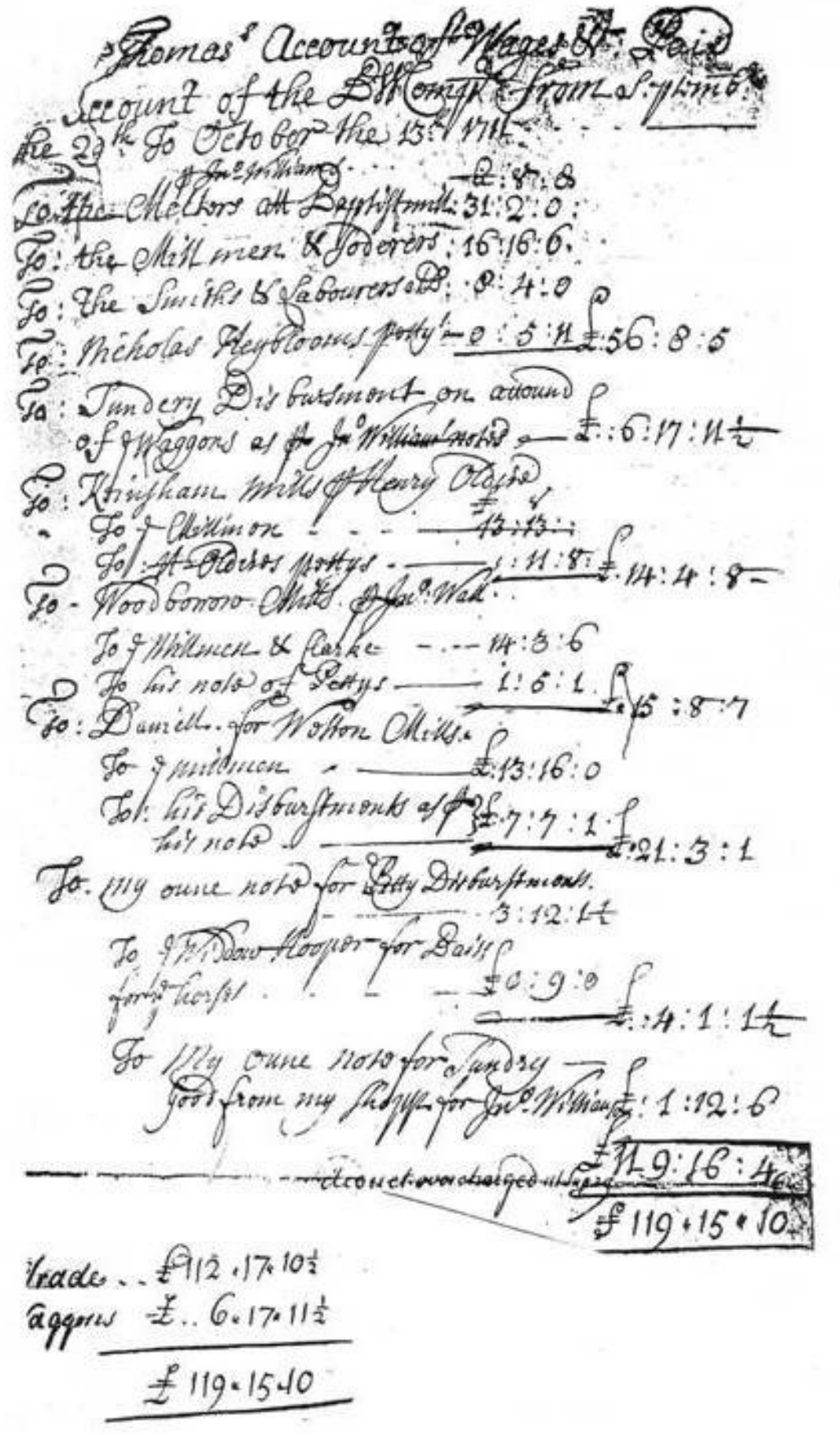


Figure 2 Bristol Brass Company Accounts - 1711

Important evidence has recently come to light which emphasises the significance of Baptist Mills and the immigrants attracted here by Darby. The evidence comprises a single-page of expenses, dated '29th September to 13th October (Figure 2), 1711, and lists Henry Oldise, a Protestant immigrant from the Low Countries, possibly the manager of the Baptist Mills. The accounts also refer to a combination of 'melters' (makers of brass) and 'millmen' (manufacturers of hollow-ware). Millmen are recorded as working at a number of sites in the Avon Valley; whereas 'melters' are only recorded at Baptist Mills, indicating that originally, the headquarters site was then solely responsible for producing brass.

Later still, in the 1720s, Heinrich Kahlmeter, of the Swedish Board of mines on a fact finding mission to gain information on the rapid progress made in British metallurgical industries, noted that many of the skilled workers at Baptist Mills had originated from the area around Aix-la-Chappelle.

The brass-wares it was proposed to manufacture ranged from very large vessels such as vats, to varying sizes of pans to carry goods or liquids in industrial or domestic situations. All were known as 'battery' from the beaten methods of construction. The manufacture of such vessels required high quality brass as the retention of impurities into the brass, such as iron (a constituent element of the copper ore), lead (often found in the same veins as the zinc ore, calamine) or sulphur (released by the combustion of coal) would cause the product to crack when worked. The standards of the component copper and zinc metals making up the brass alloy would demand serious attention.

The progress achieved at Conham, 3 miles up-stream from Bristol, in smelting complex Cornish copper ores had been with the objective of trading in copper metal or for production of copper goods. Once higher standards of refinement were accepted as a requirement for good-quality battery brass, Nehemiah Champion, originally under his own initiative, implemented plans to conduct these complicated and lengthy processes for copper production at a new site on the Avon riverside at Crews Hole, a mile or so downstream from Conham, on the outskirts of Bristol, but still separate from brass-making at Baptist Mills. By the 1720s, both the Crews Hole site and Champion were part of the brass company organisation.

With regards brass making, it appears that at Bristol, attempts had been made to introduce coal into the brass making process quite early in the century but only partially so. It is difficult to judge just how different the Baptist Mills brass making was at this stage, compared with the continental practices, where traditional brass furnaces had been entirely charcoal-fired. The change was not a straight-forward process. Undoubtedly, much experimentation was needed there in adapting the process to coal fuel, but there are no records of brass production at the headquarters site in these early days.

Illustrations of continental brass-works suggest that chimneys were fairly insignificant, whereas very substantial chimneys are recorded in the earliest-known images of the Baptist Mills site, dating from around 1734. Improvements had probably been made experimentally in the earlier years to exploit the benefits coal while coping with the harmful effects of sulphur. Other basic furnace features seem similar to those used traditionally.

Each set of three furnaces would have been worked back-to-back with another set of three in a separate compartment, all below working-floor level and exuding to one very substantially-built chimney. Each individual furnace cavity was divided horizontally in two, the lower level providing ash collection and a large air access from the exterior of the building (Figure 4). The upper furnace cavity had a depth of about 3.1/2ft, to house a number of large crucibles, with seven or eight reported variously at Baptist Mills. These were set internally with charcoal, and raw materials of refined copper in small broken pieces, and calamine which had been reduced by heating to small powdery lumps of zinc oxide. The filled Stourbridge clay crucibles would be surrounded by supplies of coal or the traditional charcoal. Each one of the set of three furnaces had an opening, said to be about a foot diameter at its top and only accessible from above at the working floor level, the only normal opening to the oven interior. The furnace lid at this level was left open, then partly closed and finally fully closed, in that order and with timing according to the requirements of the process, which lasted about twelve hours, giving two working phases per day. Management of large numbers of furnaces to the varying temperatures required, needed teams of highly skilled men, who could be relied upon to produce good supplies of quality brass.

By the early 1720s, Nehemiah Champion Jnr was in control of the company and it is clear that major improvements had been made to the basic continental brass-making methods. This enabled the production of high-quality brass which was being used for the manufacture of hollow-ware goods which were beginning to be exported widely.

In 1723 Champion acquired a patent, Patent No 454, relating to two major improvements in production. The first part of the specification was aimed at increasing the levels of zinc absorbed by copper during the furnace process. This was achieved by granulation of copper, thus replacing the larger broken pieces previously used. At the appropriate temperature, the small granules quickly absorbed a far greater proportion of zinc vapour which, in the old method, had gone to waste. The idea had taken a lengthy series of experiments to devise a practical working system, and eventually resulted in a far greater proportion of metal produced from the same quantities of raw materials. The idea of granulation was said to have been very loosely inspired by improvements in lead shot production which had been introduced in the 1690s by John Houghton in Bristol. It is clear that Nehemiah Champion junior had been working for some years to find the best procedure to adapt the idea.

Calamine Mining and Processing

The difficulties were far less in supplying zinc, the other component required for the alloy. Calamine, the carbonate ore of zinc had been known to exist on Mendip from the late 1500s which had led to the export of these high quality ores to European brass producers for the past fifty years, and was believed to need much simpler preparation which could be carried out at Baptist mills.

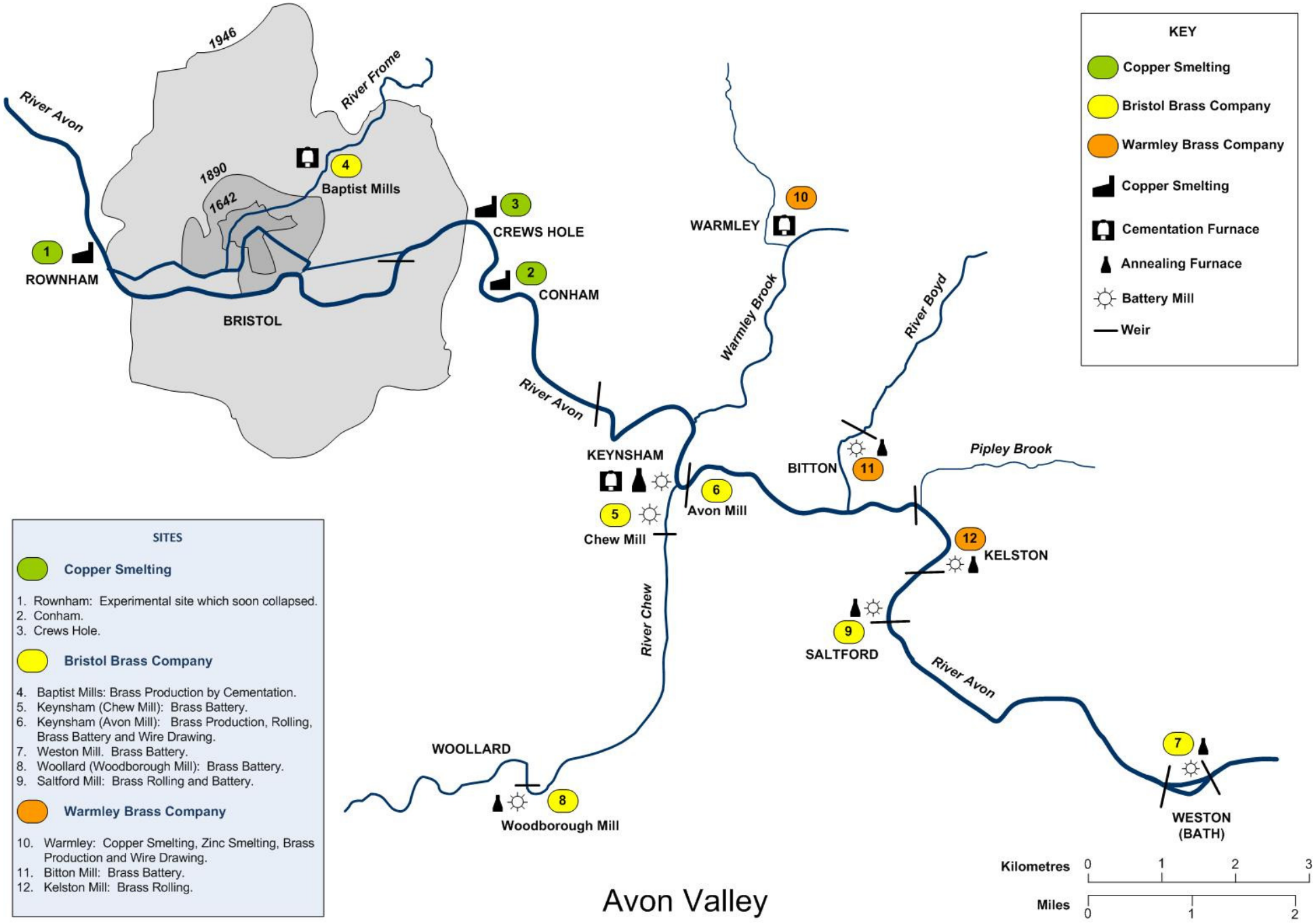


Figure 3 Avon Valley

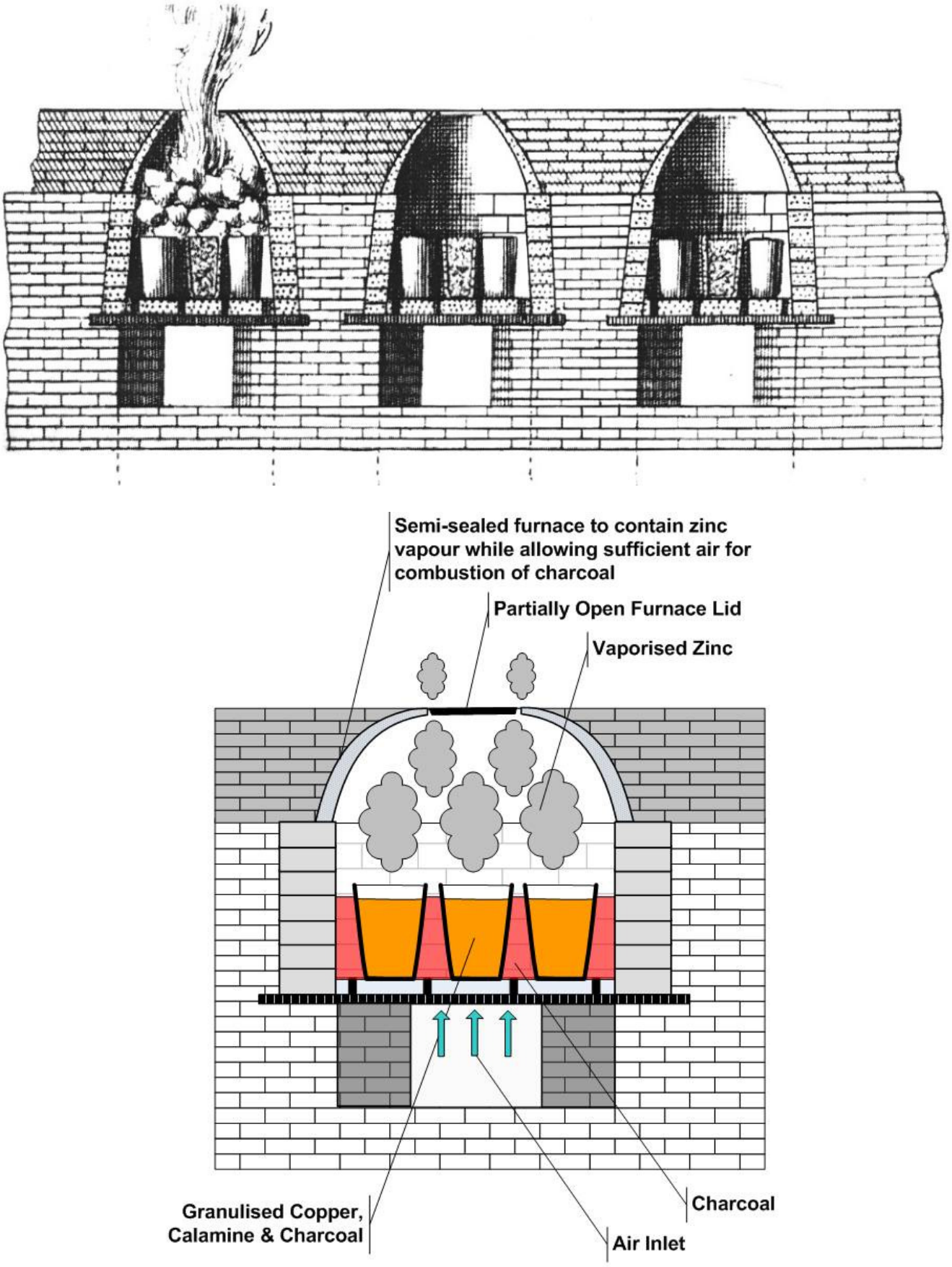


Figure 4 Cementation Furnace for Brass Production

Hollow-ware Production

The molten brass produced by the 'melters' at Baptist Mills was cast into slabs, approximately ¼" thick. These were then cut into smaller blanks, known as naps, which were then beaten into hollow-ware pans, vats or kettles. The production of hollow-ware therefore required not only the production of brass metal, but also the skills to operate water driven, trip hammers, or battery hammers, (Figure 5) to produce the range of pans, vats and kettles destined for the domestic and export markets.

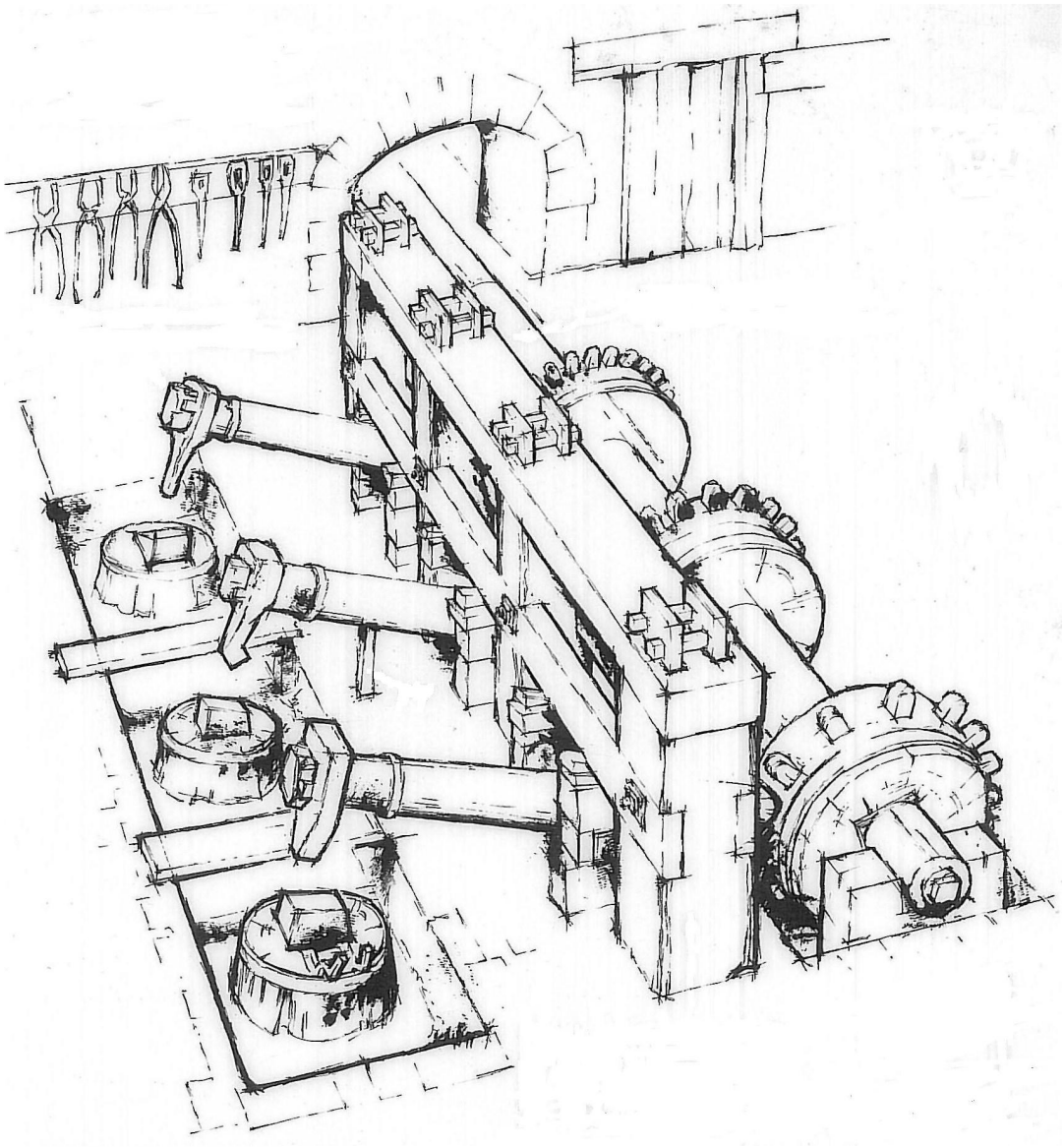
On return from the continent, with good prospects of a source of skilled battery workers in addition to brass makers, Darby and his partners at Baptist Mills must have recognized the urgent need of additional water-power to satisfy their plans. The water levels of the Bristol Frome at Baptist Mills were known to have fluctuated, and at full strength could only supply limited power to the site. If the company was to achieve their brass-manufacturing aspirations a more powerful source of water-power would have to be found.

The first expansion was to acquire the use of a mill on the River Chew at Keynsham, 6 miles from Baptist Mills. In June 1705, only three years after the company's formation, a lease was acquired on Downe Mill; Abraham Darby being one of the signatures on the lease. Downe Mill was an established mill, which had once belonging to Keynsham Abbey, located on the River Chew, just above its confluence with the River Avon. The mill, renamed Chew Mill after conversion to a battery mill, consisted of three separate sets of three hammers, each set operated by a waterwheel. Thus, this new mill-site was able to power a total of nine hammers in all. Presumably, this followed a pattern which Darby saw in the region of Aix-la-Chapelle, and this may well have become the pattern of working hammers at all of the company's sites in due course.

By 1711, additional mills had been acquired at Woodborough, also on the River Chew, 4 miles upstream from Keynsham, and at Weston, on the outskirts of Bath on the River Avon, 11.5 miles from Baptist Mills. By 1740, two additional mills had been added; the Avon Mill, on the River Avon at Keynsham, close to the Chew Mill, and finally Saltford Mill, between Bristol and Bath, 7.6 miles from Baptist Mills.

The recently discovered accounts of 1711 suggest that by that time a combination of 'melters', 'millmen' (or hammer-men) and 'soderers' (or solderers) were being employed at Baptist Mills, with 'melters' comprising about half the total. The millmen may have been engaged on battery work, or they may, in conjunction with the solderers being employed on finishing tasks, preparing the produce of the battery mills for market. Payment to 'millmen' was more or less comparable to men of the three other sites listed: Keynsham's Chew Mill; Woodborough Mill; and Weston Mill.

The inclusion of similar workers at Woodborough Mill in this 1711 record was unexpected. Upstream from Compton Dando on the River Chew, this mill had not been known to be part of the brass industry at this early time, although well recorded somewhat later in the century, when three waterwheels, each operating three hammers were listed. Such an early participation of this rather more remote site indicates a strong drive for maximum production, only eight years after the company had been founded.



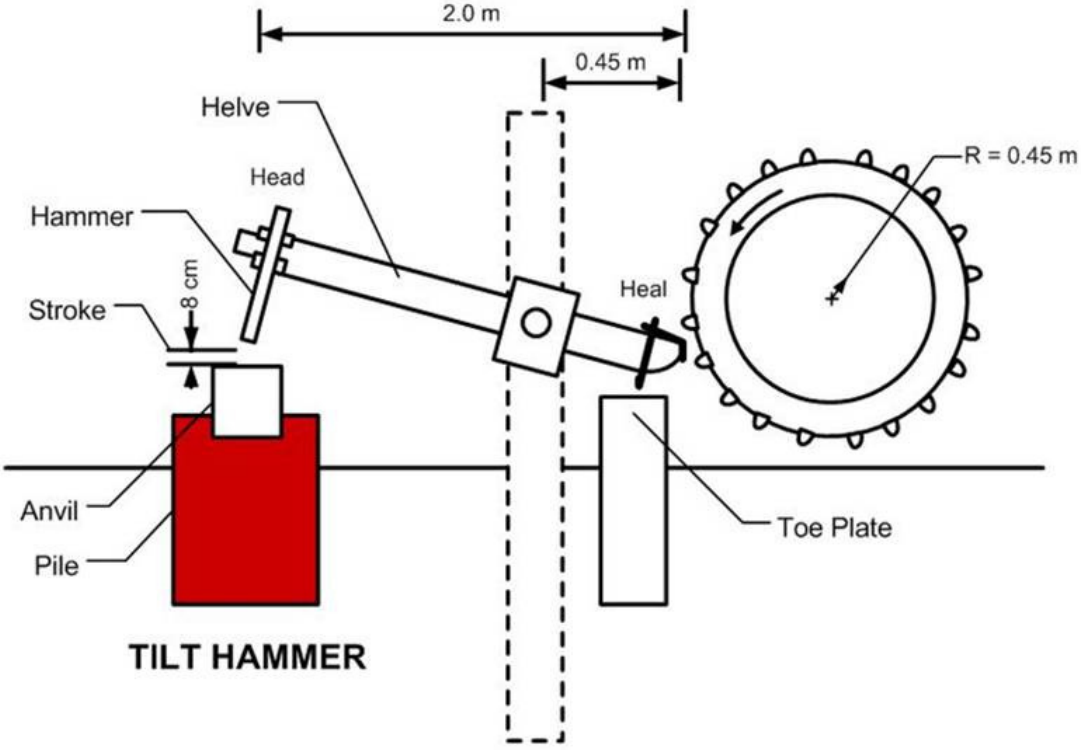


Figure 5 Battery Hammers

Further surprising payments to workers include those at Weston Mill on the north bank of the river Avon, West of Bath. Involvement in brass working there had been well noted later in the century, but not previously at this early date. Similar numbers of millmen there are suggested by the payments listed. As at Keynsham, there are records of immigrant workers in the church records at Twerton, which, is on the southern side of the river, but linked by ferry, where the men were probably housed. A plaque is still to be seen inside the church records an immigrant family from 'Veit' in Germany, a name which seems to be a haphazard adaptation of Vicht, an outlying village close to Stolberg.

In this era of increasing competence in technical expertise, the company was also adding to its production facilities, by occupying an additional mill at Saltford in 1721. Earlier records of this ancient site refer to a previous use in fulling woollen cloth. Situated on a slight bend on the Avon, it offered prospect of greater power compared with previous mill-sites on the River Chew occupied by the company. The earliest company documents refer to it as a copper mill, and although such use may have been contemplated, there are no records of this specific activity. Originally, the mill appears to have been adapted solely to house battery-hammers, very probably, as elsewhere, by powering three hammers with each of one of three waterwheels.

Annealing

The second part of Patent No 454, involved a significant improvement in the annealing of brass during its working processes and again, must have been based on some years of experimentation. Continuous cold-working, such as the continuous hammering of brass sheet to shape up the hollow-ware, eventually produced a condition known as work-hardening, in which the physical structure of the metal itself becomes distorted and if continued, started to crack. Traditionally, this had been relieved by heating a single worked piece over an open charcoal-fired flame, a lengthy process for relieving the stresses which enabled further work to continue. This had been satisfactory for a single craftsman working alone, but was hardly practical for numbers of men working together in quite cramped conditions. The new patented process enabled batch annealing by piling brass wares inside large sealed cast-iron containers which were placed inside coal-fired furnaces. Champion later devised an improvement which involved a large stone-built coal-fired 'muffle', or double-skinned furnace (Figure 6). Coal fumes could be kept entirely separated from the inner stone-built central cavity, stacked with partly-worked brass goods. Temperatures of 400-600F were needed, appropriately timed according to the work in hand. The men had no thermometers or instruments, but they had experience, and soon acquired the expertise needed in this new method. These annealing furnaces worked successfully enough to still be in use into the late 1920s when the last of the local brass mills closed.

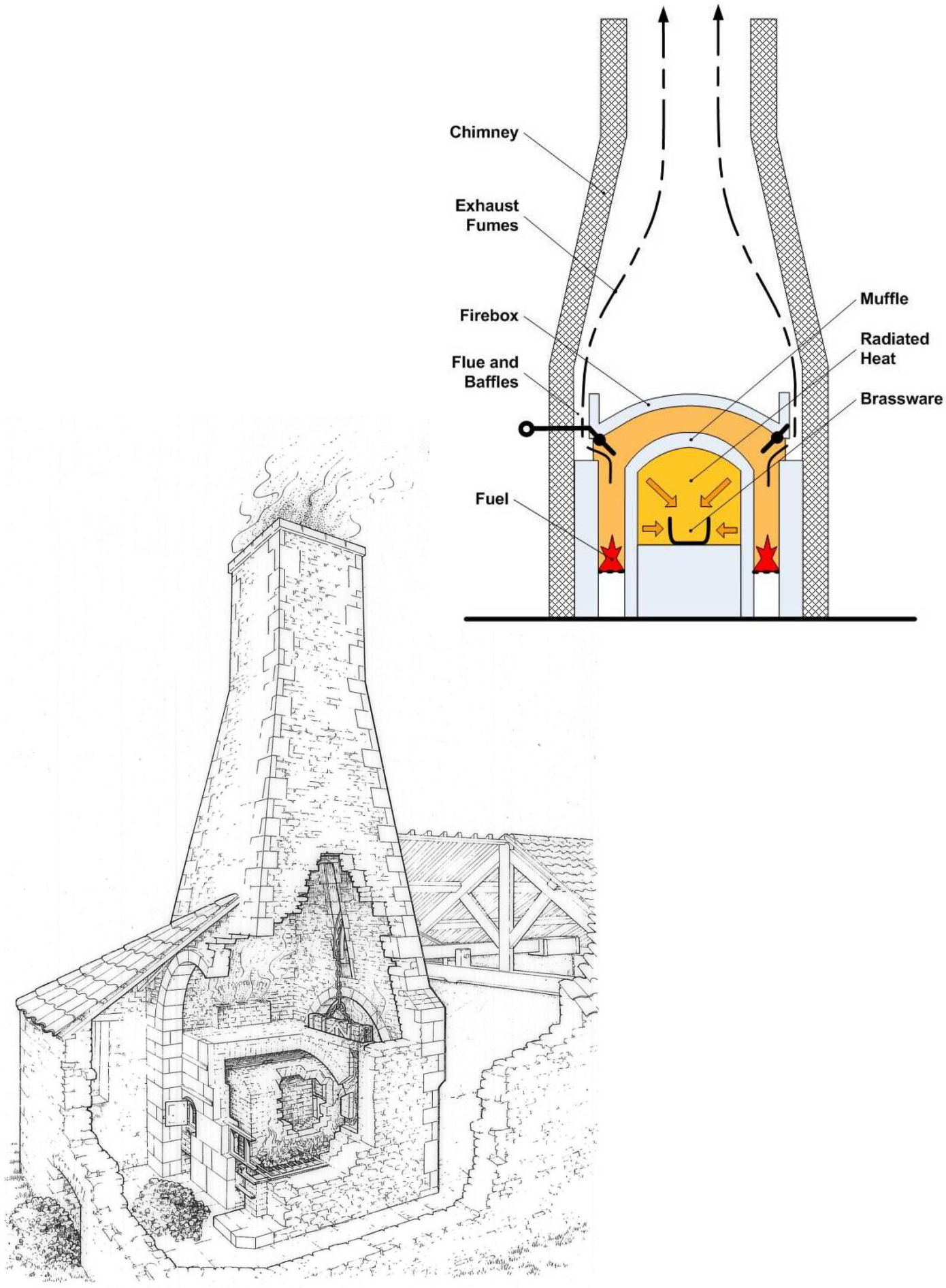


Figure 6 Annealing Furnace

The ability to develop such innovations at this time may be partly explained by the existence of the laboratory, another feature at Baptist Mills. It was first recorded in the 1720s by the Kahlmeter when referring to several types of water-powered machines he saw at the site. They included a small powered hammer for testing the number of blows that brass pieces could withstand, together with other methods of striking metal with teeth at various points. Yet more instruments were capable of cutting and flattening brass. Such a forward-looking facility was hardly to be expected in this country at this time. It has been suggested that Abraham Darby had contributed to these developments; however this is unlikely has he had left Bristol to further his work with iron some 15 years earlier.

Wire Production

Quite separately to the Bristol initiative, a different kind of work had been carried out in Esher, Surrey. This was a wire-producing area, where continental methods had been introduced for the large-scale rolling, slitting and drawing of brass to produce wire, then in demand by the woollen industry for the manufacture of combs used for carding. When slit into strip, the brass ribbon had provided appropriate stock for their new wire-drawing equipment, believed, to have been an early, use of water-powered rolling mills in this country.

Before the turn of the century the Esher brass wire company had achieved progress in smelting copper with coal, probably with cooperation of John Coster, by then working from his Forest of Dean base at Redbrook. The Esher company does not appear to have sought coal-fired innovation in brass production, which they are recorded as using traditional methods. They had succeeded, however, in acquiring new water-powered equipment and techniques in producing brass wire of high quality, known only to have been used previously on the continent. Hitherto, this product had been largely supplied locally by individual craftsmen using lengthy, ancient methods or otherwise bought from the continent.

Expansion in such new techniques must have been an attraction to the Bristol partners, who had entered into a partnership with the Esher brass wire company around 1709, following the departure of Darby to Coalbrookdale to concentrate on the introduction of coal-fired smelting of iron. The Esher company had encountered serious financial and personal problems, but production of wire was continued at Esher with financial support from Bristol. Ultimately, following further financial collapse, the new equipment and its skills were introduced to the Bristol area when a suitable site was found.

There is no direct evidence available, but it is conjectured that rolling, slitting and wire drawing machinery was installed at the final site acquired by the Bristol company, at Keynsham's Avon Mill, in the in the late 1730s. Evidence suggests that the site was well established some ten to twenty years after Saltford Mill had been acquired, local church records referring to: the death of a Mrs. Buck, in April 1742, 'at the wire-mills' (an immigrant family name first mentioned in 1707); a John Macey, born 'at the wire mills' in April of 1743; and George Harris, born in June 1743 'at the wire mills'. These two latter names suggest that they were not of immigrant origin but possibly from Esher, providing expertise from the company there.

Undoubtedly, the equipment that the wire-workers were to operate was of a similar design to that used at Esher, first noted rather more than forty years earlier. It was of particular interest to study examples in the 1990s of such wire-drawing equipment at the open-air industrial museum near Hagen in Germany. There, rather more ancient and worn types of wire drawing tables were on display to the public. Older they may have been, but they were the same basic equipment as those still powered by water, and still in use at Keynsham's Avon Mill until its closure in 1927.

Sheet Metal Production

With an eye to such new techniques, an important method of producing sheet metal had been brought to the Bristol area in 1709 by John Coster, when occupying an old mill site on the river Avon at Swineford. Having collaborated with the Esher Company before their financial collapse, he would have noted their introduction of rolling mills to provide thin sheet brass.

Although Coster was not himself interested in brass wire production, he saw foresaw great advantages in using rolling mills more widely at a time when copper or brass sheet was still being hammered from cast slabs. It was another technique which was to be adopted later by the brass company as soon as they had acquired the availability of greater waterpower.

As already indicated, Saltford mill was originally referred to as a copper mill and its initial layout is believed to have been the standard three waterwheel, each driving three hammers set up. Around 1740, the mill appears to have been modified by the introduction of a fourth wheel and removal of one set of hammers. Two waterwheels were then coupled to set of wide bed rolls to manufacture brass sheet.

It is worth noting that the use of rolling mills greatly increased in the following years when they were employed far more generally to roll brass sheet for direct sale. As with battery hammers, the greater part of these constructions would have been of timber, other than the rolls of iron or cold steel. The two sets of rolls at Saltford were described as the most powerful equipment used by the company.

The People

We have spoken of John Coster, who, although not a partner of the brass company, was very influential, and a significant supplier to, the brass company through his pioneering work on copper smelting in the Avon Valley and his earlier relationship with the Esher brass wire company.

We have also spoken of Abraham Darby, who from an early time was the 'active man' of the Bristol brass company. After Darby's continental travels, the original partners were joined by an additional four Quakers, recorded in a new deed of partnership, dated 30th November 1706. This may have resulted from Darby's drifting of interest away from brass. He had already spent considerable time investigating new ways of improving production of iron goods, and his partners had made it quite clear that they had no wish to be involved in such work. As this divergence widened, Darby withdrew from Baptist Mills from about 1708, to concentrate more on iron production at Coalbrookdale. This was followed by further widening of Baptist Mills interests in brass by collaboration with the brass-wire works at Esher in Surrey.

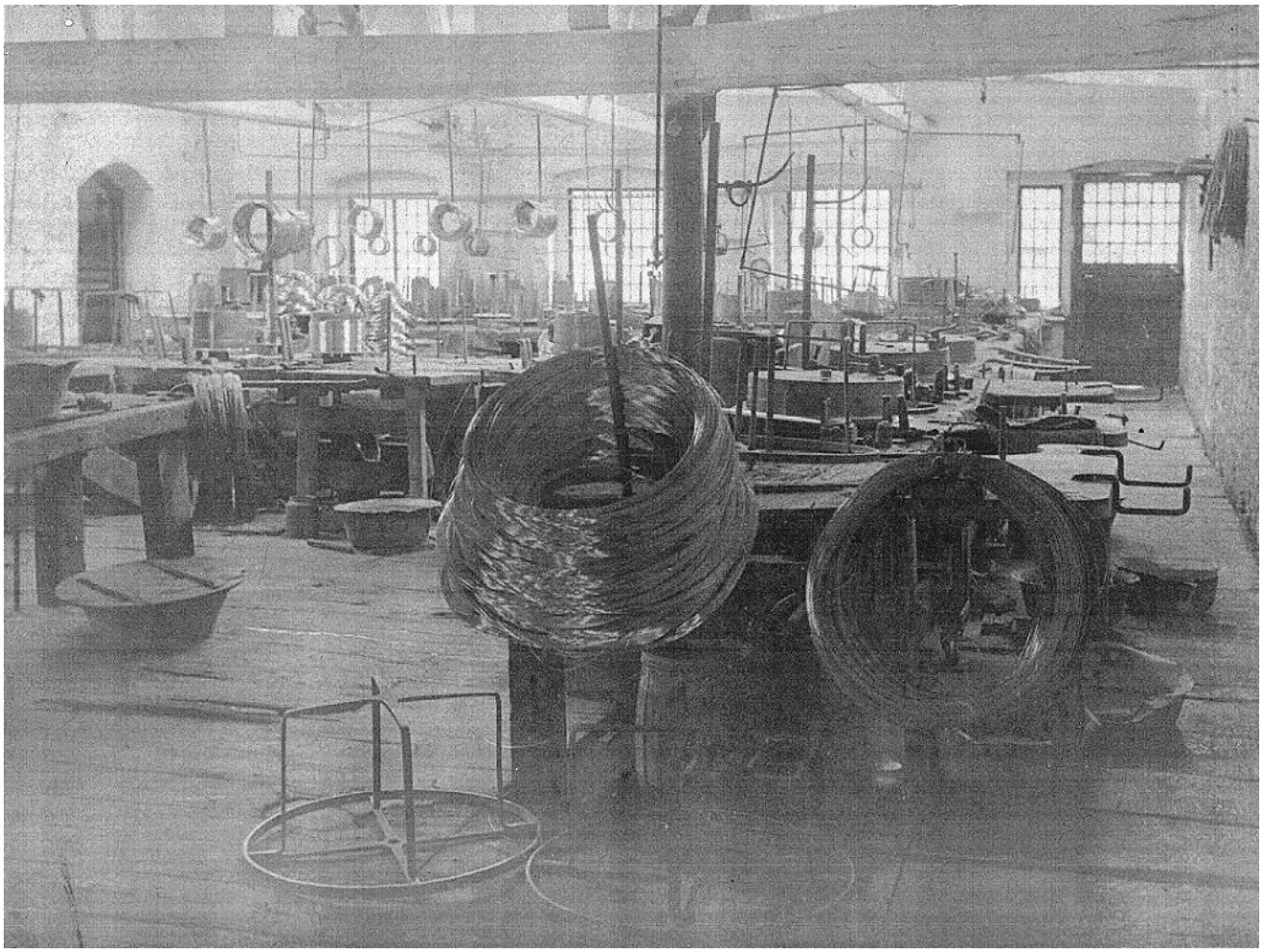


Figure 7 Rolling, Slitting and Wire Drawing

Of the families encouraged to Bristol from the continent, the 1711 accounts refer to Henry Oldise, possibly the foreman at Baptist Mills, whose name is later found in Keynsham's parish church records with other 'no parishioners', signifying that, as immigrants, they were not entitled to parish relief should they fall on hard times. Such responsibilities were eventually undertaken in a written statement by the brass company, a copy of which survives. Other men who came from the continent to operate the Chew Mill hammers may well have been among the original batch of workers persuaded to come here by Darby. Among them, were eight or so protestant families who are known because of births or marriages, recorded from 1707 onwards, in the local Parish Church. John Buck (with variable spelling) appears to have been amongst the earliest, registering the birth of his son, and a month later, a further birth was recorded by the Steger family. Descendants of some of these early immigrants' families are known to still live in the area.

The last family to which reference has been made is the Champion family; Nehemiah Snr, Nehemiah Jnr and William. Nehemiah Snr was an original partner in the Bristol company. His son, Nehemiah Jnr following his father into the company and by the 1720s had risen to become manager of the company. Nehemiah Jnr did much to further the understanding and development of the metallurgy at that time, as witnessed by the patents taken out in the 1720s. William, the youngest son of Nehemiah Jnr, was however to split from the Bristol company and establish a rival brass company based on the town of Warmley just to the North East of Bristol, of which more in the concluding section.

Zenith and Decline

On visiting Bristol in 1753, the Swedish industrial spy Reinhold Angerstein described the company, then at its zenith, as 'the Great Brass Co'. Angerstein provides a description of the Baptist Mills brass making facility, the battery mills on the River Chew at Keysham and Woodborough, the battery mills on the River Avon at Saltford and Weston, plus Champion's rival company, with its headquarters at Warmley and eventually supported by battery mills at Bitton and Kelston.

Later stages of development were still taking place in the copper furnaces. By the 1750s, the brass company had already acquired the lease of the old smelting works at Conham, and were rebuilding furnaces there, said to be in bad condition. Just downstream from Conham, the brass company had their own smelting complex at Crews Hole, where 49 furnaces were working to gradually improve methods used there by 1750.

However, the company was in trouble with Bristol authorities because of the large amount of copper waste 'cinders' (or slag) stacked on the river banks. A large part of this material had found its way to the river bed where it had interfered with navigation. After appropriate fines had been paid, the basic problem was solved by large-scale production of slag coping and building blocks from this waste, a process originated many years earlier by John Coster at Redbrook.

Large quantities of these blocks were produced and sold from Crews Hole, the coping blocks distinguished by their triangular shape, later copied at Warmley, whereas the earlier examples of the Costers were half-round, as those still surviving on sections of walls surrounding the Ashton Court Estate. The more common triangular coping and building blocks can be seen widely throughout Bristol and its outlying areas. They are reminders of a once internationally -important industry of the area.

However, the Bristol company was starting to be challenged by the new company launched by the Champions father Nehemiah and son William, at Warmley, just a few miles away. Deprived of their metallurgical expertise, the old Bristol company stuck stolidly to skills already acquired improving details where possible and enlarging their scale of production. Above all, they continued to display the considerable financial acumen they had acquired over the years. Meanwhile, the technical advance of the Champions, more particularly the younger William, enabled the introduction of new ideas and techniques at Warmley, far beyond the scope of the old company, and eventually beyond the scope of his own finances. This was particularly so in the new and expensive process for producing metallic zinc for the first time in Europe.

Inevitably, the two companies clashed bitterly, but it was not just these clashes that lead to financial collapse at Warmley and the ensuing escape of ruined shareholders to America.

The Bristol company also suffered, was disbanded, reformed and continued surviving through several changes of ownership, but above all still using its old traditional methods, slightly upgraded now and then, until the 1927.

The water-powered rolls at Avon Mill Keynsham and at Saltford remained in operation until closure of the mills towards the end of the 1920s. Unfortunately, as with the wire-drawing tables, none survive. The great efficiency of these later processes, once properly established at Saltford and Keynsham, had spelt closure in the latter part of the eighteenth century for the smaller less powerful sites. These included Woodborough Mill on the upper Chew, and Weston Mill at Bath's outskirts, which may just have edged into the new century. More significantly, the original headquarters at Baptist Mills was on the point of closure by the end of the century. The inadequate water supplies there were too unreliable and insufficient to operate the newer processes, and by this time basic brass production was taking place at Keynsham's Avon Mill, eventually being updated there. Within a few hundred yards of this newest centre of production remained the surviving battery mill at Keynsham, a still-valued part of the newly centred enterprise which continued working in this depleted number of sites until the 1880s. Its closure must have brought relief to the neighbouring area, after enduring its noisy processes for l75 years or so. Saltford villagers had to wait until 1908 for closure of its final brass hammer mill. By then it is believed to have become the last brass battery site in western Europe The remaining German battery mill at Stolberg, had ceased in 1905. Its owner, not knowing of the Saltford mill, had believed it to be the last in Europe.