The Saltford Brass Annealing Furnace

Joan Day

The brass works established at Baptist Mills in Bristol about 1702 by Abraham Darby and three partners quickly achieved some measure of commercial success and in a few years was expanding. In the last decade of the seventeenth century, Bristol had been the scene of technical innovation in the smelting of copper. Darby had come to Bristol in 1699, following a Birmingham apprenticeship to set up his own business in his trade as a maker of maltmills, but very soon became involved in the new brass-making enterprise which appears to have developed partly because of surpluses in the local production of refined copper.[1]

With the expansion of the non-ferrous industries which took place in Bristol from the first decade of the eighteenth century, brass metal continued to be made at the original premises at Baptist Mills, but additional water-mill sites were needed by the company to operate water-powered hammers. These were used for *beating* cast slabs of the metal to form brass sheet in the early years of the industry, but this same *battery* method of production was to survive for just over two centuries in the local manufacture of utensils made from brass. In the first thirty years of the century leases were taken for sites of these battery mills, as they were called, at Keynsham, Saltford, Woollard and Weston near Bath, (a list that was later to be extended). Land for the Saltford battery mill was leased in 1721,[2] on a site that had been occupied previously by a long-established fulling mill.

Situated on the River Avon, on the upper of two weirs in the parish of Saltford, the Old Brass Mills at ST 687670 can be approached by The Shallows, a river-side road which used to be called Brass Mill Lane. The remaining mill fabric consists of a much-altered and partly demolished structure of local limestone, with a complicated pantiled roof which, with study, may well yield indications of the original core of the building.[3] The structure incorporates remains of annealing furnaces, one almost complete, which endow the building with a distinctive character but, apart from remaining waterwheels, there is little surviving evidence of the plant employed for brassmaking over its 200 years of existence.

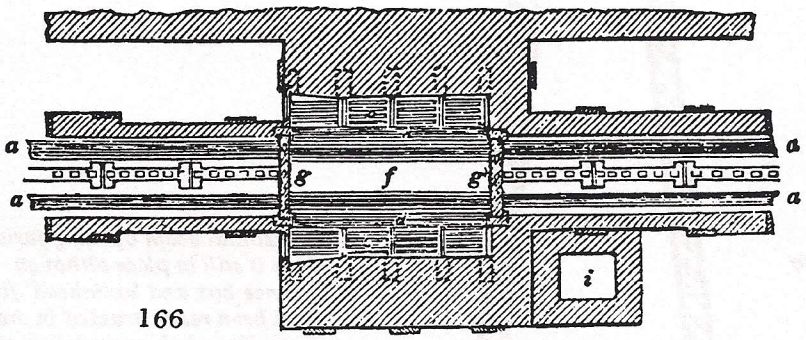
During the first half of the century the company adopted the use of water-powered rolling mills to produce its brass sheet, thus modernising its production. The rolling of copper sheet had been introduced by John Coster at Swinford, some two miles downstream, when he leased the mill there in 1709. Coster had previously been associated with William Dockwra in establishing the copper-smelting works at Upper Redbrook in 1691.[4] By 1697 Dockwra was reported at his Esher mill in Surrey, to be rolling copper instead of using the battery process for flattening ingots, an innovation for the industry.[5]

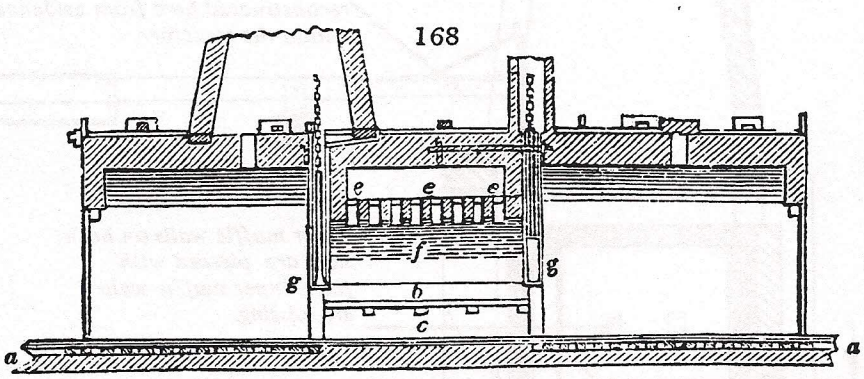
Later, at Saltford, after the introduction of water-powered rolling the battery hammers still remained for the manufacture of hollow-ware vessels. This operation was never modernised and it lingered into the twentieth century. When a valuation was made of company property in 1830, Saltford Mill then contained a rolling mill powered by two waterwheels (the upper and lower rolls of the mill would have been driven by separate wheels). Two further waterwheels provided power for two battery mills, each wheel driving three hammers. A surveyor's report of 1855 described Saltford Mill as very old and in a decaying state, but it is quite clear from a Sales Catalogue of 1862 that, by then, little had altered.[6] An additional iron waterwheel had been installed for a grinding wheel, but the four wheels mentioned earlier for driving the rolling and battery mills still remained in place, described as 15ft by 3ft 6 in, complete with wooden shafts and gearing. This same catalogue also mentions four annealing ovens, an integral part of the premises which, undoubtedly, had been in existence from the previous century.

Such annealing ovens, (or furnaces, as they are more correctly called) were standard equipment at the local brass mill where frequent annealing was required at all stages of the work. The severe mechanical treatment of rolling and battery production caused distortion in the crystal structure, making the brass hard and brittle. This could only be rectified by a process of heat treatment which softened, or annealed, the metal and enabled work to proceed to a further stage. In the few early descriptions of the techniques of brass production annealing methods are very rarely mentioned. From eighteenth-century illustrations of continental brassworks, it can be inferred that the usual practice on the Continent was to employ a structure rather similar to a blacksmith's hearth. An open fire, presumably of charcoal, is usually portrayed at waist height with pairs of large water-powered bellows providing the draught.[7]

Andrew Ure, writing in the 1830s, implies that, by then, a type of large enclosed furnace was in fairly general use both in this country and on the Continent.[8] The internal dimensions he refers to vary, with lengths up to as much as 32ft x 6ft, according to the goods being annealed. This size of furnace was heated by two fireboxes accommodated on either side of the whole length of the furnace interior. The type of fuel is not mentioned but, presumably, was not coal as furnace gases were not separated from the load being annealed. The wares were mounted on carriages which ran on rails into the furnace and, once in place, the furnace door was closed by a lever or chain balanced by a counter-weight. Ure also described two specific annealing furnaces at the Hegermuhl brassworks, near Potsdam, which differed in some details but made use of similar principles.

The furnaces used in the Bristol area were developed by the local industry during the eighteenth century and, until recently had not been thought to appear elsewhere, (although they do display some of the features described much later by Ure in the 1830s). However, recent excavation of the brass battery works at Holywell in Flintshire has revealed some remains at ground level which suggest structures similar to the annealing ovens of Bristol origin. (It is worth noting that a site at Holywell was first leased in 1758, and a brass works built by John Champion, who was closely connected with the Bristol industry). But the Holywell remains are minimal; in consequence, the almost complete furnace remaining at Saltford, together with two outer shells of similar structures at Kelston Brass Mills, about a mile distant, are believed to be the only significant remains of this type of furnace in existence anywhere. Coal-fired, and dating from the eighteenth century, they have a place in the development of coal technology in this country.





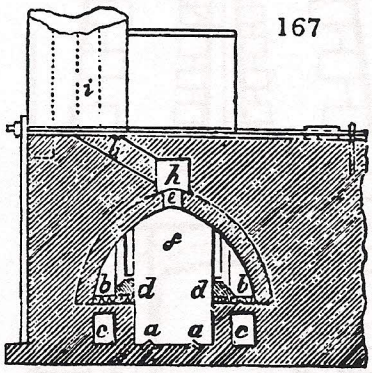


Fig. 166. shows the ground plan of the furnace and its railway; *fig. 167.* the cross section; and *fig. 168.* the section lengthwise; *a a,* the iron way bars or rails upon the floor of the foundry, for enabling the wheels of the waggon-frame to move readily backwards and forwards; *b b,* the two grates; *c c,* the ash pits; *d d,* the fire beams; *e e e,* vents in the roof of the hot chamber *f; g g,* two plates for shutting the hot chamber; *h,* the flue; *i,* the chimney.

Fig. 1 *From Andrew Ure's Dictionary of Arts Manufactures and Mines*

Brass-plate rolling – At Hegermuhl there are two re-heating or annealing furnaces, one larger, 18 feet long, and another smaller 8½; the hot chamber is separated from the fire place by iron beams, in such a way that the brass castings are played upon by the flames on both their sides. After each passage through the laminating press (rolls) they are heated anew, then cooled and laminated afresh, till they have reached the proper length. The plates are besmeared with grease before rolling.

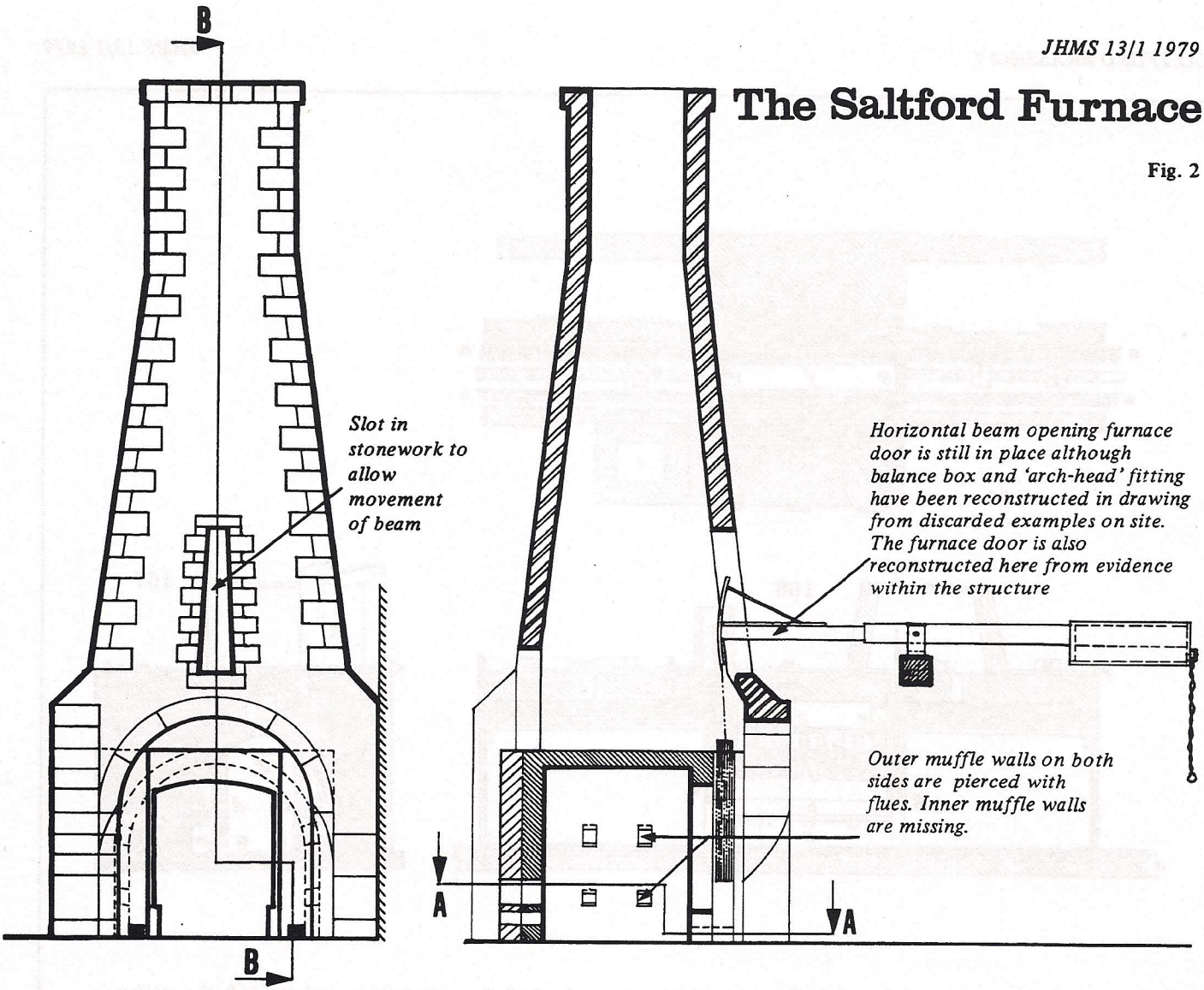
Prior to the establishment of the Bristol brass industry, coal had already been used there successfully for metallurgical purposes. The smelting of lead in coal-fired reverberatory furnaces had been achieved in the 1670s and further work had lead to the smelting of copper in similar structures by the last decade in the century.[9] By 1710, there is firm evidence that coal was fuel being used in the making of brass metal.[10]

In previous accounts it has been assumed that this was also an innovationary technique for which Abraham Darby was responsible.[11] More recent research, however, has revealed the use of coal fuel for brass-making, at Aachen on the Continent,[11a] from the previous century. Possibly, Darby may have been responsible for the successful introduction of the technique to this country through his use of a continental workforce, the local descendants of which survive to this day. There is greater evidence for the belief that the Bristol industry can take credit for the innovation of a coal-fired annealing process a few years later.

In 1723, Nehemiah Champion, successor to Abraham Darby as manager of the brass company, patented 'A New Way of Nealing the Plates and Kettles with Pitt Coale, which softens and makes the Brass as Tough and Fine-coloured as any Nealed with Wood and Wood Coale'.[12] In this early type of annealing furnace Champion protected his brass from the sulphur fume given off by the coal fuel by enclosing the

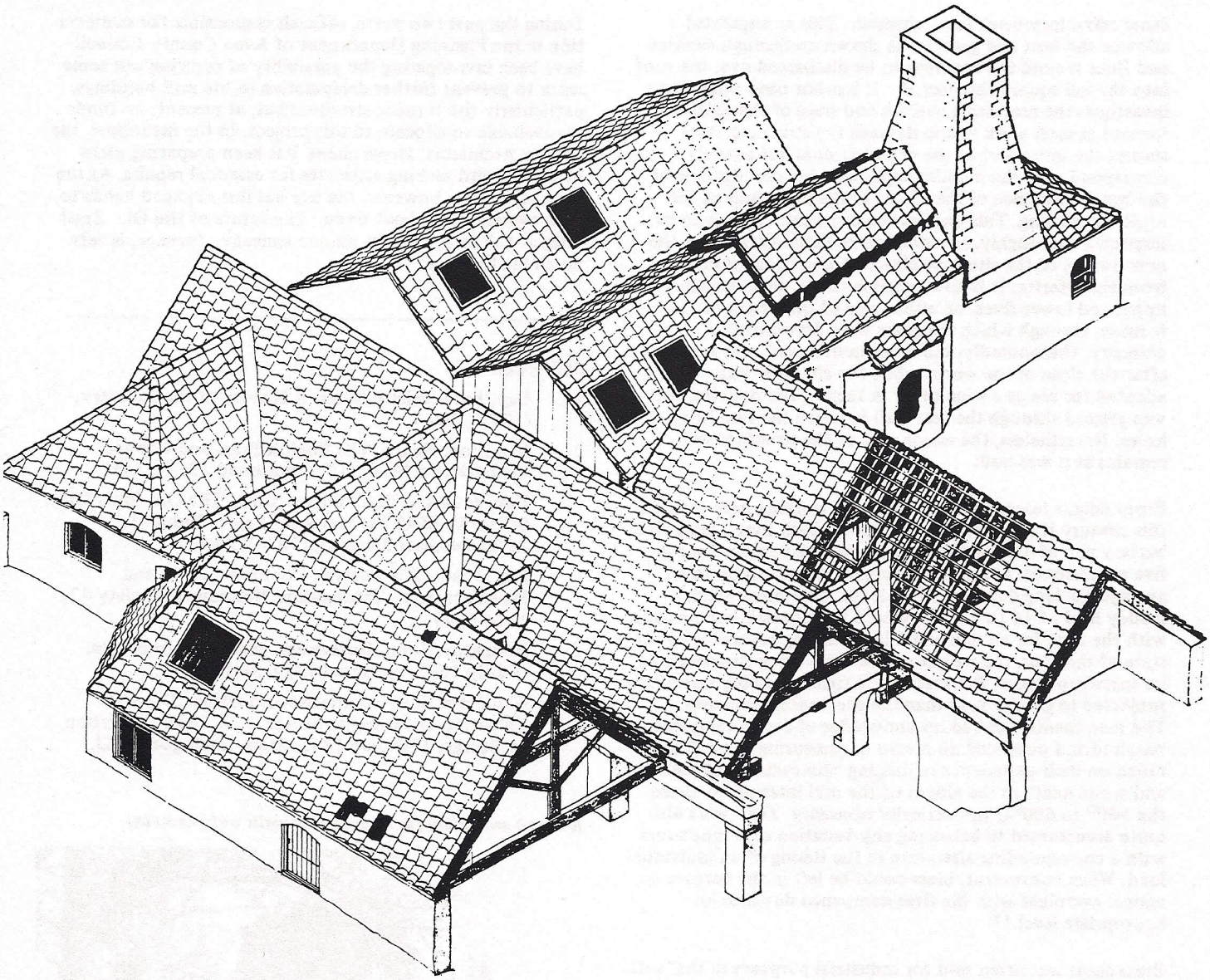
The Saltford Furnace

Fig. 2



wares in wheeled cast-iron containers which were then completely sealed with clay. The furnace interior was 5ft square with a 4ft high arched roof and 1½ft thick side walls. The fire entered the furnace through apertures in these side walls and was drawn up, and reverberated from the arched roof on to the protected boxes below.[13] The oven door could be raised and lowered by a chain, which suggests a similar arrangement to the horizontal balance beam used in the later development. (see Fig. 2) This early coal-fired annealing furnace was, therefore, a type of reverberatory furnace (in which there had been much previous local innovation in the smelting of non-ferrous metals) but the presence of coal gases in the furnace interior made it necessary for the annealed wares to be very well protected.

Between 1764-8, when Nehemiah Champion's son William built his own company's new battery mill at Kelston on the next weir downstream to Saltford mill, a more sophisticated type of coal-fired annealing furnace appeared, two shells of which remain. In this structure the furnace gases were kept in quite separate outer cavities, in the side-walls along the length and above the roof of the furnace. The inner surface of the interior was kept well smeared with clay by the furnaceman to prevent sulphur fume from penetrating to spoil the brass. Thus, the work



drawing by Megan Thomas

The Old Brass Mills, Saltford as they are today

being annealed so longer required the protection of a sealed container. The load could simply be stacked in the oven, on trolleys to facilitate handling, and it was these trolleys, or dilleys, which were manoevred into place on a railed track by means of a revolving turntable.[14]

William Champion himself may well have been responsible for this development in furnace construction, which today would be called a 'muffle' furnace, with its heating cavities surrounding, but separate from, the interior. In Champion's patent No 867, enrolled in 1767, he included with other processes, a method 'for Manufacturing Brass into Brass Wire by Stone or Pitt Coal instead of Wood now used'. As brass was nearly always worked cold during the eighteenth century, whether to roll sheet, form hollow-ware, or draw narrow strip into wire, it is difficult to imagine any other a purpose for heat treatment or for the above patent, other than for the annealing process. Members of the Champion family were past masters at obtaining protection for their inventions by giving deliberately vague or misleading descriptions of processes in their patent specifications.

The building of Kelston Mills was one of the final phases of expansion by William Champion before being declared bankrupt in 1769. All the premises of his company were subsequently taken over by the old Bristol brass company, who used them, but far less extensively, before gradual disposal of the properties. The basic design of the remaining coal-fired annealing furnace at Saltford is the same in overall measurement apart from a few minor details, suggesting that it was probably copied from those at Kelston by the old Bristol company.[15]

At the front of the furnace an archway at the base of the tapering squared stack gives access to the interior. (see Fig.2) A heavy fire-brick door would have been mounted between the arch and the inner chamber and raised by a horizontal timber beam. This was counter-balanced at the opposite end so that the door could be opened easily by lowering a chain, while the movement of the pivotted beam was accommodated by a vertical slit in the stonework of the stack. At the opposite end of the furnace another higher arch housed two fireholes which extended along either side of the whole length of the

inner refractory-brick lined chamber. This arrangement allowed the heat and gases to be drawn up through cavities and flues around the chamber to be discharged over the roof into the tall square chimney.[16] It has not been possible to investigate the remaining cavities and flues of the Saltford furnace as such work would damage the structure. As it stands, the inner part of the chamber does not entirely correspond with the detailed tape-recorded descriptions of the last furnacemen of the 1920s as the inner wall of the muffle is missing. This enables the outer muffle arch to be inspected thoroughly, however, more particularly since the new owners of the site have cleared a great deal of debris from the interior. It is now possible to see the two pairs of upper and lower flues, on either side of the length of the furnace, through which the gases were drawn to the chimney. Undoubtedly, the inner muffle wall was removed after the close of the works when the chamber was adapted for use as a wine cellar A rectangular opening also was pierced through the rear wall between the two firing holes. Nevertheless, the major part of the structure still remains as it was built.

From details remembered by the men working here early in this century it has been possible to establish that a large size battery pan of 4ft diameter would require perhaps four or five processes of annealing during its manufacture. In an average working day about five loads, each one a single trolley load of 16 to 25 cwt, would be annealed in a furnace, with the time for an individual load varying according to the state of the fires, the weight of the brass being annealed and its specific purpose. For instance, a final annealing was often subjected to greater heat than the preceeding processes. The men themselves had no knowledge of actual temperatures required and possessed no means of measuring them. They relied on their experience in judging 'somewhere between red and white heat', in the gloom of the mill interior, to assess the 500° to 600°C theoretically necessary. They were also quite accustomed to balancing any variation of temperature with a corresponding alteration in the timing of an individual load. When convenient, brass could be left in the furnace to anneal overnight with the fires dampened down to an appropriate level.[17]

Brass sheet was often sold for industrial purposes in the 'soft dark' state, as it emerged from the final annealing. If a hard bright finish was required the sheet was pickled by immersion in dilute sulphuric acid. After a thorough washing in clean running water and a careful drying in bran, the sheet received a final rolling in the Saltford finishing rolls.

The men had seen many alterations to the equipment over the years and could tell of others before their time. For instance, of the completely unsuccessful attempt to modernise one of the sets of battery hammers in the late nineteenth century by replacing timber with wrought and cast iron.[18] The project was abandoned eventually but these and other modifications left their mark on the mill buildings and made interpretation difficult. One set of older hammers continued working until 1908 but the rolling mill did not come to a halt until 1925. When the mill finally closed the remaining annealing furnace was still capable of good service.

After the brass mills ceased to work a bungalow was built on part of the site and the old buildings were adapted for various purposes. One section was used as a squash court, the annealing furnace was modified, as mentioned, for the storage of wine, whilst the large remaining waterwheel was employed to generate electricity. These alterations have created further difficulties in the interpretation of surviving structures. In more recent times the whole island site has been used for the building and storage of boats.

During the past two years, officials responsible for conservation in the Planning Department of Avon County Council have been investigating the possibility of carrying out some work to prevent further delapidation in the mill buildings, particularly the furnace structure but, at present, no funds are available to allocate to this project. In the meantime, the county Architects' Department has been preparing plans of the site and making estimates for essential repairs. At the time of writing, however, the site has just changed hands to new owners in the boat trade. The future of the Old Brass Mills at Saltford, with its unique annealing furnace, is very much in abeyance.

SOURCES

1 Day, Joan. **Bristol Brass: A History of the Industry**, (1973), 33–7.

2 Hamilton, Henry. **The English Brass and Copper Industries to 1800**, (1926 reprinted 1967), 148.

3 Day, Joan and BIAS Survey Unit, 'The Old Brass Mills, Saltford', **BIAS Journal 9** (of Bristol Industrial Archaeological Society), (1976), 20-3.

4 Day, Joan. 'The Costers: Copper-Smelters and Manufacturers', **Transactions Newcomen Society 47**, 1974-6, 49

5 Houghton, John. **Husbandry and Trade Improv'd**, (9 July 1697, reprinted 1727), vol II, 191.

6 Gloucestershire county Record Office. D 1628, Valuation of Property, Sturge, 17.8.1830; Valuation by Sturge, 17th Feb 1855; Sales Catalogue, 1862.

Kelston annealing furnace (outer walls only remain)

photograph by Roy Day

7 Van Natrus, L Pouy, Jand Van Vuuren, C. **Groot Volkomen Moolenboek**, Amsterdam (1734, reprinted 1969) Pt 2, Plate VII, Kooper-Moolen, (By courtesy of Martin Watts);
Galon, J. **L'Art de convertir le Cuivre rouge en Laiton ou Cuivre jaune**, (1764).
Diderot, D. **Pictorial Encyclopedia of Trades and Industry**, (1763 Paris, reprinted 1959 New York) Vol I, Plate 145.

8 Ure, Andrew. **A Dictionary of Arts, Manufactures and Mines**, (1839), 166 & 168.

9 Jenkins , Rhys. 'Copper Works at Redbrook and Bristol', **Transactions Bristol & Gloucestershire Archaeological Society 63**, (1945), 145-54; 'Copper Smelting in England: Revival at the end of the Seventeenth Century', **Transactions Newcomen Society 24**, (1943–4), 73-80.

10 **Journal of the House of Commons**, (1712), 161.

11 Mott, R A. MS 'Revolution in Iron', Ch 14, 192 (I am grateful to Dr Mott for allowing me to read this chapter, unpublished at the time of writing); 'Abraham Darby (I and II) and the Coal-Iron Industry', **Transactions Newcomen Society, 31**, (1967), 49-57; **The Triumphs of Coke**, (1965), 16.

11a Weigels,Christoph **Abbildung der Haupt-stande** (1698) by courtesy of John Morton, who kindly drew this to my attention, from research arising from his forthcoming thesis at Birmingham University.

12 **Patent Specification**, No 454, (1723).

13 Swedenborg, E. **De Cupro**, (1734), 354; English Translation, Searle, A H. British Non-Ferrous Metals Research Association, Misc. Publication 333, p 343.

14 **Day, Bristol Brass**, 147–50 and 214.

15 ibid, 89-94.

16 ibid, 150, Additional details from notes and tape recordings of conversations between the author and Mr A E Shellard, Mr T G Shellard and Mr H Barnett, former employees at the mill.

17 ibid.

18 de Soyres B, 'History and Particulars of the Brass Battery Process', **Transactions Newcomen Society, 28**, (1952) 131-5;

ACKNOWLEDGEMENTS

I am indebted to members of the survey unit of Bristol Industrial Archaeological Society who measured the Old Brass Mills site, to my husband Roy for measuring and drawing the annealing furnace and to Megan Thomas of Avon County Architects' Department for the three-dimensional drawings of the site. I must also thank the past and present owners of the mill for their co-operation in allowing access, and to the Conservation Group of Avon Planning Department and DoE Inspectorate of Ancient Monuments for their interest in the future of this site

The front arch of Saltford annealing furnace

photograph by George Watkins

Exterior of furnace at Saltford

photograph by Roy Day