The Composition of Bristol Brass

The Material

During the excavations and restorations at Saltford Mill, two pieces of sheet brass were recovered. One was very thin (<0.5 mm) but the other was more substantial (>2 mm). Metallographic examination of a polished section showed that it was extensively worked and annealed, and not a cast plate.

A sample was also taken from a nest of three unfinished brass bowls recovered from the River Avon just downstream of the Brass Works at Bath which operated in the late 18th-early 19th century but was closed by 1812.

The Blaise Castle House Museum, Bristol holds an extensive collection of local brassware. From this a selection of brass pans was sampled varying in size from domestic cooking pans to large milk pans used by the dairy trade and other large vessels made for export to Africa, America and the Far East (Day 1973 pp 169-170). Unfortunately, few of the pans were marked or easily dateable beyond the 18th or 19th century, although most should lie between 1750-1850.

Samples were also taken from a selection of the brass heads of the standards belonging to the local friendly societies and used at the head of their annual processions. The ornamental brass heads on the standards are only found in the South West, especially in the Bristol region dating from the late 18th to early 19th century and it seems logical that the brass was produced locally. Finally, a late 17th century sheet brass chestnut warmer and an 18th century sheet brass spit jack both local, conclude the items sampled for analysis.

Technical

The samples were taken with a steel scalpel, or drilled with a small hand-held modeller's drill mounted with a size 60 (I mm diameter) bit. Between 2 and 15 mg of clean metal turnings were collected in each case. The samples were analysed by atomic absorption spectrometry using the methods detailed in Hughes et al 1976. The analyses have a precision of ± 1% for the copper and zinc, and about ± 20% for the minor and trace elements. Most elements could be detected down to at least 0.005% in the metal. The elements Co, Au and Mn could not be detected at this level. The detection limit for tin varies and is quoted in each case.

Discussion

The metals are of brass, with the exception of the large copper pan, T9174. Although all the brasses only contain small amounts of lead and traces of other metals, they do fall into two quite distinct groups, probably reflecting the method by which the brass was made. One group is high in zinc (>.30%) and these have rather low lead contents and relatively small traces of iron, tin and other trace elements

Table I: Bristol Brasses

Lab.	Description	Provenance	Cu	Zn		Pb	Sn	Ag	Fe	Sb	Ni	Au	Co	As	Mn	Cd	Bi
103	Brass Sheet	Saltford Mill	67.5	31.0		1.10	.05	.010	.085	.030	.075			.100		.200	.035
104	Bowl	Weston Mill, Bath	66.5	30.0		2.70	.05	.050	.060	.030	.035			.200		.005	.085
113	Sheet	Saltford Mill	66.0	33.2		0.65	.07	.010	.040	.015	.050			.250			.003

Table 2: Bristol Brasses from Blaise Castle House Museum

Reg. No.	Description		Cu	Zn		Pb	Sn	Ag	Fe	Sb	Ni	Au	Co	As	Mn	Cd	Bi
T 9174	Large Pan	Battery Pan	99.2	0.008		0.1	0.1	0.04	0.13	0.05	0.06		Tr	0.31	Tr	Tr	0.03
T 7558	Old Wick Society Standard	Society Standard	77.4	17.15		1.7	0.6	0.08	0.42	0.04	0.05	Tr	Tr	0.35	Tr	Tr	0.15
TA 2235	Large Pan	Battery Pan	75.0	17.56		1.5	1.1	0.08	0.4	0.04	0.11	Tr	0.01	0.1	Tr	Tr	Tr
T 7715	Chilcompton Society Standard	Society Standard	76.4	19.05		2.5	0.6	0.08	0.38	0.05	0.06	Tr	Tr	0.29	Tr	0	0.1
T 7515	Westbury on Trym Society Standard	Society Standard	76.2	19.14		3.0	0.7	0.08	0.48	0.05	0.06	Tr	Tr	0.35	Tr	Tr	0.12
TA 207	Bilton Society Standard	Society Standard	75.2	19.43		2.6	0.6	0.09	0.53	0.05	0.06	Tr	Tr	0.21	Tr	Tr	0.04
T 7506	Butleigh Society Standard	Society Standard	75.1	19.97		2.8	0.7	0.08	0.39	0.05	0.05	Tr	Tr	0.39	Tr	0	0.11
T 7557	Kingswood Society Standard	Society Standard	73.7	20.09		2.6	0.9	0.07	0.62	0.07	0.06	Tr	Tr	0.16	Tr	Tr	0.07
T 7571	E & W Stow Society Standard	Society Standard	73.3	21.34		2.2	0.7	0.08	0.87	0.06	0.05	Tr	Tr	0.39	Tr	0.01	0.13
T 7531	Iron Acton Society Standard	Society Standard	74.3	21.48		2.4	0.3	0.07	0.13	0.04	0.04	Tr	Tr	0.34	Tr	Tr	0.1
T 7580	Wedmore Society Standard	Society Standard	73.1	22.80		2.3	0.9	0.07	0.31	0.04	0.06	Tr	Tr	0.3	Tr	0.01	0.09
T 9250	Spit Jack	Spit Jack	70.4	23.87		2.8	0.2	0.06	0.27	0.04	0.03	Tr	Tr	0.14	Tr	Tr	
TA 2236	Large Pan	Battery Pan	72.3	23.97		1.8	0.6	0.07	0.37	0.04	0.1	Tr	0.01	0.08	Tr	Tr	0.02
TA 94	Wedbury on Trym Society Standard	Society Standard	71.4	23.99		1.9	0.4	0.08	0.28	0.08	0.07	Tr	Tr	0.28	Tr	0.02	0.07
T 9173	Pan	Battery Pan	70.4	25.50		1.5	0.4	0.06	0.38	0.03	0.12	Tr	Tr	0.05	Tr	0.01	Tr
T 2034	Pan	Battery Pan	66.2	30.40		0.4	Tr	0.04	0.11	0.03	0.03	Tr	Tr	0.09	Tr	0.03	Tr
T 8922	Pan	Chestnut Warmer	67.5	30.47		3.1	0.4	0.05	0.13	0.05	0.05			0.16	Tr	Tr	
J.T.Ralls	Pan	Battery Pan	67.1	33.22		0.5	Tr	0.03	0.17	0.02	0.04		Tr	0.05	Tr	0.01	0.02
T 9839	Pan	Battery Pan	65.6	33.73		0.9	Tr	0.02	0.02	0.02	0.11	Tr	Tr	0.07	Tr	0.01	0.04
T 7583	Willsbridge Society Standard	Society Standard	62.7	37.11		0.5	Tr	0.02	0.08	0.02	0.03	Tr	Tr	0.07	Tr	0.02	Tr
TTC 1875	Large Pan	Battery Pan	64.2	37.34		0.9	Tr	0.03	0.24	0.02	0.06			0.07	Tr	0.02	0.06

The second group has correspondingly less zinc (< 26%) and these brasses have more lead, together with substantial traces of iron and tin

The century between 1750 and 1850 to which most of the artefacts belong witnessed a complete change in the way that brass was made in the Bristol region. In 1750 almost all brass was still made by the traditional cementation process. This is described in detail by Day (1973), but put very simply, the local calcined calamine ores were mixed with coke (or charcoal) and finely divided copper, placed in a sealed crucible and heated to about 1000 ^{0} C, producing brass directly. In 1738 Champion had patented his process for producing metallic zinc by distillation but through most of the 18th century brass made from the copper and zinc metals was expensive and used mainly for costume jewellery alloys such as pinchbeck or for scientific instruments. By 1860 as Percy (1860) records brass was almost universally made by mixing the two metals, or speltering as it was and still is known (itself a highly skilled operation, see Hull 1950). Such great differences in these two ways of making brass are reflected in the composition of the metal. Several technical authors, such as Ercker in the 16th century and Nehemiah Champion in the early 18th century, have commented on the maximum amount of zinc they could get into the copper; for Ercker it was 29% and for Champion it was 28%. The validity of these claims is reinforced by the many hundreds of Roman, Medieval and Islamic brasses analysed by the authors and others; none are known with more than 28% of zinc, although many approach that figure (Craddock 1985).

Haydecke and Werner (1970) carried out experiments in which they heated first copper, and then a 40% zinc brass in the presence of zinc oxide and charcoal at 1000^{0} C. Significantly in both instances the product was a 28% zinc brass. The figure of 1000^{0} C is critical, below that temperature the reaction barely proceeds at all, but if much higher, then the forming brass melts to form a puddle in the crucible bottom with only a very limited surface area exposed to further absorption. However, Nehemiah Champion claimed he could raise the percentage of zinc absorbed to 33% (Day 1973, pp 5961) and from the 16th century brasses are known containing up to 33%. (NB the 17th century chestnut warmer, T 8922, with 30.5% zinc). Percy (1860 p 616 records that at the Forest Works, Birmingham in 1781, 33% was the maximum zinc content attainable.

A high iron content was another feature of cementation brass. The copper was reacted directly with the calcined ore under very reducing conditions and any iron minerals present were reduced to metal and dissolved in the forming brass. This is evident from the analyses and from contemporary comments. Thus Watson (1786) reported the claims of Emerson, the Bristol brass-maker, that his brass, made by speltering 'is quite free from knots or hard places arising from iron, to which other brass is subject and this quality, as it respects the magnetic needle, renders it of great importance in making compasses'.

The calamine ores inevitably contained some galena, although this was carefully picked out by hand as far as possible. Cementation brasses tend to have a small percentage of lead. However, zinc produced by distillation will also have some lead, as it is quite volatile. Fortunately, Watson (1786) has given some indication of the levels one could expect in late 18th century zinc. He records that a cubic foot of zinc from India weighs 7,240 oz, from Goslar in Germany 6,953 oz, and from Bristol 7,028 oz. This equates roughly to 5%, 1% and 2% respectively of lead in the zinc, assuming lead was the only impurity and that the zinc was cast. If this was the case then it is possible to calculate approximately how much lead one could expect in Bristol brass. If the metal has approximately $^{1}/3$ zinc, then it should contain about 0.6-0.7% of lead from the zinc on Watson's figures plus any lead from

the copper. One of the pans, T9174, is of unalloyed copper and this has 0.14% lead, 0.09% of tin, and 0.125% of iron and gives a useful indication of the intrinsic purity of the copper before alloying. Thus a 70:30 brass made by speltering could be expected to contain around 0.1-0.2% of Pb from the copper and 0.4-0.8% from the zinc, ie around 0.5-1% of lead overall, and this is the range of lead contents in the high zinc brasses, such as T7583, T1875, T2034, J T Ralls, T9839, and the samples from Saltford (although not the brass bowls from the Avon with 2.7%). Thus, the zinc, lead and iron content seem to correlate together and are indicative of the process. In this instance, those with over 30% zinc are likely to have been made by speltering, those with less than 26% by cementation. (The chestnut warmer, T8922, with 30.5% is an exception but the iron and lead contents confirm what its date dictates — namely that this must be a cementation brass).

If the zinc, lead and iron are indicative of process, what of the tin content, and other trace elements which all seem lower in the high zinc brasses? A possible explanation is that this reflects the different sources of copper that were used at different periods. Until the late 18th century copper ore from Cornwall was smelted in Bristol itself (Day 1973). After that copper ore from a variety of sources, Anglesey, then Cornwall and latterly sources from all over the world, smelted at Swansea, supplied the Bristol brass makers (Barton 1978). Cornish copper was noted for its tin content and thus the regular and quite high tin content in the low zinc alloys probably suggest a Cornish source for the metal. However, improved copper refining at Swansea in the early 19th century drastically reduced the tin content. Thus, an ingot of copper smelted by the Rose Copper Company at Swansea in 1805 using Cornish ore was found to be free of tin at least down to 0.1%. (The ingot was recovered from the wreck of EIC vessel 'Britannia' and is now in the British Museum).

Thus, the relatively high tin content could indicate copper smelted in Bristol from Cornish ore in the 18th century.

Summary

Analysis of the brasses reveals two compositional groups, one with high zinc (>30%) and low levels of iron, tin and lead, and the other group with less, but still substantial, zinc 26%) and higher iron, tin and lead. The first group are likely to have been made by mixing copper and zinc metals, ie speltering, and the second group made by reacting copper with calcined zinc ore and coke in a closed crucible, ie cementation. Cementation brass seems to have been made in Bristol up to the 1830's (Day 1973) and speltering continued into this century. The high tin in the copper probably denotes a Cornish source. Cornish ore was smelted in Bristol only until the late 18th century. Copper smelted at Swansea from Cornish or other ore sources in the 19th century seems to have had much less tin, thus it is possible that in general the cementation brasses are of the late 18th century, whereas the high zinc brasses are after the 1830's. However, items from both groups could easily belong to the early 19th century. Perhaps all that can be said with any confidence is that the high zinc brasses (excluding the chestnut roaster) are unlikely to be pre-19th century and the cementation brasses are unlikely to be post-1830.

D Hook and P T Craddock

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