solders, *ie* yellow-gold colour, melting temperature below 800°C, strong adhesion, corrosion resistance, fluidity, wettability at a level of properties of the Au/Ag/Cd/Cu 750 - 30 gold solder. The Xi'an workers have developed new gold- and silver-palladium alloys which meet the Chinese requirements of biocompatibility, mechanical properties, chemical properties and cast accuracy.

2 Alloys and Materials

A plenary lecture entitled 'Progress of Research and Applications of Precious Metals Micro Irregularly Shaped Composites' was given by Li Mingli, Bai Wenchao, Li Yin'ee and Wang Jinming of the Northwest Institute for Non-Ferrous Metals Research, Xi'an, China. Switching contacts and spring push buttons in communications technology, keyboard contacts in computers and electronic devices, and plug connectors in electronic systems require the contact function to be absolutely reliable during long-term use. As they have an excellent stability, gold and high gold content alloys of other precious metals cannot be replaced by any other precious metal.

3 Refining and Recovery

There were a number of papers in this section on various aspects of gold refining. The titles were as follows: 'Solvent Extraction of Gold(I) in a Mixed Alcohol-Diluent-Surfactant-Au-(CN)²⁻-System' by Hwang Kwn and Chen Jing of the Kunming Institute of Precious Metals; 'Studies on the Performance of Extracting Au(III) from HCl Medium with Petroleum Sulfoxide' by Gu Guobang, Yi Xiaoyun and Li Yanli of the Institute of Chemical Engineering, South China University of Technology, Guangzhou; and 'Adsorbing Gold with Activated Carbon Fibre from Cyanide and Chloride Solutions' by Lu Yuehua and Shui Chenjing of the Kunming Institute of Precious Metals.

4 Extraction and Metallurgy

Amongst the gold papers presented in this section were: 'Optimization of Gold Grade in Production Using Regression and Genetic Algorithm' by Q.X. Yun, Z.Q. Wang, C.W. Lu and X.Z. Lan of Xi'an University of Architecture and Technology, describing a new approach which has been used in Jinshan gold mine in China; and 'Mathematical Models of Lime-Roasting Pretreatment of Refractory Gold Ore' by Zhang Pengfei and Chen Jin from Changsha Railway University and Central South University of Technology, Changsha describing approaches relevant to the gold ore located in Hunan.

All the papers and posters presented at the Symposium are published in a comprehensive hard-backed conference proceedings book* edited by Professors Deng Deguo, Lan Xinzhe, Yang Yikun and Li Guanfang. Much of the work described from laboratories in China was of an 'upstream' nature (3), being basic research with an industrial orientation, and it was encouraging to see so many young people making the presentations.

David Thompson

REFERENCES

- 1 D. McDonald and L.B. Hunt, 'A History of Platinum and its Allied Metals', Europa Publications Ltd for Johnson Matthey, 1982
- 2 D.T. Thompson, *Gold Bull.*, 1998, **31**, 111; 1999, **32**, 12
- 3 E. Konecny, C.P. Quinn, K. Sachs and D.T. Thompson, 'Universities and Industrial Research', The Royal Society of Chemistry, Cambridge, UK, 1995

*The book of Proceedings can be obtained (60 US\$, including postage) from Ms Li Ming, Kunming Institute of Precious Metals, Kunming 650221, Yunnan, China; Fax: +86 871 515133).

BOOK REVIEW

Hallmark – A History of the London Assay Office

By J S Forbes, Unicorn Press, London, 1999, pp. 367.
ISBN 0 906290 260 Price £35

Hallmarks serve as a guarantee of precious metal content and represent an early form of consumer protection. The idea originated with the invention of coinage by the Lydians of Asia Minor sometime in the seventh century BC. By stamping fixed weights, or coins, of precious metal with their distinctive mark, the minting

authority sought to provide an assurance of their value. The Romans occasionally marked ingots of gold and silver with official stamps guaranteeing purity and, from the late fifth century AD, similar marks were applied to wrought metal. The practice of hallmarking silverware was introduced in France in 1275 and it spread to much of western Europe by the early fourteenth century.

The foundations of the hallmarking system in England were laid by the passing of a statute of Edward I in 1300, which decreed that all silver articles had to be up to the sterling standard of 11 troy ounces

and 2 pennyweights (equivalent to a 925 millesimal purity). This quality had to be demonstrated by an assay undertaken by "the guardians of the craft," who would stamp the silver article with a leopard's head as a mark of conformance. In 1327, the goldsmith's guild was granted its first charter by Edward III but it was in 1478 that the Assay Office was consolidated as a permanent institution with the appointment of Christopher Elyot as the first full-time, salaried assayer. Remarkably, the Assay Office has occupied the same site within the Goldsmith's Hall complex close to

Figure 1 *Silver-gilt tazza bearing the hallmark for 1584, while Thomas Keeling was assayer, published with permission from The Worshipful Company of Goldsmiths.*

London's Guildhall for over six and a half centuries without a break. Also in 1478, the date letter was added to the mark of the manufacturer, following the French example, and together with the maker's mark and the leopard's head it completed the set of the London hallmarks that was to be maintained over the centuries. By contrast, the compulsory hallmarking of gold articles had to wait until the enactment of the Plate (Offences) Act of 1738.

John Forbes, a retired Deputy Warden of the Goldsmith's Company, spent seven years of research tracing the history of the London Assay Office. And what a remarkable story he has succeeded in unfolding. He was greatly assisted in his task by the minute-books of the Goldsmith's Company, which run from 1334 onwards, apart from the loss of a single volume covering a period of thirteen years in the sixteenth century. The survival of these precious volumes is little short of a miracle. The early minute-books were

rescued from the fire of London in 1666 by a quick-thinking goldsmith and city alderman, who commandeered a cart to carry away the Goldsmith's Company's plate and records to safety. Forbes also garnered material from other collections, including those of the Public Records Office and the British Museum.

Considerable attention is paid to the personalities associated with the London Assay Office. For example, the author charts the running battles of Thomas Keeling, assayer for almost two decades in the sixteenth century, with Richard Martin, a powerful city figure and Warden of the Mint. This episode and several others related in this book illustrate the repeated hostility attracted to the assayers over rejected wares, which had to be broken up, or purported damage to articles by sampling. In the early years, serious offenders against the hallmarking regulations were "named and shamed" by being put in the stocks in the Goldsmith's Hall, in full view of guild members. However, the life of the assayer could not have been too stressful, because since 1478, there have only been 41 head assayers, making the average period of office more than twelve years. Forbes leads the reader through the annals of the Assay Office and conveys its vicissitudes with the immediacy of contemporary events. The incessant pleas of assay staff to their employers for an increase in salary strike a particularly modern chord! For collectors of antique silverware, this book is indispensable and they will instantly recognise the names of famous gold- and silversmiths which cross its pages. The author describes the introduction of the different standards, including the Britannia Standard for silver, explaining the circumstances for their adoption.

For this reviewer, one of the more fascinating themes running through this book is the endurance of the fire-assay technique, or cupellation, through the ages and it remains the most cost- and time-effective method for assaying gold items. It is the oldest quantitative analytical technique used on metals and it

was a spin-off from the development of silver and gold extraction and refinement sometime after 3000 BC(1). A sample of the item is taken as a scraping. This is weighed, wrapped in lead foil and placed in a crucible (or cupel) of bone ash. It is then heated in a muffle furnace, which results in the base metals being oxidized and absorbed into the crucible. The residual pellet is reweighed, to determine precious metal purity. For gold alloys, a further stage is necessary in which the silver is removed chemically from the pellet. This operation, traditionally known as "parting," was formerly accomplished using a mixture of brick dust, salt and "misy" (sulfates of iron and copper). A strikingly similar recipe for purifying gold is described in the oldest surviving metallurgical text, the Leiden Papyrus X, dating from the early fourth century AD(2). Forbes points out that modern assays of a series of surviving silver and gold standards dating back to 1560, which were prepared by the Assay Office for the Royal Mint, are remarkably accurate considering the crude tools, furnaces and weighing balances that were then available. This is despite the fact that a scientific understanding of the process of cupellation was only gained in the later eighteenth century, which only goes to show that it is possible to reliably operate a sophisticated technology without knowing how it works!

Forbes augments his narrative with a wealth of well-chosen illustrations, some in colour, see for example Figure 1, and framed vignettes on selected topics. There are also a useful series of appendices and end-notes. Typographical errors are few, although the notes to Chapter 2 are awry and "Inigo Jones" is referred to in the index as "Indigo Jones." The photograph of the silver-gilt cup and cover on page 208 is out of focus. But these are tiny blemishes in what is a well-written and thoroughly stimulating book.

David M Jacobson

1 A. Oddy, *Gold Bull.*, 1983, 16, 52

2 L.B. Hunt, *Gold Bull.*, 1976, 9, 21