"Palladium; or, New Silver"

NO STRANGER TO SCIENTIFIC CONTROVERSY

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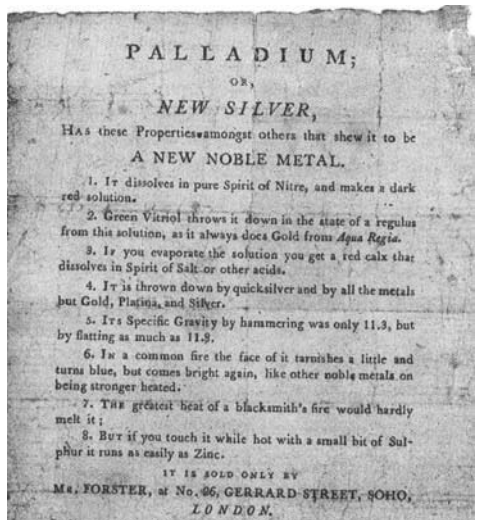
The recent surge of interest in palladium, an element whose history has not been afforded the same coverage in this Journal as that given to platinum, has prompted this account of the discovery and preliminary investigation of this important member of the platinum group of metals. The first written reports about palladium resulted in controversy, confusion and embarrassment; its inclusion in jewellery in the early twentieth century, and more especially some recent claims concerning palladium electrodes, had similar effects. A number of the people who contributed in various ways to the introduction of this metal to the scientific community in the early nineteenth century are also considered, briefly.

In April 1803 a small advertising leaflet listing some properties of what was claimed to be a new metal called palladium or new silver, was distributed anonymously to a number of scientists in London; it announced that the metal was available only from Mr. Forster of Soho. [Adolarius] Jacob Forster (1739–1806), a dealer in minerals, was abroad at the time so prospective purchasers had to approach his wife, Elizabeth, for samples of the metal. However, when William Nicholson, editor of the *Journal of Natural Philosophy, Chemistry and the Arts*, sought to establish who had supplied the palladium, Mrs. Forster maintained that she did not know the name of the "genteel young man who gave her the metal for sale". Nicholson reprinted in his journal the information given on the leaflet (1), but, not surprisingly, the unusual way in which this new element had been brought to the attention of the scientific community, aroused the suspicions of at least some of the first people to hear about it.

Prominent among the sceptics was the chemist Richard Chenevix who, having read on the 29th April what was claimed in the leaflet, formed the opinion that it was a piece of deception. He therefore obtained and made a preliminary investigation of a sample of the "new metal", and finding that its characteristics did not resemble those of any known metal, returned to Forster's shop at No.26 Gerrard Street and purchased all the remaining stock (2). Having carried out a considerable number of hurried experiments



PALLADIUM;
OR,
NEW SILVER,
HAS these Properties amongst others that shew it to be
A NEW NOBLE METAL.

1. IT dissolves in pure Spirit of Nitre, and makes a dark red solution.
2. Green Vitriol throws it down in the state of a regulus from this solution, as it always does Gold from *Aqua Regia*.
3. If you evaporate the solution you get a red calx that dissolves in Spirit of Salt or other acids.
4. It is thrown down by quicksilver and by all the metals but Gold, Platina, and Silver.
5. Its Specific Gravity by hammering was only 11.3, but by flatting as much as 11.8.
6. In a common fire the face of it tarnishes a little and turns blue, but comes bright again, like other noble metals on being stronger heated.
7. THE greatest heat of a blacksmith's fire would hardly melt it;
8. BUT if you touch it while hot with a small bit of Sulphur it runs as easily as Zinc.

IT IS SOLD ONLY BY
Mr. FORSTER, at No. 26, GERRARD STREET, SOHO,
LONDON.
In Samples of Five Shillings, Half a Guinea, & One Guinea each.

J. Moore, Printer, Drury Lane

In April 1803, this leaflet was distributed to a number of people in London, advertising a new noble metal which could be obtained only from a shop in Soho, owned by Jacob Forster, a collector and dealer in minerals. The cost worked out at about one shilling a grain, this being approximately six times the price of gold at that time

Richard Chenevix
1774–1830

This noted chemist was a native of Ireland, although of French extraction. His first English language paper was published in 1801, the year in which he was elected a Fellow of the Royal Society. He lived in France on a number of occasions, and nine of his chemical memoirs were published in that country. Apparently Chenevix enjoyed arguments, which perhaps explains his persistence during the palladium controversy. In later life he engaged in literary pursuits

"He sent in his memoir to the Royal Society, and two evenings were spent in the reading of it" (3), this being on 12th and 19th May 1803. At this time Chenevix was already an established analytical chemist, and a Fellow of the Royal Society with some 16 scientific papers and a textbook on chemical nomenclature to his credit. He had travelled widely on the continent of Europe where he had met some of the leading scientists of the day. Clearly, he was not content to accept without question all of the claims made by other scientists, for he had already engaged in a number of arguments about scientific matters, and made no secret of the fact that he believed palladium to be a hoax. In fact, erroneous announcements of the discovery of new elements were not unusual during the nineteenth century.

The investigations carried out by Chenevix showed that the specific gravity of the samples varied from piece to piece, between about 10.97 and 11.48, but that their other properties were as described on the sales leaflet. None the less he doubted the elemental nature of the samples, and was convinced that palladium was only an alloy of platinum. He formed the opinion that the element most able to mask the true properties of platinum, while hiding its own, was mercury. He therefore turned his attention from analysis to synthesis, and set out to reproduce the supposed alloy. As a result of his work he soon claimed that he had "formed palladium by the immediate union of platina and mercury", and went on to "describe the means by which I have attempted to produce it, whether they failed, or were attended with success." (4) During one of his experiments he produced a fused button, calculated to consist of about two parts of platinum and one of mercury, which "was not to be distinguished from palladium." (5)

For another experiment he enlisted the help of Mr. W. H. Pepys who used his powerful galvanic battery to heat a platinum wire partly immersed in mercury, but although the wire was brought close to its melting point the two elements did not combine to form palladium (6). Conversely, when Humphry Davy used the galvanic batteries at the Royal Institution to ignite a strip of bought palladium no mercury was detected, even though the metal "burned with a very vivid light . . ." (7).

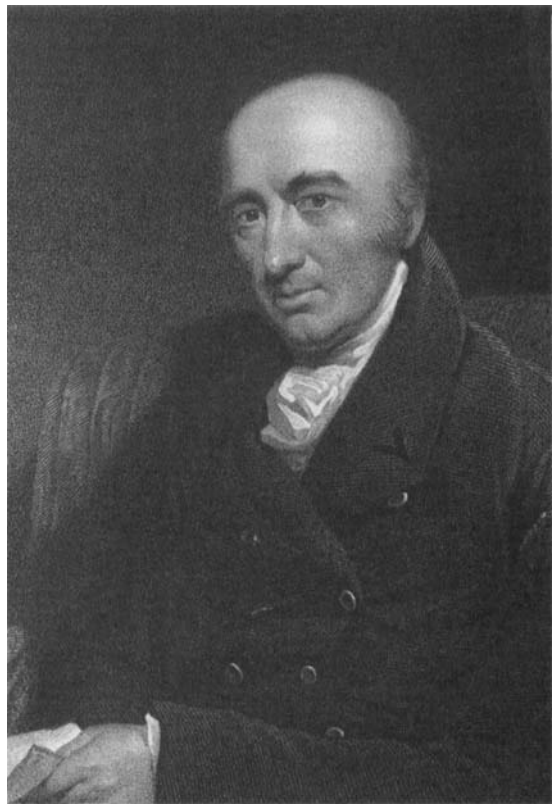
Despite such set-backs Chenevix was convinced that he had produced palladium, and that it was not a new element. In a comment, however, which is every bit as pertinent now as it was when he wrote it nearly two centuries ago (8), he reminded his fellow scientists that although it was dangerous to accept new claims without the most careful examination,

> "The philosopher, indeed, will feel no humiliation in being forced to correct or to extend his knowledge; and will not altogether disbelieve a fact, because he can adduce no parallel instance, or because it is not in unison with his received opinion. Such conduct would be raising an unsurmountable barrier against the progress of science:"

Further on in the paper, when referring to his

William Hyde Wollaston
1766–1828

During the course of a brilliant career, Wollaston made a number of fundamental discoveries in several branches of science. Generally regarded as the outstanding figure in the history of platinum, he was the first to refine the metal on a commercial scale, and it was during his investigations that he discovered the new element which he named palladium. To prevent others learning of the direction, and the progress, of his work he chose to establish his priority to palladium by the anonymous sale of samples through the Forster's shop. He also discovered rhodium, which he announced in the more usual way, by a paper presented to the Royal Society



own palladium investigations, he emphasised:

> "The general importance of the principle, and the extensive influence it is likely to have upon chemistry, demand that it should be treated by multiplied researches. The experiments that can elucidate it are of the most delicate nature, and require particular care; for they do not always succeed, unless performed under the most favourable circumstances." (9)

The purchase of the total remaining stock of palladium by Chenevix must have restricted the opportunity for others to conduct their own analysis. But on May 4th, only five days after first learning of the new metal, he sent one of the notices and a little piece of the palladium he had purchased to the distinguished French chemist Nicholas Louis Vauquelin (1763–1829) for examination. Vauquelin checked the properties against the claims made in the notice and found them to be correct. He was unable to detect either platinum or mercury in the sample; also he found that the addition of sal ammoniac to a solution of platinum and mercury gave a copious precipitate but this did not occur when it was added to a solution of palladium. To his report the editors added a footnote which reads, in translation, "all this must give rise to doubt." (10)

Notable scientists in Germany who contributed significantly to our knowledge of the platinum group metals, but who failed in their attempts to synthesise palladium from platinum and mercury in the ways described by Chenevix, included the analysts Valentin Rose and A. F. Gehlen, the distinguished chemist M. H. Klaproth and Professor J. B. Trommsdorff of Erfurt. Thus, Chenevix's work failed to pass what was then, and still remains, the most critical of tests; it could not be confirmed by the independent investigations of his peers.

Another Fellow of the Royal Society who attempted to synthesise palladium was William Hyde Wollaston, but it will be shown later that

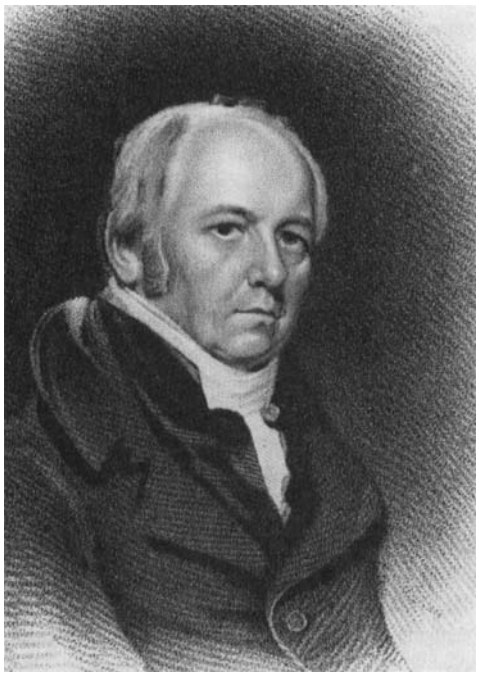
he could not be considered an independent investigator. Wollaston's notebooks record that in addition to conducting trials with platinum and mercury, he also investigated platinum and iron, and was satisfied that palladium could not be manufactured from these components (11).

Perhaps surprisingly, Chenevix does not seem to have been deterred by the fact that such eminent scientists were unable to repeat his results. His work was widely reported, and "the artificial synthesis of palladium by one or more of his methods became a popular pursuit throughout Europe." (12) He later reported that no more than four out of one thousand attempts to synthesise palladium had been (supposedly) successful; but this only reinforced Chenevix's belief that perseverance would be required to discover the secret of its formation (13).

A Reward Offered for Producing Palladium Artificially

A second intriguing notice concerning palladium appeared in London in early 1804, when Nicholson published an anonymous letter, dated December 16th, 1803, which had been sent to him (14). This offered a reward of £20 to anyone who, in the presence of three chemical assessors, could produce palladium artificially. Having established that the handwriting was the same as that on the previous communication, and also that the £20 had been deposited with Mrs. Forster as claimed in the letter, Nicholson selected two Fellows of the Royal Society, Charles Hatchett and Edward Howard to serve with him as adjudicators. No doubt hoping for a journalistic scoop, Nicholson expressed the hope that "the commission will enable me to present to my readers an account of whatever may be the result of this public invitation." (15) As far as is known, the services of these eminent men were not required, and the money was later retrieved.

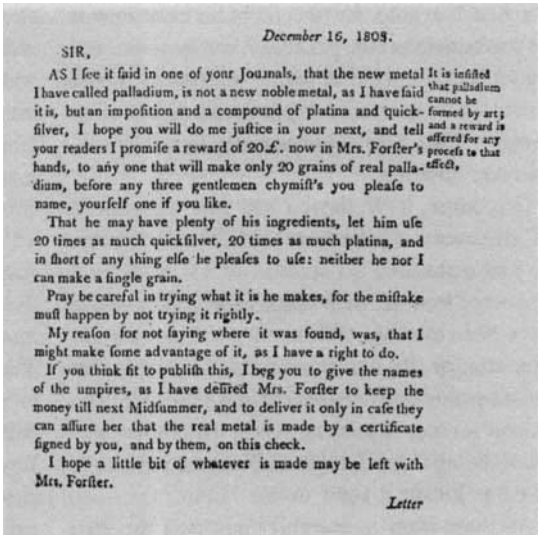
The next major event in this fascinating saga, and a lost opportunity to set the records straight, occurred on 24th June 1804 when Wollaston read to the Royal Society a paper entitled "On a new Metal, found in crude Platina" in which he set out to prove the existence and to examine the properties of a previously unknown metal which he had named *Rhodium* (16). In the paper he



William Nicholson
1753–1815

Born in London, Nicholson had a varied career in India and Europe. Commercial agent, scientist, inventor, patent agent and publisher, in 1797 he started the *Journal of Natural Philosophy, Chemistry, and the Arts*. His contribution to the story of palladium was as a communicator; he was one of the people to receive the leaflet announcing the availability of palladium, and reprinted it in the next issue of his popular journal. He was later asked, again anonymously, to select three chemists to oversee attempts to produce palladium from other materials, a challenge which he publicised in his journal. He also reprinted information on palladium from both English and foreign language journals

In a section devoted to scientific news, and headed "Reward of Twenty Pounds for the Artificial Production of Palladium" Nicholson's *Journal of Natural Philosophy, Chemistry, and the Arts* carried Wollaston's second anonymous communication, this time offering £20 to anyone who could make twenty grains of palladium before an audience of three chemists selected by Nicholson



December 16, 1809.

SIR,

AS I ſee it ſaid in one of your Journals, that the new metal I have called palladium, is not a new noble metal, as I have ſaid it is, but an impoſition and a compound of platina and quick-ſilver, I hope you will do me juſtice in your next, and tell your readers I promiſe a reward of 20*£*. now in Mrs. Forſter's hands, to any one that will make only 20 grains of real palla-dium, before any three gentlemen chymiſt's you pleaſe to name, yourſelf one if you like.

It is inſiſted that palladium cannot be formed by art; and a reward is offered for any proceſs to that effect.

That he may have plenty of his ingredients, let him uſe 20 times as much quickſilver, 20 times as much platina, and in ſhort of any thing elſe he pleaſes to uſe: neither he nor I can make a ſingle grain.

Pray be careful in trying what it is he makes, for the miſtake muſt happen by not trying it rightly.

My reaſon for not ſaying where it was found, was, that I might make ſome advantage of it, as I have a right to do.

If you think fit to publiſh this, I beg you to give the names of the umpires, as I have deſired Mrs. Forſter to keep the money till next Midſummer, and to deliver it only in caſe they can aſſure her that the real metal is made by a certificate ſigned by you, and by them, on this check.

I hope a little bit of whatever is made may be left with Mrs. Forſter.

Letter

stated that, as a result of his scientific study of a solution of native platina in aqua regia, he was convinced that:

> "the metallic substance which was last year offered for sale by the name of Palladium, is contained (though in very small proportion) in the ore of platina."

and that considering the difficulties in trying to synthesise palladium or to separate it into other metals,

> "I think we must class it with those bodies which we have most reason to consider as simple metals." (17)

In a postscript to a paper written in Freyberg dated June 3rd 1804, and read to the Royal Society on January 10th 1805, Chenevix records that Wollaston had mentioned to him more than a year earlier that "He has found that palladium is contained in very small quantities in crude platina." (18) Chenevix observed that the fact that palladium could be found in nature did not settle whether it was an element or an alloy. Furthermore, he claimed that the process to which platina was subjected before it arrived in Europe would be sufficient to account for the presence in it of a small amount of palladium.

In the next month Nicholson received a letter from Wollaston, dated February 23rd 1805, in which Wollaston admitted that he was the author of the first anonymous communication concerning palladium, which he had discovered, and thanked Nicholson for the candour with which he had communicated the information about palladium that had been passed to him (19). With the mystery explained, the matter moved towards a conclusion when on 4th July 1805 Wollaston read to the Royal Society his paper "On the Discovery of Palladium; with Observations on other Substances found with Platina", in which he gave an account of the way he had detected, and subsequently obtained, palladium (20).

This paper should have finished the controversy once and for all, but apparently this was not the case. As late as 1809 Joseph Cloud (1770–1845) of the Philadelphia Mint, prefixed an account of experiments he had made on a discoloured ingot of gold received from Brazil in 1807, with the words:

> "Notwithstanding the numerous experiments that have been made by several eminent chemists, on a metallic substance, discovered by Doctor Wollaston, in combination with crude platinum, and by him called palladium; there still remains much doubt with respect to the existence of such a simple substance." (21)

Having again noted that palladium was found in combination with crude platinum, Cloud claimed "It has been my fortune, however, to obtain it from a different source;..." this being

the Brazilian gold. By the end of his experiments he was convinced the palladium was genuine, and that it had occurred in nature alloyed with gold "without the presence of platinum, or any other metal". This final comment may have been incorrect, however.

Of course, if Wollaston had first announced his discovery of palladium to the Royal Society, or had published an account of his work in a respected journal, then much controversy would have been avoided. While his conduct may appear strange, the explanation that he gave for his most curious behaviour is entirely plausible. His reason for not disclosing where palladium was found being "that I might make some advantage of it, as I have a right to do." (14)

As has been admirably narrated in this Journal previously, Wollaston and his friend Smithson Tennant formed a working partnership in 1800 to engage in various chemically-based enterprises (22, 23, 24), including the scientific investigation of platinum and its preparation for commercial use. Their partnership was kept a secret, and when Wollaston eventually developed a way of producing malleable platinum the method was also closely guarded. Indeed, details of the process were only published in late 1828, when Wollaston knew that he was close to death, seven or eight years after the business had ceased. Initial expenditure was considerable, not only for the purchase of crude platinum but also for chemicals and apparatus, and it was to be five years before annual revenue exceeded expenditure and another four years before the platinum enterprise began to show an overall profit.

During the refining of platinum Wollaston undertook an investigation of the portion of the platina that was soluble in aqua regia, while Tennant concentrated on the black insoluble residues. As a consequence, Tennant isolated osmium and iridium, while Wollaston discovered first palladium and then rhodium. He estimated that the palladium amounted to about one part in two hundred of platinum, so under the circumstances it was quite understandable that he did not want to be diverted from his platinum activities to investigate in detail the properties of this new, but apparently exceedingly scarce element. At that stage he did not want to publicise his work on platinum, neither did he wish to forgo any scientific recognition or commercial advantage that might eventually result from a more detailed examination of the materials. Aware that chemists on the European continent were actively and successfully engaged in the investigation of platina, and, perhaps, suspecting that their efforts would lead them to the new elements, Wollaston wished to establish his priority but without disclosing his identity. The latter constraint severely limited his ability to accomplish the former; for example, the editors of the *Philosophical Transactions* of the Royal Society did not publish papers from anonymous sources. The notice and the offer of palladium for sale through Mrs. Forster enabled Wollaston to achieve his purpose, but according to Sir Joseph Banks, President of the Royal Society, Wollaston's reputation in the scientific community was damaged by the episode (25).

Banks had become involved in the controversy in an unfortunate way. The Royal Society presents the Copley Medal annually to the scientist who is judged to have published the most important results on some aspect of natural history, and in late 1803 Chenevix was a strong contender for the next award. Wollaston was aware of the situation, possibly because he had received the medal the previous year. Therefore in an unsuccessful attempt to save the Royal Society from embarrassment when it eventually became known that Chenevix's synthesis and investigation of palladium was largely wrong, Wollaston admitted his discovery of palladium to the President. The situation was clearly difficult for Banks, as Wollaston asked him not to disclose the secret. In fact, Wollaston's information was disregarded and Chenevix received the medal (26).

In the end, Wollaston made no significant financial gain from his discovery and sale of palladium; indeed, it appears that 97 per cent of the palladium he separated from the crude platina was still available at the time of his death in 1828 (27). During the early years palladium sales were held back by the fact that most potential applications for it could be satisfied equally well by

Percival Norton Johnson
1792–1866

After being apprenticed to his father, the assayer John Johnson, Percival started his own business on 1st January, 1817. Moving to Hatton Garden in 1822, his business in assaying and refining the precious metals and producing vitreous colours grew rapidly. Johnson was also active in the mining and smelting of the silver-lead ores found in Devon and Cornwall. He was one of the founders of the Chemical Society, and was elected a Fellow of the Royal Society in April 1846

platinum, which was more readily available, and cheaper. Some of the palladium was used alloyed with gold, producing a white alloy upon which Edward Troughton engraved the graduation scales of astronomical and navigational instruments. Other scientific instrument makers including Dolland and Jean Nicolas Fortin followed the lead of Troughton (28, 29) but the demand was not large and Wollaston gave most of his unused palladium to the Royal Society (30). It was to be many years before a fuller understanding of the properties of palladium, and a significantly lower price, led to the identification of applications for which it could be used advantageously.

Much more important and interesting information regarding Wollaston's early work with palladium is contained in his notebooks (23). For example, an entry for 3rd August 1802 referred to the new metal as "palladium" and he later wrote that it had been named after the planet that had been discovered nearly at the same time by Dr. Olbers (20); the minor planet Pallas being discovered on the 28th March 1802 by the German astronomer Heinrich W. Olbers. Another entry relates to the determination of the specific gravity of a binary alloy of lead and C, and on the facing page a note records

> "the upper part of the opposite page was written July 1802. I believe the C meant Ceresium a name which I once thought of giving to Palladium."

(Ceres, the first and largest asteroid to be discovered was sighted by Giuseppi Piazzi on 1st January 1801, an observation which was confirmed in 1802). Data in another of Wollaston's notebooks suggest that he had left nearly 1350 grains (2.8 troy ounces) of palladium with Mrs. Forster, and that by the time the account was closed in May 1805 only 420 grains had been sold, of which 332 grains had been purchased by Chenevix in April and May 1803 (31).

Percival Norton Johnson

Several years later, in July 1812 the *Philosophical Magazine* carried a paper by Percival Norton Johnson, described as an assayer of metals, reporting that although pure platinum is not affected by nitric acid, if it is alloyed with gold and silver it then becomes soluble in that acid (32). It is not clear whether Johnson thought this was an original observation; we now know that is was the basis of a technique

used earlier in Spanish South America to separate platinum from gold, and it was certainly known in Paris in the late 1770s. Be that as it may, appended to the paper was a note of considerable interest and significance. In this Johnson and his father reported that some gold arriving from Brazil contained so much palladium that the colour was changed, and that coins made from it were suspected as being counterfeits.

In due course Percival Norton Johnson moved to Hatton Garden and built up the business that was to become Johnson Matthey. But before this happened, Johnson was contracted to refine the gold brought into London by the Imperial Brazilian Mining Association. This Association had been formed in December 1824 to mine at Gongo Soco, in the Brazilian province of Minas Geraes, some 180 miles north of Rio de Janeiro. As had been reported previously by Wollaston, the gold contained a significant amount of palladium, both as particles of native palladium and alloyed with the gold. In the latter, the palladium content varied from, perhaps, one or two up to a maximum of 8.2 per cent. Prior to 1832 the gold was brought to London in the form of crude bars cast at the Government Mint at Sabara, but these contained varying amounts of iron, palladium and tellurium. As a result the bars were discoloured and some were brittle; the latter, being rejected by the Bank of England's smelters, were unsaleable (33). On the other hand, the non-brittle bars were refined at the Royal Mint but the process resulted in the loss of all the palladium. After 1832, however, the export of gold from Brazil in the form of powder was permitted, and by this time Johnson had

> "discovered the means of separating from the gold all the metals in combination with it, and which consist of silver, platina, palladium, rhodium and iridium....palladium is a metal but little known, and is found to be most valuable in the construction of astronomical, nautical and experimental instruments, being perfectly free from all oxydation, and quite malleable, and will no doubt increase in value as its excellent qualities become more generally understood." (34)

Indeed, his success in refining this difficult gold, which contained tellurium in addition to palladium, "led eventually to the full recognition of his firm as refiners and their appointment as Assayers to the Bank of England." (35) More immediately, as a result of his scientific investigations and his accumulated technical skills, Johnson was able to add significant value to the ore imported by the Imperial Brazilian Mining Association.

As Wollaston had found, applications for the recovered palladium did not develop rapidly. In July 1823, Aimé Puymaurin, then Deputy Director of the Paris Mint, wrote a paper detailing the properties of palladium, as determined by Jean Robert Bréant, one of the assayers at the mint. He had undertaken the refining of 1000 kilogrammes of Spanish platina from which he had recovered some 900 grammes of palladium. Bréant used part of this palladium to strike a medal which he presented to Louis XVIII of France; then in 1824 when King Charles X succeeded his brother, Bréant presented him with an ornate cup consisting of a palladium bowl mounted on a silver base (36).

In an attempt to identify further industrial applications, Johnson also sought to promote a greater awareness of palladium by making suitable presentations. For example, in 1826 a massive ceremonial chain made of palladium was presented to King George IV (37). The promotional exercise lasted at least until 1845, when Johnson presented to the Geological Society sufficient palladium to make their prestigious Wollaston Medal for several years. In time such early uses as for the scales of scientific and astronomical instruments, reflectors for lighthouses, analytical weights, jewellery, and for dental purposes, were supplemented by medical and electrical contact applications, and uses based upon the remarkable ability of palladium to absorb vast amounts of hydrogen.

The latter property was discovered by Thomas Graham (1805 – 1869) who, after studying the behaviour of hydrogen when exposed to heated platinum, found that palladium could absorb up to six hundred times its own volume of hydrogen (38). He also investigated the absorption of hydrogen by silver-palladium alloys, made by George Matthey, a property which finds major

In about 1819 Jean Robert Bréant (1775–1850), an assayer at the Paris Mint, undertook to refine 1000 kilogrammes of platina which had been sold by the government in Spain. Having taken advice from Nicolas Louis Vauquelin, an eminent chemist and analyst and the recipient of a piece of the palladium purchased by Chenevix, Bréant extracted from the platina about 900 grammes of palladium. From this he made the bowls of two decorative cups, the larger being presented to King Charles X and now preserved in the Trianon at Versailles. Bréant also made a number of palladium medals, one of which was presented to Louis XVIII in 1823; another, illustrated here at actual size, was struck to commemorate the opening of the Museum of the Département des Monnaies et Médailles in 1833 by King Louis Philippe I and Queen Marie Amélie

industrial application for the production of ultra-pure hydrogen (39). The topic continues to interest academic investigators – as evidenced by the preceeding scientific paper by F. A. Lewis, X. Q. Tong and R. V. Bucur, and a number of Abstracts of the current literature, in this issue of *Platinum Metals Review.*

The Platinum-Palladium Jewellery Debate

Although platinum had been used by the inhabitants of South America for the fabrication of ornaments in pre-Hispanic times (40), until the start of the twentieth century the platinum metals were little used for the manufacture of jewellery on a large scale. As a result there was no necessity to indicate the composition of a platinum article, in the way that the minimum purity of a gold or silver item is defined by the carat or sterling mark stamped on it. With the use of platinum for jewellery increasing from about 1906, however, opportunities for deception arose. The problem was worst in the United States of America, where, by the early 1920s, four or five times as much platinum was being used for jewellery as in the whole of Europe. As a result, the New York State Stamping Act of 1920 included a section dealing with the composition of platinum jewellery which reads, in part,

> " The standard is 925/1000 fine which not only includes the platinum metal alone, but also the other metals in the platinum group, and if tests are made all the metals in this family group of platinum may be included".

Similar legislation was passed in the states of Illinois and New Jersey.

Although most U.S. platinum jewellery was manufactured in these three states, it became apparent that Federal Law would be required. Experience of how the state regulations had worked in practice indicated that, for a variety of reasons, modifications would have to be incorporated when drafting the Federal Law. Concern arose over the relative cost of the other platinum group metals that were added to pure platinum to

catalytic converters (51). Clearly an objective assessment of the role of palladium in automobile emission control catalysts is another aspect of the remarkable story of palladium that should be left until the next century.

Current Demand

In conclusion, it is interesting to note that notwithstanding the early controversial history of palladium and the more recent surges in excitment associated with the metal, demand for palladium in 1990 amounted to 3.425 million ounces (52); major uses being in the electrical and electronics industries, for dental alloys, as a component of emission control and chemical process catalysts, and for jewellery.

Acknowledgements

This account has been compiled from information given in the relevant sections of "A History of Platinum and its Allied Metals" with additional material gleaned mainly from the references therein. In particular it owes much to the referenced papers by Professor M. C. Usselman. The illustration of the leaflet announcing the sale of palladium is reproduced by courtesy of the Syndics of Cambridge University Library, the portraits of Chenevix and Nicholson by courtesy of the National Portrait Gallery, London.

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