George Matthey and the Building of the Platinum Industry

SEVENTY YEARS OF ACHIEVEMENT IN REFINING AND FABRICATION

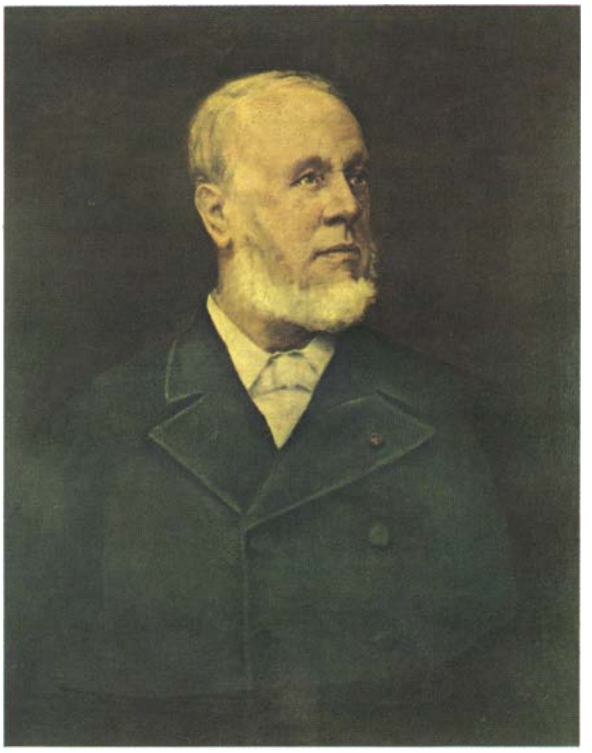
By L. B. Hunt

Johnson Matthey & Co Limited

Just a hundred years ago, on April 3rd, 1879, a paper on platinum refining was read to the Royal Society by George Matthey, at that time the senior partner in Johnson and Matthey. His election as a Fellow had been proposed during the previous month by a number of distinguished scientists, and he was described on the candidate's certificate as:

> "Distinguished as a Metallurgist, having special knowledge of the metals of the Platinum Group. The development of the Platinum Industry was mainly due to his efforts"

The extent to which he was regarded in scientific circles is evident from the very influential support he received, the names including those of Sir Frederick Branwell, President of the Institution of Mechanical Engineers, Robert Hunt, Professor of Physics at the Royal School of Mines, and earlier one of the Prince Consort's scientific advisers, Sir William Abney, later President of both the Physical Society and the Royal Astronomical Society, Jean Baptiste Dumas, the great French chemist and statesman, Charles Wurtz, Professor of Chemistry at the Sorbonne, H. C. Sorby, the pioneer metallographer, and William Roberts-Austen, chemist to the Royal Mint.



George Matthey F.R.S.
1825–1913

Joining P. N. Johnson as an apprentice at the age of thirteen, he retired as Chairman of Johnson Matthey and Co Limited when he was eighty four. During this extraordinarily long career he developed the refining and fabrication of platinum from a laboratory scale to a successful industrial operation upon which his successors have been able to build

From a portrait in the possession of Johnson Matthey

He was duly elected F.R.S. in the following June, and he might then well have considered himself to be at the high point of his career. Yet, after a little over forty years in the company he had a further thirty years of active work ahead of him before retirement.

George Matthey was born on May 8th 1825, the elder son of Percival Norton Johnson's great friend John Matthey, a wealthy stock broker and foreign exchange dealer, whose father Simon had left his home town of Le Locle in Switzerland in about 1790 to settle in London. In 1838 Johnson, with plans for the expansion of his then very modest business in mind, concluded an agreement with John Matthey whereby, in return for an injection of new capital, the latter's two sons should be apprenticed to him. George at once entered the business to work in the assay laboratory, to be followed by his younger brother Edward in 1850.

At the time of George's entry, and until 1845, the firm was known as Johnson and Cock, and besides benefiting from Johnson's own excellent training the young Matthey was fortunate in having W. J. Cock as his mentor in the very early days of platinum refining and fabrication.

Johnson's Enterprise

To appreciate what manner of business he entered and the circumstances that were to lead to his domination of the platinum industry for a period of more than fifty years we have to return to Johnson's initiative in founding the enterprise. At the age of 25 he had separated from his father's long established practice as an assayer in the City of London and on January 1st 1817 had set up for himself as "Assayer and Practical Mineralogist" initially in the City and then, in 1822, in Hatton Garden.

On the very first day of his independence Johnson married Elizabeth Lydia Smith, one of whose elder sisters, Anna Maria, had seven years earlier married Thomas Cock, a wealthy young man who until then had been an assistant in the famous laboratory and pharmacy of William Allen at Plough Court in Lombard Street. This establishment was then one of the great centres of scientific research and discussion in London. Allen was a friend of Humphry Davy, John Dalton, Alexander Tilloch and other leading scientists, and he gathered around him a number of young men to form a research school.

Johnson's ideas for the development of his infant business included the refining of gold and silver, but he had also interested himself keenly, while still in his father's practice, in the new metal platinum, then of interest only to a handful of scientists and with very few applications. He had in fact contributed a paper to the *Philosophical Magazine* on the subject as early as 1812, and with his father had provided Wollaston with most of the native platinum for his researches.

Thomas Cock's Platinum Process

In the meantime his new brother-in-law Thomas Cock had, under Allen's guidance, developed a method of refining platinum and of producing a malleable ingot by powder metallurgy. An account of his process was published in Aitkin's "Dictionary of Chemistry and Mineralogy" in 1807, more than twenty years before Wollaston disclosed his somewhat more sophisticated procedure to the Royal Society.

Thus when Johnson embarked on platinum refining, on a very small scale, it was Thomas Cock's method that was employed, and it was Cock himself who supervised operations. He had withdrawn from Allen's laboratory on his marriage in 1809, he had ample means to indulge his interests, and he spent much of his time in the Hatton Garden laboratories until his death in 1842.

Johnson meanwhile had developed a number of interests in the then booming lead, copper, silver and tin mines of Devon and Cornwall, eventually becoming the owner of several mines, and this side of his activities involved him in long and frequent absences from London. He looked around therefore for a younger man to assist him and his choice

The young George Matthey, from a portrait painted in 1845 when he was twenty. It was in this year that he first took charge of the platinum laboratory after his training under Johnson and Cock

settled on his nephew, Thomas Cock's second son William John, who although in practice as a solicitor promptly abandoned this profession when in 1834, at the age of 21, he was offered an apprenticeship in Johnson's business with the promise of a partnership in three years time.

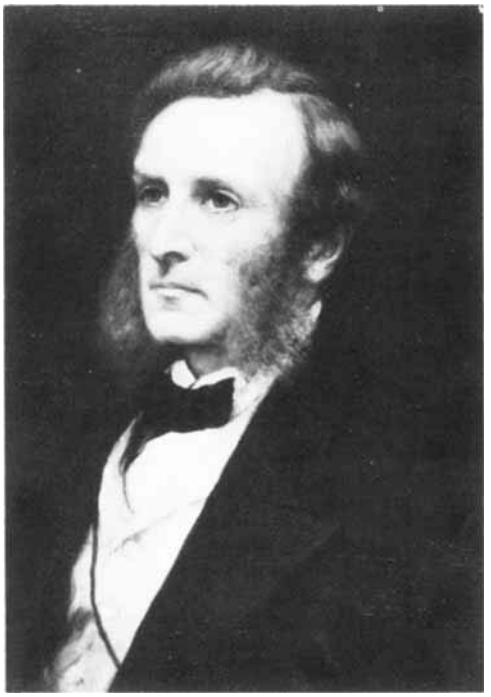
By the time George Matthey joined the business in 1838 Cock had acquired a considerable knowledge of chemistry and metallurgy, had re-organised the gold refining operations and improved the melting practice for both gold and silver. Shortly after the death of Thomas Cock the one elderly workman who had carried out the small amount of platinum refining under his supervision reached retirement age, and W. J. Cock took charge of this also, and began to increase the size of ingot from a mere 6 ounces to about 60, replacing an old screw press with a small hydraulic one. But in the midsummer of 1845 his health failed and he retired from his partnership.

George Matthey, now twenty years old, had been working under Cock's tuition since 1838, and had already shown a particular interest in the small scale platinum refining, and he was now put in charge of these operations. He set about his new task with great determination, and there now began that remarkable period of persistent scientific endeavour combined with an acute business sense (Cock, although a great chemist, was no business man) in which George Matthey transformed a laboratory activity into an industrial enterprise and made platinum available for use throughout the world.

The work was hard, and the hours were long—from 7 in the morning until well after 6 in the evening, for six days a week. Cock had been given but a short time in which to begin re-organising platinum production, and George Matthey had to put in hand the preparation of larger, sounder and more malleable ingots as well as introducing more effective separation of the other platinum metals and their refining. By December of that year he was supplying Michael Faraday—for his studies on magnetism—with wire and foil in both platinum and palladium, with rhodium, iridium and osmium in metallic form and with a number of compounds of all five metals. (Ruthenium was not discovered until 1844).

The Great Exhibition of 1851

In 1849 the Prince Consort, then President of the Royal Society of Arts, put forward a suggestion to hold a Great Exhibition to further the application of science to industry, but his proposal met with great opposition from many quarters. Johnson, like many other industrialists, was unwilling to support the exhibition, but young George Matthey realised the opportunity it presented and finally persuaded his employer to take part to the extent of a small glass case containing platinum crucibles, capsules and a large basin, together with specimens of palladium and some of its alloys and specimens of iridium and rhodium. A prize medal was awarded for



William John Cock
1813–1892

The son of Thomas Cock, Johnson's brother-in-law, who had devised a method of producing malleable platinum while working at Plough Court, W. J. Cock was a partner with his uncle from 1837 to 1845, when he retired on account of his health. He returned in 1854, no longer as a partner but to help his young colleague George Matthey in the platinum refinery. He was a founder member of the Chemical Society and contributed a paper on the refining and alloying of palladium in 1843

this exhibit, but any pride or pleasure that Matthey had taken in this success was very swiftly dissipated when he walked along to see the exhibit mounted by his French competitor, Quennessen of Paris. There he found a large platinum still, holding thirty gallons, made "in one piece without seam or solder", for the concentration of sulphuric acid.

Russian Platinum Supplies and a Partnership

This at once stiffened his resolve to become pre-eminent in the platinum business, and he now also had a much more assured supply of raw material. Hitherto the only source of native platinum was the Choco area of Colombia, and much of the meagre flow from there was smuggled out. A new source was discovered on the eastern slopes of the Ural mountains in Russia, but the Tsar's government quickly imposed an Imperial monopoly and insisted that all refining should be undertaken by the Mint at St. Petersburg. However, in 1850 George Matthey was successful in coming to an arrangement with one of the mine owners, Prince Demidov, whereby he became the sole refiner and selling agent, platinum to be delivered in parcels of 1000 ounces at a time. This achievement, finalised in the October of 1851, prompted P. N. Johnson to take the young man into partnership, the name of the firm then being changed from P. N. Johnson & Co to Johnson and Matthey. Thereafter Johnson, now aged 59, began to relinquish control of the business, leaving Matthey in more or less full charge.

The size of the platinum ingots had now reached 500 ounces, and the rolling of these into sheet had to be contracted out to a firm in Birmingham. To expedite the fabrication and sale of platinum boilers George Matthey retained the services of one of the very early chemical engineers, William Petrie, and together they effected marked improvements in design and construction. So rapid was their progress that they were able to exhibit a much larger and more efficient piece of equipment at the Paris Exhibition of 1855, while further improvements were introduced over the next few years, culminating in 1861 with Matthey's development of the fusion welding of platinum with a blow-pipe, a technique which greatly improved the quality and reduced the cost of the boilers and helped to put Johnson and Matthey in the lead in the platinum business.

Up to this time the only means of producing platinum in malleable form was the powder metallurgy method of pressing the sponge in a mould and hot forging, introduced by Thomas Cock and Wollaston. While a number of scientists had succeeded in melting

Henri Sainte-Claire Deville
1818–1881

Professor of Chemistry at the École Normale in Paris, Deville followed up his researches on the production of aluminium by studying the melting of platinum. In 1857 he and Debray devised the lime-block furnace fired by a mixture of oxygen and coal gas, a method that George Matthey was quick to adopt and to put to commercial use

Jules Henri Debray
1827–1888

First a pupil then an assistant and later a collaborator of Deville's, Debray eventually succeeded him as Professor at the École Normale. Their association was extremely close, and their joint work on the melting of platinum and its alloys extended over many years, as did their friendship with George Matthey

small samples, the resulting metal was nearly always brittle because of contamination by carbon or refractory materials. But a major development sprang from George Matthey's visit to the Paris Exhibition in 1855. Here he became friendly with a M. Paul Morin who was associated with the Société d'Aluminium, an enterprise founded by Henri Sainte-Claire Deville, Professor of Chemistry at the École Normale in Paris, to exploit his process for producing aluminium by the reduction of aluminium chloride with sodium. This successful work led him on to investigate the melting of metals that had so far proved to be difficult. To this end he employed a mixture of coal gas and oxygen, and with his assistant Jules Henri Debray he devised a simple piece of equipment consisting of two large blocks of lime, each hollowed out and then placed one over the other, in which they could melt platinum in considerable quantity. The lime was not only a suitable refractory material but also served to absorb any slag resulting from the oxidation of base metal impurities.

The Successful Commercial Melting of Platinum

French and British patents were filed for this process in the name of Debray, and a letter from him to George Matthey, dated August 18th, 1857 and offering him the English rights in the process, arrived in Hatton Garden. Matthey immediately recognised the

potential value of this development and replied on the 27th expressing his interest and a wish to see the process in operation, his letter ending:

> "You may not be aware that I am *the only* refiner and worker to any extent in Platina in this country; it will be therefore for your consideration which is most advantageous, to allow any one indiscriminately to participate in the patent, or to confine your negotiations entirely to me"

Before the end of September George Matthey was in Paris, bringing with him a quantity of platinum and residues for trial melting in the Deville and Debray furnace. The results were highly satisfactory, and the negotiations were finalised with M. Morin when a cheque for £500 was handed over for the assignment of the British patent (No.1947).

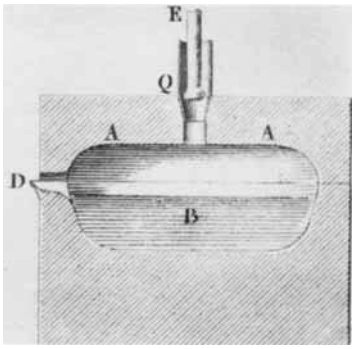
The process was at once put in hand in Hatton Garden, but there were many difficulties, and it was several years before satisfactory operation was achieved. Oxygen was not then available commercially, and had to be prepared on the spot from manganese dioxide, while the pressure of the London coal gas was extremely low. W. J. Cock had returned to Hatton Garden, no longer as a partner, but in his own words "to help out", and he proved an invaluable assistant to his younger colleague in getting the process going, although his health began to fail once again and he finally left in September, 1861. A few entries in Cock's diary earlier in that year indicate some of the difficulties.

> "Wednesday, 6 Feb. Read Deville's last letter to Matthey. Prepared and set iron retort in furnace room and charged it with 98 lbs ox manganese. Fixed the necessary pipes to gasholder.
>
> Friday, 8 Feb. A little rain. Set retort again and lit fire. When some oxygen had come over the retort melted. Had old wrought iron retort re-fitted.
>
> Monday, 11 Feb. A little snow. Charged wrought iron retort and set in ready in furnace for lighting tomorrow morning.
>
> Tuesday, 12 Feb. Fine. Oxygen fire kept going all day, but ox came over very slowly.
>
> Wednesday, 13 Feb. A little rain. Tried fusion of platinum with G.M. . . . Dr. Faraday was present."

One week later Faraday delivered his famous "Lecture on Platinum"—one of his last appearances at the Royal Institution—in which he described the new melting process and referred to "Messrs Johnson and Matthey, to whose great kindness I am indebted for these ingots and for the valuable assistance I have received in the illustrations".

In March George Matthey had to appeal to Deville. Part of his letter reads:

> "For nearly two years I have been working in this manner and am afraid you will be disappointed with me. I can only assure you that my numerous disappointments have rather increased than diminished my efforts to succeed, and if you will yet suspend your judgement of me and grant me a little assistance I do hope to realise some great and profitable results"



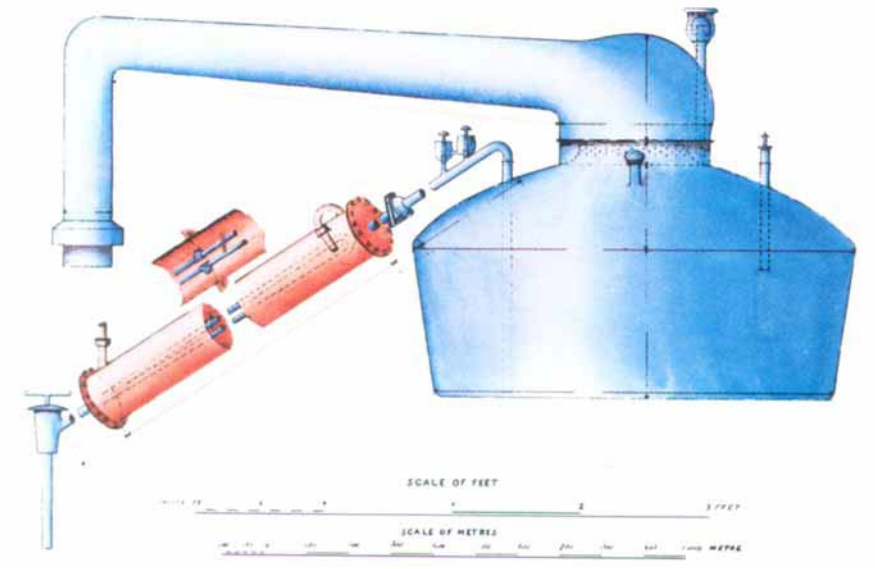
An original drawing of the lime-block furnace devised by Henri Sainte-Claire Deville and J. H. Debray for the melting of platinum. The upper cylinder A was hollowed out and pierced at Q to receive the oxygen-coal gas burner E, the lower block B also being hollowed out to hold the platinum, which was cast through the pouring hole D by tilting the furnace. George Matthey acquired the British patent in 1858 and after some initial difficulties successfully operated this type of melting unit for many years until the introduction of the high frequency furnace

Deville's response was to invite Matthey to Paris, but he found himself unable to leave Hatton Garden and Cock went instead. In addition, Deville sent over his "garçon de laboratoire", one Jules, who established that the major trouble lay in the impurities in the oxygen.

By the end of May success had been achieved. Progress continued, the size of melt increased, and in March of 1862 Deville came to London and together Matthey and he cast a huge ingot, measuring twelve inches by eight by six, and weighing 3215 ounces. It was placed on display at the Second International Exhibition of Industries in London that year together with a large sulphuric acid boiler capable of producing two tons of rectified acid per day and numerous other forms of platinum, including tubes joined by fusion welding with a blow-pipe flame, and a specimen of melted iridium.

During these tedious struggles with the new melting process the structure of Johnson and Matthey underwent a major change. George's young brother Edward had been apprenticed in 1850 at the age of fourteen, and in 1855 had been persuaded by George, conscious of the need for a more professional chemical and metallurgical knowledge in the business, and with a great deal more foresight than most of his contemporary industrialists, to embark on a course of study at the Royal School of Mines (then known as the Government School of Mines, in Jermyn Street). Here Edward had the benefit of instruction by von Hofmann in chemistry and by the great John Percy in metallurgy, and in 1860 he was made a junior partner together with a nephew of Mrs. Johnson, John Scudamore Sellon, the firm now becoming Johnson Matthey and Co.

Edward concentrated on the gold and silver refining side of the business—a very



From 1855 until well into the twentieth century one of the major uses of platinum was for the construction of boilers to concentrate the weak sulphuric acid produced in the lead chamber process. George Matthey was primarily responsible for the growth of this activity and several hundred boilers were supplied to acid manufacturers throughout the world. Each quotation was accompanied by a large coloured drawing such as this, much reduced in reproduction here

profitable activity which served to finance the developments in platinum—while Sellon took charge of commercial affairs, leaving George Matthey with more time and energy to devote to the refining and melting of his beloved platinum and to seeking applications for it in the growing industries of the time.

The Search for Applications

In his correspondence for the years 1865 and 1866, there are to be found letters advocating the electroplating of platinum on brass and gun metal, the supplying of platinum sheet for Grove cells, seeking business for platinum foil for the contacts on the new electric telegraph systems, as well as stimulating agents he had appointed in European countries and in the United States to greater efforts in the sale of platinum laboratory apparatus and sulphuric acid boilers.

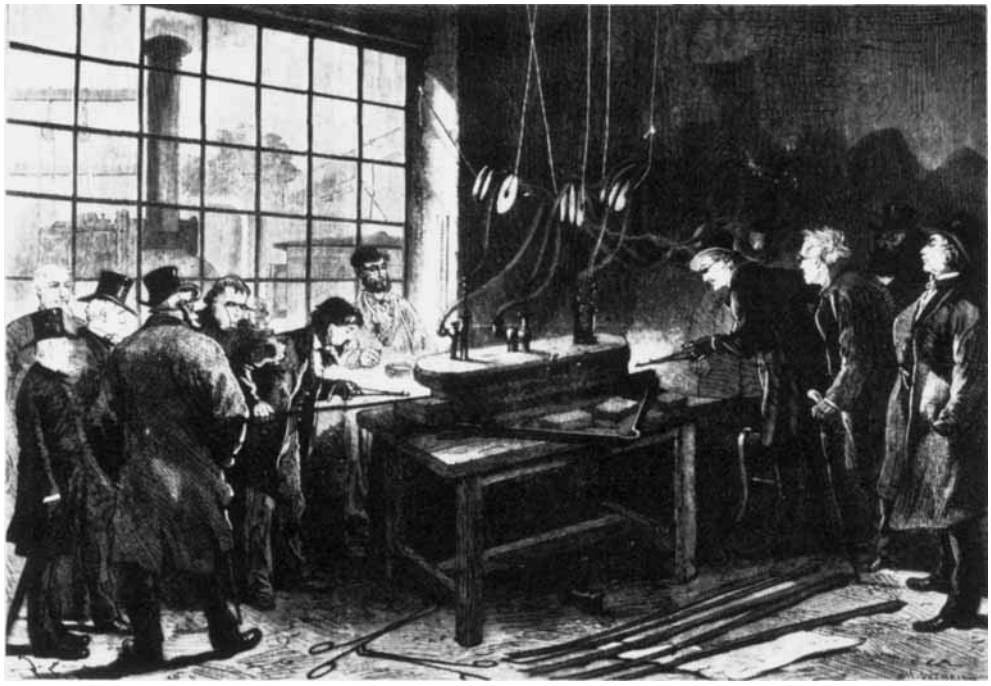
In 1867 an International Exhibition was to be held in Paris, and George Matthey and his colleagues determined to show what a British firm could achieve. The exhibit comprised over 15,000 ounces of platinum, including two huge boilers, the largest of which was immediately sold to a sulphuric acid manufacturer in Rouen under the noses of the French competition. This exhibit, unlike those of most other British exhibitors (which showed a distinct decline from the high days of the 1851 Great Exhibition in London) created something of a sensation in showing platinum manufactures on a scale never so far imagined. The exhibit was awarded a gold medal "for perfection and improvement in the working of platinum" and George Matthey was created a Chevalier in the Légion d'Honneur. The prestige of Johnson and Matthey in their field was established beyond doubt.

The Standard Metres

George Matthey was entitled to take great pride and pleasure in this achievement, just fifty years after the foundation of the firm by Johnson, but it was during the course of this exhibition that another significant matter was first set in train. The Russian delegate to the exhibition was Professor Moritz Jacobi, the senior scientist in the Academy of Sciences in St. Petersburg, and a keen advocate of a system of internationally agreed standards of physical measurement. His discussions with the French scientists resulted in the formation of an International Metric Commission for "the construction and verification with the best appliances of modern science of new international standards of the metre and the kilogram". Deville and Debray had already proposed the use of an alloy of platinum with 10 per cent iridium for standard metres and kilograms, but many years of work and discussion lay ahead before satisfactory standards were produced, years in which George Matthey was to play an active and important role in supplying the platinum and iridium, in making a great many large castings and in machining the bars.

Difficulties encountered with small amounts of iron, rhodium and ruthenium detected in the earlier alloys prompted Matthey to turn to a new method of refining, involving preliminary alloying with an excess of lead to facilitate the removal of rhodium and iridium, and it was this process that he described to the Royal Society in 1879 in his paper "The Preparation in a State of Purity of the Group of Metals known as the Platinum Series, and Notes upon the Manufacture of Iridio-Platinum", a paper that was quickly reproduced in both the German and the Russian scientific periodicals.

The production of standard metres and kilograms went on for over twenty years, the last orders from the French Government being delivered in 1887. One result of this substantial usage of iridium–platinum was undoubtedly a greater understanding of refining and melting problems and a distinct improvement in purity, both of great value in the later applications of the platinum metals, while the long association with the French scientists, particularly Deville and Debray, brought him their close friendship and from time to time their invaluable advice.



George Matthey played an important part in the production of standard metres and kilograms in high purity iridium-platinum for the International Metric Commission. In 1874 three large castings, weighing 80, 85 and 95 kilograms, were cut into pieces and remelted to ensure homogeneity into a single casting measuring 142 by 18 by 8 centimetres and weighing 236 kilograms. This operation, carried out at the Conservatoire des Arts et Métiers in Paris, was conducted by George Matthey and Henri Tresca, Professor of Mechanics at the Conservatoire and Secretary of the French section of the International Metric Commission. Both Deville and Debray were present as technical advisers. This engraving, from the French magazine L'Illustration of May 16th, 1874, shows the melting operation in progress

By 1880 the platinum business had developed into a prosperous activity and George Matthey, while continuing for many years yet to supervise the refining and melting, could turn his attention, as well as his undoubted charm and business sense, to maintaining and extending his contacts with the scientific community outside. He had been a member of the Chemical Society since 1871, he joined the Royal Society of Arts in 1881, serving as Vice-President from 1884–86 and again from 1889–91. He was also a member of the Royal Institution, and became Vice-President in 1896–97. At a meeting there in 1895 to hear a lecture by Roberts-Austen on rarer metals Matthey supported the lecturer with a display of melted and rolled iridium, large specimens of rhodium and osmium and a large mass of palladium valued then at £2,500,000.

He was for many years a leading figure in the Worshipful Company of Goldsmiths. Elected to the Livery in 1853, and to the Court in 1865, he became Prime Warden in 1872 and again in 1894. His advice on questions of assaying was of great assistance to the Company, and on their behalf he played an important part in establishing the City and Guilds Colleges in Finsbury and South Kensington, serving for many years on their governing bodies.

His friendship with a great number of scientists of his time was of mutual benefit, as he was always ready with encouragement and the provision of the platinum metals without charge to those studying their properties and applications. Thus he provided the pure wire for Callendar's first resistance thermometer in 1885, and the platinum for

William Jackson Pope's early researches on its organo–metallic compounds at the turn of the century. When the usefulness of the platinum metals in the form of thermocouples was first recognised he not only provided Professor P. G. Tait of Edinburgh with samples of platinum and of several iridium–platinum alloys in the form of wire in 1872 but later, when rhodium was found to be the preferred alloying element, encouraged his brother Edward to carry out a research to confirm the absolute reliability and freedom from inhomogeneity of the rhodium–platinum alloy.

The sulphuric acid boiler remained, however, the largest single use of platinum, and great numbers were fabricated for users all over the world until the early 1900's, when the contact process, using a platinum catalyst, came into use. The last recorded case of a boiler being taken out of service was as late as 1926 when two remaining boilers from an original set of 26, built in 1895, were returned to Johnson Matthey as scrap by the African Explosives plant at Modderfontein.

For many years too the lime-block furnace remained the preferred method of melting platinum, although it had certain disadvantages, and for a number of purposes the older technique of pressing the platinum in the form of powder followed by hot forging was still in use. In 1882 George Matthey was persuaded by Sir William Siemens to carry out trials of platinum melting in the newly developed arc furnace, but rejected its use on account of the absorption of carbon from the electrode and an improved method of melting had to await the introduction of the high frequency furnace in 1920.

First Chairman of the Limited Company

In 1891 Johnson Matthey was incorporated as a limited company and George Matthey, now aged 66, became Chairman and although he began to leave the conduct of the business more to Sellon and Edward Matthey, he retained supervision of the platinum refining. He finally retired in 1909, but a year earlier he had been nominated by the newly formed Institute of Metals as their first honorary member "in view of his wonderful record in the science of metallurgy".

He died at his home at Eastbourne on February 14th, 1913, at the age of 87, and a leading article in *The Times* a few days later included the following paragraph:

> "The death of Mr. George Matthey, F.R.S., serves to remind us of the part which the rare and precious metals have played in the general advance of practical science within the last half-century. Many a physicist and many a chemist has gained distinction as the result of researches upon the properties of platinum, iridium, and other metals which such metallurgists as Mr. Matthey have enabled them to obtain in the desired form and condition; and too often have they forgotten that the glory and honour should by right be shared with those who have laboured to produce the specimens upon which they have operated."

And so this astonishingly long career came to its close. When George Matthey joined Johnson in 1838 railways were in their infancy and stage-coaches were still a major means of transport. Well before he retired he had produced the platinum ignition tubes used on the first motor cars, and later the iridium–platinum contacts for the early magnetos.

Beginning on a laboratory scale, platinum refining and fabrication developed under his creative guidance and determination and his keen eye for new applications. The earliest recorded figures show sales of around 15,000 ounces in 1860, increasing to some 75,000 ounces a year in the 1880's. On the foundations he so painstakingly laid his successors in the company, with the discovery and exploitation of the South African deposits twenty years after his retirement, were enabled to build and expand a platinum industry that for some years now has had an annual output of well over a million ounces.

Acknowledgements

The writing of this appreciation would not have been possible without the long and diligent researches of my colleague Donald McDonald whose "A History of Platinum" was published by Johnson Matthey in 1960, nor without access to copies of George Matthey's voluminous correspondence preserved in the company's archives.