# The Powder Metallurgy of Platinum

## AN HISTORICAL ACCOUNT OF ITS ORIGINS AND GROWTH

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*The history of the powder metallurgy of platinum may well be claimed to be the history of powder metallurgy itself. For very many years all the malleable platinum used in industry was made by this process, developed independently in Spain, in England and in Russia. The author outlines the struggles of the early workers in this field and discusses the cause of the cracking which they occasionally reported.*

The first powder metallurgy products were small articles of jewellery which were made from platinum by the "Pre-Columbian Indians" of Esmeraldas (the most north-westerly province of Ecuador) in a period prior to the Spanish conquest. These people were the first to have observed the presence of platinum among mixed gold and platinum alluvial deposits in any region in the ancient world and the native workers found a way to separate them, probably by laboriously sorting them grain by grain from one another with something like a knife blade on a very smooth board. The products of their craftsmanship were discovered in 1879 by T. Wolf and further discoveries were made in 1906. Some of the articles are preserved in the Danish National Museum in Copenhagen and in the Museum of the American Indian in New York, and the finds have been particularly studied by a Danish investigator, Paul Bergsøe (1), who showed that they employed the quite sophisticated powder metallurgy technique of sintering in the presence of a liquid phase. He wrote:

> "The small grains of platinum were mixed with a little gold dust and small portions placed upon a piece of wet charcoal; when the gold runs it will coat the grains of platinum with gold . . . the grains are simply 'soldered together'. If the piece is now further heated by means of the blowpipe, ... a portion of the fused gold permeates the platinum and simultaneously a little of the latter is dissolved in the molten gold. This mixture of gold and platinum can now withstand a light blow of the hammer, especially when hot; by alternately forging and heating it is possible gradually to build up an homogeneous mixture. All the specimens found are small, which is natural, since they cannot be larger if they are to be exposed to the maximum degree of heat that can be produced from a bit of charcoal and a blowpipe."

It is difficult, at this stage of our technological development, to appreciate fully the remarkable skill and ingenuity of the craftsmen who developed this process at a time when so little was known of all that goes to make up our present ways of thinking of metals. It is, however, interesting to reflect on the reasons which dictated the choice of powder metallurgy methods. These appear to be that:

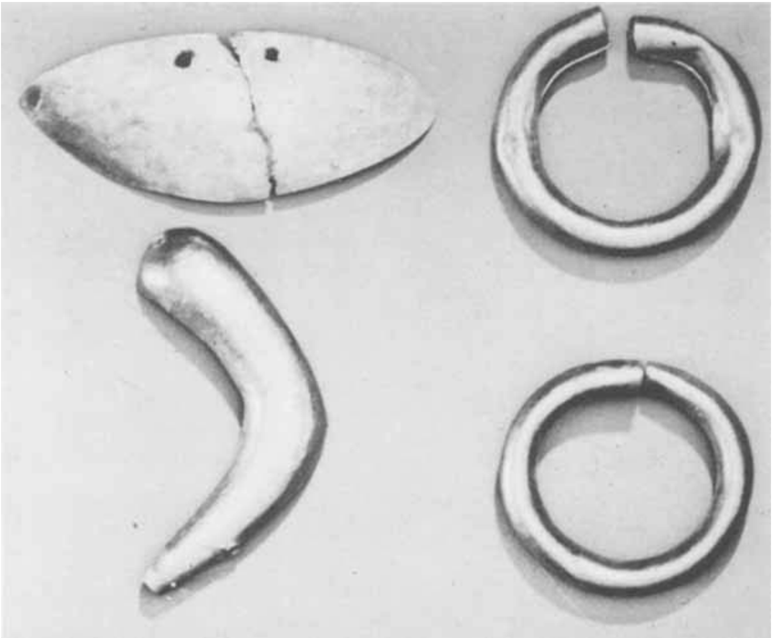
(1) The only form in which the platinum was available was that of powder particles.

(2) No means were known for melting them.

(3) The platinum particles were noble—they did not oxidise on heating.

These same considerations remained to influence the development of more conventional powder metallurgy methods for making malleable platinum when the metal was first introduced into Europe after its recognition by William Brownrigg in 1750–1751.

The chemical methods early developed for producing pure platinum all yielded the metal as a spongy precipitate which easily rubbed down to a mass of powder. Among the first to succeed in welding the particles to a coherent malleable mass was the mineralogist Nicholas



*The earliest examples of powder metallurgy, these are but a few of the many articles of platinum jewellery made by the natives of South America well before the Spanish Conquest that began in 1512 A.D. and are now in the Museum of the American Indian in New York. The internal diameter of the rings is just over 1 cm, and all the articles were made by sintering small grains of platinum with a proportion of gold to provide a liquid phase*

Anne de l'Isle (and not, as is often quoted, Jean Baptiste Louis Rome Delisle) (2) who some time before 1775 wrote to his colleague L. B. Guyton de Morveau, later known as Citizen Guyton, (the compiler of a Dictionary of Chemistry) saying that:

> "he had not employed any flux, that he had simply treated his platinum in a double Hessian crucible on the fire of a forge animated by the wind of two blowers, and that he had obtained a very compact and brilliant button which could be flattened and filed, and moreover was reasonably malleable; the two little buttons which he enclosed with his letter furnish a most complete proof of this"(3).

Many of de l'Isle's circle of friends in Paris repeated his experiments, and Pierre-Joseph Macquer, Professor of Chemistry in the Jardin du Roi, in particular (who had succeeded in 1758 in melting platinum by means of a large burning mirror) appreciated very clearly the nature of the mechanism by which the platinum particles were consolidated. He wrote:

> "particles of platina being infinitely divided in the precipitate . . . show the extraordinary effect on their agglutination in the proportion of their points of contact . . . (and) solid masses result which have all the appearance of quite dense metal, melted and solidified by cooling, but they are really nothing but the result of a simple agglutination among an infinite number of infinitely small particles"(4).

A number of his small malleable discs of platinum were distributed among his friends by de l'Isle, but there is no evidence that he ever worked on any but a laboratory scale. Count Carl von Sickingen, who was the Ambassador at the French Court of the German Princedom of the Palatinate, found time apart from his official duties to develop a similar process further (5) and was successful in making a small ingot which he later drew to wire as fine as 0.0052 inch in diameter, a feat not repeated for many years.

The application of these ideas to quantity production was slow to develop in England,

**Pierre François Chabaneau**
**1754–1842**

*Born at Nontron in the Dordogne, at the age of twenty he left France to teach French and Physics at the newly established Seminario at Vergara in the north of Spain and later became Professor of Chemistry there. In 1786 he was able to announce that he had succeeded in producing malleable platinum but the process was kept secret on the order of the King of Spain. It was later revealed as a powder metallurgy process*

France, Germany or Scandinavia; but in Spain the efforts of Pierre François Chabaneau represent an important stage in the history of the platinum industry. As a young radical-minded French teacher he was induced by two of his students, the sons of the Count of Penaflorida to go to the newly-established Real Seminario Patriotico at Vergara near San Sebastian and close to the north coast of Spain to teach French and Physics. In 1781 the two de Elhuyar brothers became associated with the Seminary (the younger as Professor of Mineralogy) and rapidly made their name by the isolation for the first time of metallic tungsten. This was in 1783. Thereafter they took up work on platinum which was being imported from the Spanish-ruled South American territory of Colombia—in particular from the region of Quito in the north western province of present day Ecuador. How far the work was shared between the three in the early stages is uncertain, but very shortly the de Elhuyars left Spain on their appointments as Directors General of Mining in the new provinces overseas, leaving Chabaneau, who took over the Chair of Chemistry, to carry on alone. So successful was he that he was very soon able to announce, probably in 1786, that he had produced malleable platinum.

## The Process Kept Secret

The events that followed set a pattern that the platinum industry has followed ever since. The King of Spain made a strict order that Chabaneau's process should be kept secret; and this order was so well observed that the work remained quite unknown to the outside world for nearly 150 years, and was only brought to light in 1914 when an obscure pamphlet (6) published in 1862 came into the hands of Louis Quennessen (7), the head of the Paris firm of platinum refiners. The King installed Chabaneau in one of the Royal Palaces in Madrid, made him a Director of a Chemical Laboratory in Madrid devoted to the refining and fabrication of platinum, created a special Chair in the school of the Natural History Museum with a large annual salary and a life pension, and caused a medal to be specially struck in platinum in his honour. Chabaneau remained in charge of the work until 1799, when, largely on account of poor health, he left Spain (renouncing his pension) and retired to his native country where he lived tranquilly "to enjoy the repose so needed and so welcome after all his labours" until his death in January 1842 at the age of 88. He was succeeded by Joseph-Louis Proust who had come from France in 1786 on the King's invitation and had been lecturing and doing research for eleven years at the Artillery School at Segovia. He considerably increased the rate of production of platinum, while the laboratory of Calle del Turco, where he worked in Madrid, became famous because of its wealth in instruments and utensils of platinum.

## The Platinum Age in Spain

From 1786, until Napoleon's second invasion in 1808 brought about the destruction of the laboratory, so large a business was carried on in platinum that this period has been called "the platinum age in Spain". The quantity of malleable platinum turned out over the 22 years may have averaged 14,000 to 18,000 oz Troy per year—say one third of a million ounces in all.

At some time around 1787 the Spanish ambassador in Paris made arrangements for Chabaneau to take some of his malleable platinum to Paris so that Janety, the court jeweller, could demonstrate his skill in fabricating it.

Janety had been producing snuff boxes, watch chains, spoons and "a set of buttons of the most rare beauty for the King", all at a very reasonable price by the very dangerous arsenic process in which a solid bar was first cast from an alloy of platinum with about 25 per cent by weight of arsenic, a brittle eutectic alloy melting at about 550°C. The bars were then carefully heated by stages in a muffle to drive off the arsenic and were subsequently forged to shape. It is a wonder that Janety survived the dangers of the process for more than thirty three years, and he lived to about 1823.

Janety was unsuccessful in his attempts to persuade Chabaneau to reveal details of the Spanish process, but Chabaneau, for his part, did not find his powder metallurgy process to run as smoothly as he would have wished. The ingots, all too often, cracked and sometimes even crumbled away under the hammer—all for no apparent reason. Jules Delanoue, the early biographer of Chabaneau, tells (6) how the Count d'Aranda, visiting the laboratory "found Chabaneau in a frenzy engaged in throwing out of the doors and windows his dishes, flasks, and ores as well as all the solutions of platinum which he had prepared with so much trouble and difficulty, saying 'Away with it all! I'll smash the whole business; you shall never again get me to touch the damned metal'; and in fact he broke up all the apparatus of the laboratory".

Nevertheless, the work did go on and Delanoue records that only three months later Chabaneau showed d'Aranda a large cube of platinum measuring 10 cm along the sides, and weighing about 750 ounces Troy.

**Joseph-Louis Proust**
**1754–1826**

***Born in Angers the son of an apothecary, Proust spent three years at Vergara, returned to France and then in 1786, at the invitation of the King of Spain and on Lavoisier's recommendation, came again to Spain and in 1799 succeeded Chabaneau in charge of a well equipped laboratory in Madrid. Here Proust continued and extended the work on platinum fabrication until in 1808 his laboratory was destroyed by a mob during the siege of Madrid by Napoleon's forces***

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Chabaneau had his own silversmith, Don Francisco Alonzo, whom he trained in making jewellery and scientific instruments. One of the most beautiful examples of his work, said to be the first object produced after Chabaneau's return from France, is a large chalice, made for the King, and presented by "King Charles III of Spain and the Indies" to Pope Pius VI and now in the Treasury at St. Peter's, Rome (8).

The overthrow of the Spanish Empire during the Napoleonic wars and the disturbances of the French revolution not only wrecked the Spanish platinum industry but also caused the groups of chemists and physicists that had formed in France to be disbanded. Lavoisier was executed in 1794. The official supplies of Spanish platinum also dried up. Thus it is not surprising that the next developments in the powder metallurgy of platinum were made in England, where supplies of platinum were becoming available from the smuggling trade between New Granada and the Caribbean island of Jamaica.

## Developments in England

In February, 1800, Richard Knight, the young son of an ironmonger of Foster Lane, Cheapside, published in the *Philosophical Magazine* (9) an account of "A new and expeditious process for rendering platina malleable". This followed very closely on the lines already described but introduced one minor improvement. He noted that earlier workers found difficulty in consolidating the relatively loose sponge left after chemical refining.

> "The mass is so spongy", he wrote, "that it is hardly possible to get a single stroke applied to it before the welding heat is gone; and though by peculiar dexterity and address some have in this way succeeded, it has been found to require such innumerable beatings and hammerings, that most of those who have attempted it have either failed entirely or given it up as being too laborious and expensive."

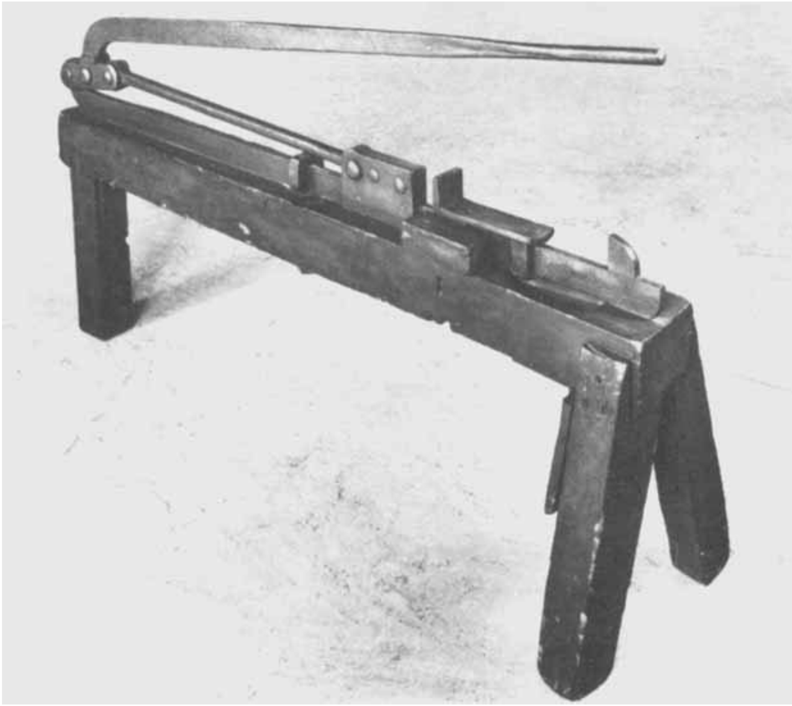
He accordingly first tamped the dry precipitated platinum into a tapered crucible using a tapered plug made of the same fireclay. The assembly was heated and when red hot the plug was pressed down and then used to hammer the platinum mass "as hard as the nature of the materials will permit". This process had the added advantage of avoiding contact of the hot platinum with iron, which so readily contaminates it.

The publication of this paper probably did much to stimulate interest in the metal, in particular by a group of young men who were accustomed to hold monthly meetings (the Askesian society) under the guidance of William Allen. Allen, a member of the Society of Friends, was proprietor of the Old Plough Court Pharmacy in Lombard Street which was to become known in later days as Allen and Hanburys Ltd. In his laboratory small articles of platinum were being made early in 1805.

One of those who took special interest in this work was Thomas Cock, who later became brother-in-law to Percival Norton Johnson, the founder of the firm of Johnson Matthey and Co Limited. Cock worked as an assistant to Allen until his marriage in 1809, and among his contributions (10) to the technique of the powder metallurgy of platinum the following may be mentioned: (a) He seems to have been the first to give attention to the rate and temperature of heating of the ammonium chloroplatinate precipitate in order to control the particle size of the platinum powder. (b) He also seems to have been the first to briquette the platinum by cold compression before sintering. This he performed by packing the powder in layers into the mould, using a wooden plug which was hammered into the mould after each addition of platinum. Finally, an iron punch was forced into the mould "by means of a strong screw press" so that "almost every particle of air is forced out from among the platina".

## Wollaston's Successful Process

In essence, however, these men, like all the other earlier workers in platinum excepting Chabaneau, were laboratory workers, interested mainly in their scientific enquiries. The first Englishman to undertake the production of malleable platinum as a large scale process was William Hyde Wollaston, who was born in 1766 in Norfolk and educated first at Charterhouse and afterwards at Caius College,



*By far the most important exponent of the powder metallurgy of platinum was William Hyde Wollaston, who made available very large quantities of the metal but kept his process a secret until just before his death in 1828. This is the toggle press he designed for compressing his platinum sponge before forging into bars. The design of the press, which is preserved in the Whipple Museum of the History of Science in Cambridge, enabled the applied power to be multiplied three hundred times or more, and the resulting high pressure produced a cake of platinum strong enough to be handled during the heat treatment process*

Cambridge. There he became friendly with Smithson Tennant, the discoverer of iridium, who later for a short time was Professor of Chemistry at the University. Wollaston qualified as M.B. in 1787, was elected a Fellow of the Royal Society in 1793, practised medicine at Bury St. Edmunds for some years, but retired in 1800 and came to live in London. He set up a laboratory behind his house at 14 Buckingham Street, Fitzroy Square, and there until his death on 22nd December, 1828 he worked out and practised the refining of platinum and its fabrication on a considerable scale. He commenced operations by acquiring, with financial help from Smithson Tennant, nearly 6000 ounces of native platinum and made a careful scientific study of the products obtained when this was dissolved and refined. The discovery and the elf-like announcement of palladium as a new element was an important consequence of this activity. From this beginning, he developed (and, following the earlier traditions of the Spanish industry, kept secret all his life) a powder metallurgy process that worked consistently, and was moreover a commercial success. From 1800 to 1821 he is known to have treated 47,000 ounces of native platinum and to have made 36,000 ounces of malleable metal, which he sold for a total of about £30,000. The greatest single use for this platinum was, remarkably enough, as a lining for the touch-holes of pistols and sporting guns, where it served to resist the corrosive action of the fumes of the gunpowder. Of greater importance industrially was its use for the manufacture of boilers for the concentration of sulphuric acid to make oil of vitriol, replacing the fragile glass vessels used earlier. Wollaston entered into an arrangement with Kepp, a coppersmith, of Chandos Street to make these vessels, and for this he is known to have supplied nearly 7000 ounces of metal. In addition, about 1300 ounces of Wollaston's platinum went into the manufacture of laboratory crucibles.

When Wollaston was forced to discontinue work (mainly through difficulties in obtaining supplies of crude platinum) he was persuaded to describe his process in a Bakerian Lecture to the Royal Society (11), read on 20th November, 1828, just a little more than a month before his death. The essential features of his procedure as he described it may be briefly indicated:

(1) Precautions were taken to remove iridium as completely as possible.

(2) The platinum salt was decomposed at as low a temperature as possible "to occasion the particles of platina to cohere as little as possible; for on this depends the ultimate ductility of the product" and the grey product was rubbed between the hands to powder "so fine as to pass through a fine lawn sieve".

(3) Great care was taken not to use anything harder than wood to break up any aggregates and not to burnish the particles, since "every degree of burnishing will prevent the particles from cohering in the further stages of the process".

(4) The fine powder was washed well, removing any soluble salts, leaving a uniform pulp ready for pressing.

(5) The slurry was introduced under water into the die, a well greased brass barrel about $6\frac{1}{4}$ inches long, tapered slightly, and closed with steel plugs.

(6) Pressure was applied to the plugs by a toggle press "in which the applied power was multiplied three hundred times or more", to yield a hard cake.

(7) The cake was heated to redness in a charcoal fire and then placed on a layer of clean quartz, covered by a refractory pot, and sintered for twenty minutes at the maximum temperature that could be reached in a wind furnace. It was then ready for careful hot forging.

## An Air of Mystification

Wollaston's paper is, on the face of it, a plain unvarnished cook-book type account of the process he "put in practice for a series of years, without seeing any occasion to wish for further improvement". At the outset, there is a suggestion that other workers had not always exercised sufficient care in purifying the platinum from all traces of iridium. This has given rise to a widespread impression that the presence of traces of iridium were responsible for irregularities in the products of earlier workers.

This, however, simply is not true, and Wollaston must have known it to be untrue, since it is not conceivable that he, so closely associated with Smithson Tennant, the discoverer of iridium, had not observed its action as an alloying element with platinum. Mixtures of platinum and iridium powders can be consolidated, and worked with even greater ease than can pure platinum, and for years powder metallurgy was the preferred means of preparing alloys containing from 5 to 30 per cent iridium.

It is suggested that this rather impish attempt to cloud the issue of the secret of perfection in powder metallurgy is in line with Wollaston's known liking for mystification. It is evident that Wollaston always wished to keep his process secret and it was only under some pressure from colleagues in the Royal Society that he was induced to prepare his Bakerian lecture. However, Wollaston's paper does little to explain how he avoided the splits, breaks, and snapped samples recorded in his notebooks for 1801.

## Platinum Powder Metallurgy in Russia

Mention should here be made of one very successful early application in Russia of the powder metallurgy of platinum. In 1819, platinum was first discovered in the gold fields of the Urals and by 1825 such extensive alluvial deposits had been found that platinum was declared to be a state monopoly.

Working remarkably quickly, a group of Russian workers under Pyotr Grigorievich Sobolevsky, succeeded by 1827 (before the publication of Wollaston's paper) in developing a successful procedure for making malleable platinum by powder metallurgy. In details, Sobolevsky's process differed slightly from that of Wollaston. The platinum "sponge" was pressed dry and cold in a screw press and the resulting tablets (we would call them green compacts) were heated to whiteness and re-pressed in the same equipment, yielding in one operation a dense malleable product which could subsequently be forged to strip or rod and fabricated. A proposal that Russia should have a platinum coinage was approved by the Emperor in 1827 and the issue of 3-rouble coins began in 1828. For the next 18 years, the production of platinum coins continued, and by 1846, when the platinum currency was withdrawn on fears of price depreciation, 485,505 ounces Troy of platinum had been minted as 3-, 6- and 12-rouble coins. This was "the first period of the Russian platinum industry" and, again, it relied entirely on powder metallurgy as a manufacturing method. A point of interest is that iridium was not removed in refining and the coins contained some 1 to 4 per cent iridium. Of the total coinage issued about three-quarters were returned by the public; and of this most was later purchased for refining under arrangements negotiated by Johnson Matthey.

## The Probable Cause of Early Failures

An unanswered question arises from this review of the early history of the powder metallurgy of platinum. What was the cause of the cracking—which at times caused disruption in the production of malleable platinum as described so graphically to visitors to Chabaneau's laboratory and as recorded in some early notebooks of Wollaston.

The suggestion that this was associated with the presence of iridium has been discussed and refuted. Other attributions in the literature have been to:

(1) The uncontrolled use of calcium hydroxide as a precipitant for removing impurities from the original aqua regia solution.

(2) Silica inclusions in the calcined platinum sponge.

The alleged effect of lime was described by Jules Delanoue (6) in 1862 as follows:

**Karl Karlovitch Klaus**
**1796–1864**

*Also known in his German style as Carl Ernst Claus, Professor of Chemistry at Kagan and later at his native Dorpat, Klaus carried out a long series of researches on the platinum metals and discovered ruthenium. His knowledge of the chemistry of the platinum metals was recognised by the Russian government when in 1863 they encouraged him to visit refineries and laboratories in France and Germany in order to prepare a treatise on the subject. In this monograph on the platinum metals, published in 1883, long after his death, he pointed out that the presence of silica in the calcined platinum sponge could account for the brittleness and cracking encountered by earlier workers*

"No one knew then, and indeed few know now, that lime does not precipitate platinum in artificial light, but that in daylight the metal is completely precipitated by this reagent. Chabaneau, working with lime at night, had been enabled to precipitate all the other metals which were in solution, while his platinum was left unprecipitated and purified. Repeating the operation by day, platinum and all were thrown down, and he was completely at sea, without being able to suspect the reason."

Presumably this implies that Chabaneau then went on to forge the unpurified platinum; and that the impurities in some way caused the cracking. The "disadvantage of dissolved silica", some of which may be precipitated with platinum, was pointed out as long ago as 1883 by Claus (12), who wrote that:

"the silica remains in the sponge and is capable later during the heating of the platinum crucible of uniting intimately with the platinum, indeed of alloying with it, and therefore making it brittle and unsuitable for use."

As we now know silica itself cannot alloy with platinum, but reduced metallic silicon attacks platinum with extreme rapidity, forming a eutectic melting at 830°C which penetrates rapidly deep into the metal along the grain boundaries.

There are at least three ways in which a platinum pressing may be contaminated by silicon. First, entrapped precipitated silica, as observed by Claus, may be reduced *in situ* if the pressing is heated in a reducing atmosphere. In these conditions, platinum acts as a catalyst for the reaction $SiO_2 + R = Si + RO_2$, encouraging it to proceed with relatively weak reducing agents R. This it does by removing Si atoms from the reaction zone as soon as they are produced, the atoms diffusing along the grain boundaries. A similar mechanism may conceivably occur between a platinum bar and the refractory on which it is supported. Wollaston states that he used clean $SiO_2$ sand for this purpose. Normally, it would not be expected that the forge fire would be sufficiently reducing to cause damage, but it is possible that a temporary failure of the air supply might lead to trouble. Finally, if sulphur-containing fuels are used or if the air-supply is contaminated with a sulphur-containing lubricating oil, there is a possibility that the volatile compound $SiS_2$ may be formed by reaction of sulphur, carbon and a siliceous refractory (13). This compound attacks platinum vigorously, with disastrous results.

So it would appear that slight unsuspected changes in the heating arrangements—a sudden check of the air supply when the temperature of the glowing coals was particularly high, the inclusion of some pyrites in the coal, some sulphur-containing compounds in waste added to brighten the fire, even some organic compounds in the grease used on the forge tongs—any of these would be expected to contribute to these disastrous plagues of cracking.

## Modern Practice

In England, powder metallurgy remained the only method of producing malleable platinum until about 1858, when platinum started to be melted in the lime block furnace invented by Deville and Debray. Thenceforth, for many years, both processes were used side-by-side on an increasing scale; and it was not until about 1930 that, with the introduction of the electric induction furnace and the use of such refractories as zircon, melted platinum accounted for the greater part of the industry's production.

A limited quantity of platinum has, however, always been made by the powder metallurgy process; the dry powder is usually compressed at about 50 ton/in$^2$ in steel dies and the compacts are sintered at a temperature of about 1300°C, supported on a plate of pure alumina or similar refractory. The sintered compact is either forged immediately after withdrawal from the furnace or it is hot-rolled, and further fabrication then follows normal practice.

The microstructure of annealed fabricated power-metallurgy platinum shows simply an equi-axed array of crystals with a small amount of porosity and perhaps a few inclusions. It is difficult to distinguish with certainty between porosity and inclusions, even when great care is taken in preparing and etching the section.

Powder metallurgy was used for nearly a

century for crucibles, dishes, and laboratory platinum-ware generally, for large scale evaporators, and it was used for at least half a century for thermocouple wires; and as melted platinum came into use the two materials were employed interchangeably with no noticeable distinction.

However, as was shown particularly by Middleton, Pfeil, and Rhodes (14) in 1949, powder metallurgy platinum may be more resistant to grain growth and may retain its strength at high temperatures better than melted platinum.

It was suggested by these authors that the special characteristics of powder metallurgy platinum were due to a "small amount of suitably dispersed porosity, which has the effect of hindering crystallisation". The effect, however, although appreciable in compacts sintered at the low temperature of 900°C, is only slight in compacts sintered at 1300°C normally used in production; and experience over the years indicates that the performance of platinum of either type of manufacture is virtually indistinguishable.

There is still some discussion concerning the exact nature of the "dispersed porosity" which acts as the grain boundary blocking agent in powder metallurgy platinum. Among the possibilities suggested are: (a) voids, (b) gas pockets of entrapped air or chlorine, (c) traces of ammonium chloride or undecomposed platinum chloroplatinate. Perhaps all three are involved at one time or another. Traditionally wires of the two forms of platinum—powder metallurgy or melted—may be distinguished by melting the tips in a small blowpipe flame. Previously melted platinum remelts quietly to a bead; the powder metallurgy wire will splutter and spark.

## Dispersion Hardening of Powder Metallurgy Platinum

The deliberate addition of a non-metallic refractory blocking agent to platinum during production by powder metallurgy can be very effective in preventing grain growth. Nearly forty years ago the addition of small amounts of thoria was proposed by Smithells, following the then established practice in the production of tungsten wires for lamp filaments. A small amount of thorium nitrate was added to the solution of platinum salt before final precipitation, with the result that a uniform distribution of particles of $ThO_2$ was produced after ignition and decomposition. Wires made from this material retained a fibrous structure, particularly fitted to resist grain boundary attack by lead compounds when in service as sparking plug electrodes in aircraft engines. In the most recent development, sophisticated techniques (15) have been developed to form extremely fine distributions of $ZrO_2$ to yield ZGS platinum with a highly aligned stable recrystallised structure which confers outstanding resistance to high temperature deformation.

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