

# Production of Platinum Wedding Rings by Powder Metallurgy

Peter M. Raw • Consultant to Engelhard-CLAL, Carteret, New Jersey

The application of powder metallurgy to the production of application of powder metallurgy to the production of wedding rings is believed to be the first example of the use of powders for the mass production of jewelry. However it is somewhat humbling to learn that powder metallurgy was used to make platinum jewelry between the 1st and 4th Centuries AD in Ecuador. Items of jewelry (platinum contents 26 to 72%) from this period still exist and the technique used to produce the jewelry is believed to have utilized liquid phase sintering. Particles of gold were mixed with grains of platinum (alloy) and heated on wood charcoal. The grains were thereby soldered together, and further heating with a blowpipe enabled the hot metal to withstand the blow of a hammer, alternate forging and heating enabling the jewelry to be produced.<sup>(1)</sup>

Moving forward to the 18th Century, the identification of the platinum group metals led to chemical refining and separation techniques but no obvious way to convert the metallic sponges into workable metal because of their high melting points. Success was

eventually achieved by Woolaston in 1805 and, again, powder metallurgy was the route. His pure platinum sponge was compacted in a horizontal press, the compact was heated slowly on a charcoal fire, further heated in a furnace and then hammered (forged) while hot and this technique was used to produce platinum crucibles.<sup>(1)</sup>

The technique was, of course, superceded as the ability to melt platinum was developed. Nowadays platinum is routinely melted and investment cast to make jewelry products directly or statically cast and converted to sheet, wire or tube as start material to produce platinum chain, bracelets, bangles and wedding rings.

Some 5 years ago at Engelhard-CLAL UK, precious metal wedding ring production was identified as a process which gave a very low yield of finished product. Powder metallurgy was proposed as a technique which offered the prospect of a much greater yield of finished product when applied to rings which were ideally suited to a press and sinter approach because of their axial and radial symmetry. This potentially high yield is, of course, the reason why powder metallurgy has developed so much in the last 30

years or so, especially in the automotive industry.

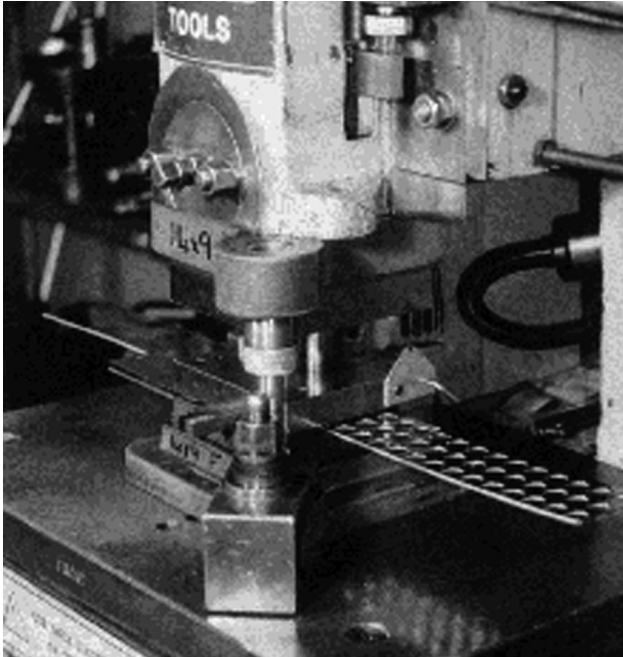
A project was initiated at Engelhard-CLAL to investigate the feasibility of making 9 karat yellow gold wedding rings by a press and sinter route and, in due course, high-quality rings were produced. The successful process comprised:

- Water atomize alloy
- Dry and sieve powder
- Vacuum degas
- Press into cylinders
- Sinter in a reducing atmosphere
- Re-press or squash the cylinders
- Re-sinter
- Ring roll to finished size
- Anneal

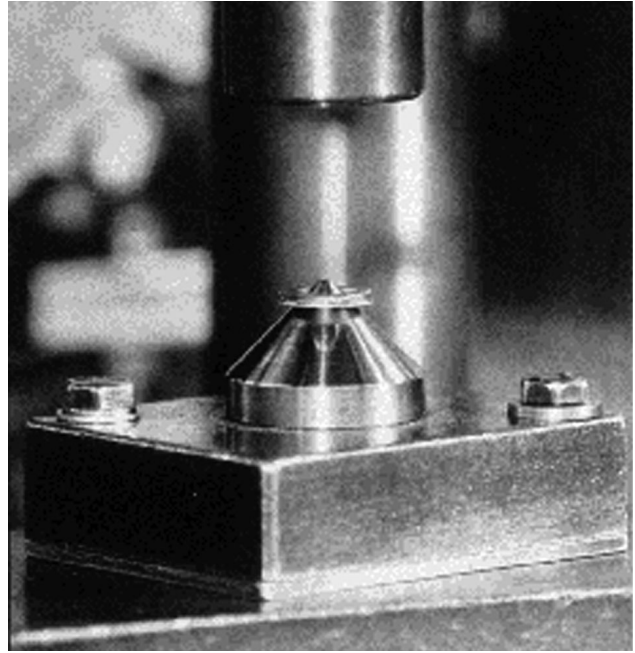
Fig. 1 illustrates the gold rings at the various stages of manufacture. The properties of the finished rings were found to be superior to conventionally-produced rings and the economic benefits were forecast to be very significant. At that stage production equipment was identified, purchased and commissioned and commercial ring production started in late 1997. By August 2000 some 500,000 karat gold rings had been produced by the new process<sup>(2)</sup> for which a patent application has been made.<sup>(3)</sup>



Fig. 1: Gold powder and rings at various stages of manufacture



*Fig. 2: Blanking of washers from platinum alloy sheet.*



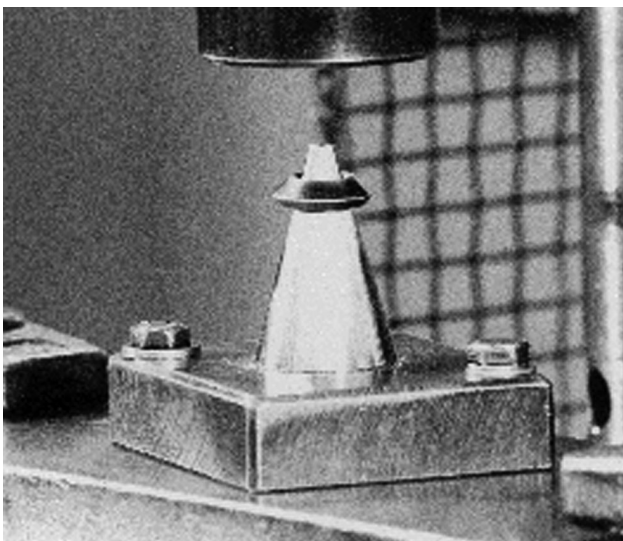
*Fig. 3: Platinum alloy washer ready for pressing into hollow cone.*

From the original work on 9 karat gold alloy it proved relatively easy to extend the process to a full range of 9,14 and 18 karat gold alloys and it seemed a logical step to consider making platinum rings by a similar technique. In fact the task was made easier because there ex-

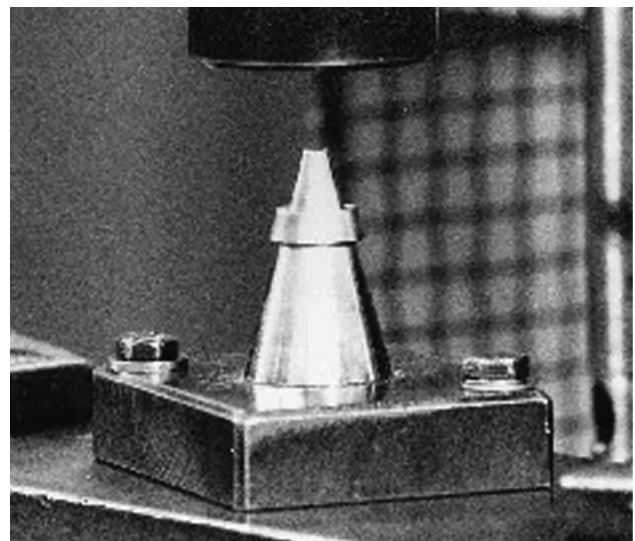
isted a long history of making industrial platinum alloys at Engelhard-CLAL by a powder metallurgical route and so platinum alloy powder manufacture and handling were already routine operations.

The purpose of this paper is to outline the traditional methods for

making platinum wedding rings and then describe the development of the press and sinter approach to the stage where platinum alloy powder production and ring manufacture from the powders are now routine operations. The properties of the rings are also detailed and the bene-



*Fig. 4: Platinum alloy washer after first pressing operation.*



*Fig. 5: Platinum alloy washer after second pressing operation.*

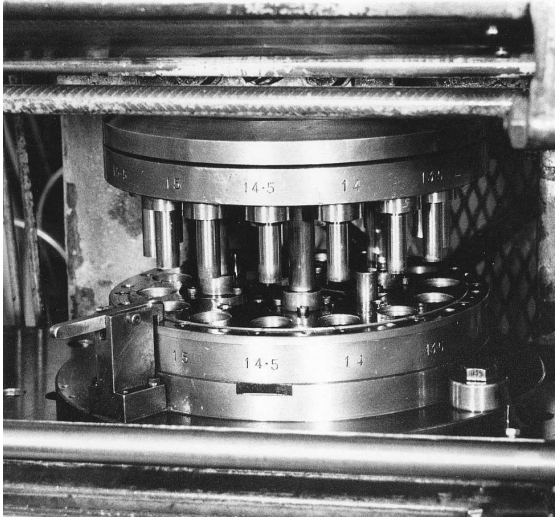


Fig. 6: Drawing platinum alloy cones into hollow cylinders



Fig. 8: Platinum alloy disc cut from sheet and cupped.

fits that the new process brings are discussed.

### TRADITIONAL RING-MAKING ROUTES

Two techniques were in general use for producing platinum-based wedding rings at Engelhard-CLAL at the time this work was undertaken. The first technique involved making washers and “doughnuts” and comprised the following stages:

- Cast the platinum alloy into a sheet ingot

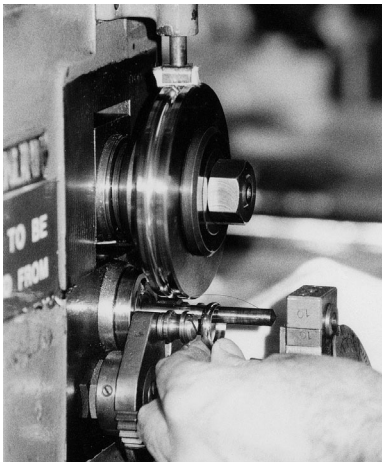


Fig. 7: Rolling platinum alloy cylinders into finished ring blanks.

- Cut off the shrinkage cavity and machine the ingot surface
- Roll to sheet, annealing as necessary
- Blank out washers and anneal
- Press the washers into hollow cones in two stages and anneal
- Draw the cones into hollow cylinders (doughnuts) and anneal
- Press (squash) the doughnuts to finished ring height and anneal
- Roll the doughnuts to finished ring blanks and anneal

*Some of these steps are shown in Figs. 2 - 7.*

The second technique involved making platinum alloy tube and parting off cylinders for rolling to finished ring blanks. These steps comprised:

- Cast the platinum alloy into a sheet ingot
- Cut off the shrinkage cavity and machine ingot surfaces
- Roll to sheet, annealing as necessary
- Cut out a disc of the required size
- Press the disc into a cup and anneal
- Repeat the cupping and annealing operations until reaching a

- size suitable for drawing
- Cut off the closed end and draw the tube to finished size, annealing as necessary
- Part off cylinders
- Ring roll the cylinders to finished ring blanks and anneal

*Fig. 8 shows an alloy disc cut out of rolled sheet alongside several cupped discs, while Fig. 9 is a view of the cupping press.*

The ring blanks after manufacture would be supplied to specialist



Fig. 9: Press used for cupping operations.



Fig. 10: Water atomized platinum powder

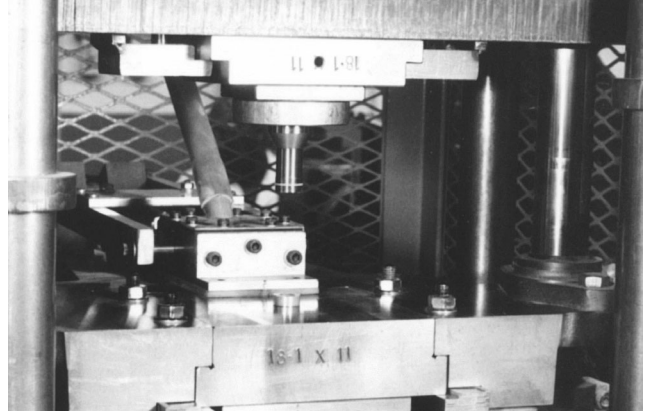


Fig. 11: Press arrangement showing powder feeder, shaker and die

ring finishers for any machining, polishing, diamond cutting and engraving.

Both of these ring-making techniques were labor intensive, time consuming (particularly because of the frequent annealing treatments necessary) and material inefficient. The overall yield of finished ring blanks compared with the start weight of metal was about 25% and so 75% of the melt weight of the alloy was returned for re-melting or refining - a very strong argument in favor of a powder metallurgical approach where yields of up to 90% are possible.

#### DEVELOPMENT OF A POWDER ROUTE FOR PLATINUM RING PRODUCTION

Having established powder metallurgical manufacturing routes for karat gold alloy rings it became a relatively straightforward task to undertake the work necessary to define the conditions for producing rings in platinum. The alloy initially selected for this work was platinum-3% copper, one of the alloys in use for ring making in the UK. The process which was eventually specified comprised the following stages:

- Water-atomize alloy powder

- Dry at 110°C
- Sieve to <150µm
- Press powder into cylinders at 20 - 40 tsi pressure
- Sinter in air at 1550°C
- Re-press (squash)
- Ring roll to size
- Anneal at 900°C

Rings were supplied to customers for assessment and, as was the situation for gold rings, not only were the rings found to be satisfactory but clearly identifiable benefits were apparent. The rings proved to be more ductile than conventionally-produced rings and easier, therefore, to size. Engraving of the rings was straightforward with the patterns being sharper while the edges of the rolled rings were more uniform and required less finishing. As a result, full-scale production of platinum-3% copper rings for the UK market began in late 1998 with different size press tooling accommodating different sizes of ring.

Water atomization is the preferred powder production route to produce the irregular-shaped particles necessary to give good particle interlocking on pressing. A water atomizer was already available at Engelhard-CLAL, used to make platinum powders for a range of industrial products and, from this experience, sieving to less than 150µm was felt likely to give a good

was felt likely to give a good compromise between a high yield of usable powder and strengths of pressed cylinders sufficient to allow handling without damage. This turned out to be the case. Fig. 10 depicts atomized powder in the base of the water atomizer.

The requirements for pressing were essentially to allow automatic pressing and ejection of compacts while maintaining a constant compact weight. A hydraulic press which met these needs had been obtained for gold ring production and this was perfectly satisfactory for platinum. Fig. 11 shows the press in operation. The automatic feed system of the press allows the production of one compact every ten seconds or so with powder being dispensed on a volume basis. For every batch of powder a few rings are pressed under the specified operating conditions for the particular size of ring required, and the weight and height of each ring is determined. If necessary, minor adjustments can be made to the size of the die cavity to ensure the correct weight of ring, and to the pressing pressure to achieve the correct ring height and, therefore, pressed density. The press will then operate automatically to produce pressed compacts until the batch of powder is fully utilized.

Pressing pressures of between

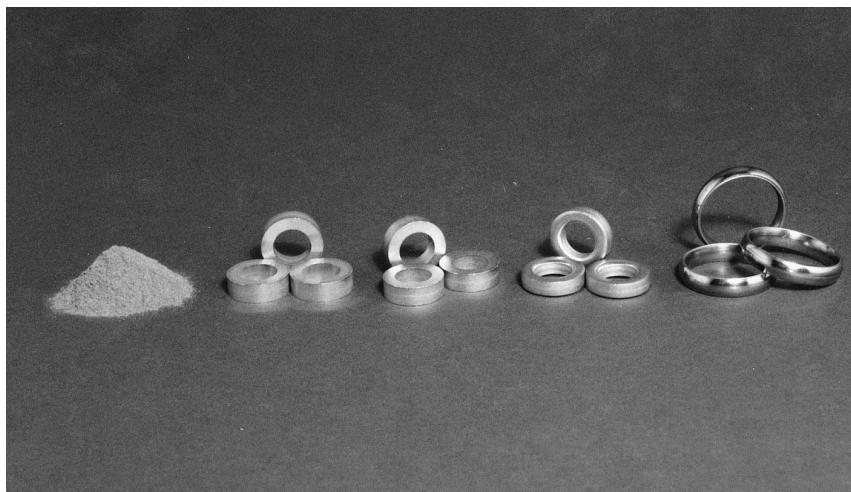


Fig. 12: Platinum alloy powder and rings at various stages of manufacture.

30 and 40 tsi were found to give pressed densities of 75 to 80% of the theoretical, which was sufficient to allow handling of the pressed compacts without risk of damage.

Initial sintering trials were made using temperatures of up to 1400°C but the sintered compacts cracked on ring rolling and exhibited significant porosity. Eventually 1550°C was chosen for sintering the rings but this was later reduced to 1450°C. Sintering is carried out in air in a muffle furnace with the compacts packed in zirconia containers.

Squashing and ring rolling are carried out in exactly the same way as was practiced with conventionally-produced rings.

The various stages in making the platinum-copper rings are depicted in Fig. 12.

As production experience built up other platinum alloys were con-

sidered. Platinum-4.9% copper, (an alternative alloy in the UK market), platinum-4.8% ruthenium (widely used in the US), and platinum-8% copper-1.8% cobalt (an alloy proposed for the Far East) were all produced in powder form and converted into rings for evaluation. Processing details for all the alloys are summarized in Table 1.

#### PROPERTIES OF RINGS MADE FROM PLATINUM ALLOY POWDERS

Detailed evaluations were carried out on rings made in platinum-3% copper. In finished ring form the density was in excess of 99.5% of the theoretical, with only occasional traces of porosity seen on metallographic examination. Any porosity present always appears in the central areas of the ring where it is of no consequence. A typical section is shown in Fig. 13.

The grain size of the rings made from powder is considerably finer than that of conventionally-produced rings, as illustrated in metallographic sections of both types of ring in Figs. 14 and 15. The respective average grain diameters are 0.07mm and 0.03mm.

The hardness of rings produced from powder is slightly higher than the conventional rings, as would be expected from the finer grain size. This, in turn, is likely to result in improved wear characteristics.

An important aspect of ring production is uniformity of weight and the powder route that has been developed gives good consistency. Twenty, nominally 11g, platinum-copper rings selected at random from a batch gave a spread from 10.897g to 11.128g, with an average ring weight of 11.033g.

In terms of ability to be machined, sized and engraved the new rings were judged by ring finishers to be superior to those produced from rolled sheet.

Production of the new rings started in late 1998, and by August 2000 some 40,000 platinum-copper rings had been manufactured and sold, largely platinum-3% copper but including some platinum-4.9% copper. The range of ring sizes has covered ring weights from 2.6g up to 25g with different tooling being required for the different ring sizes.

A batch of platinum-4.8% ruthenium rings was evaluated here at Engelhard-CLAL in the US and it was found that, on detailed machin-

Platinum Alloy	Melting Range, °C	Atomization Temp., °C	Pressing Pressure, tsi	Sintering Temp., °C
Pt-3Cu	1745-1755	2100	30	1450
Pt-4.9Cu	1720-1740	2100	31	1450
Pt-4.8Ru	1810-1830	2130	35.5	1450
Pt-8Cu-1.8Co	1690-1720	2100	31	1450

Table 1 Processing Conditions for Platinum Alloy Powders used for Ring Manufacture

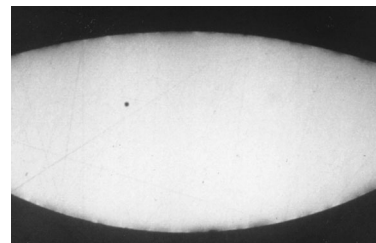


Fig. 13: Cross-section through platinum-3% copper ring (x30).

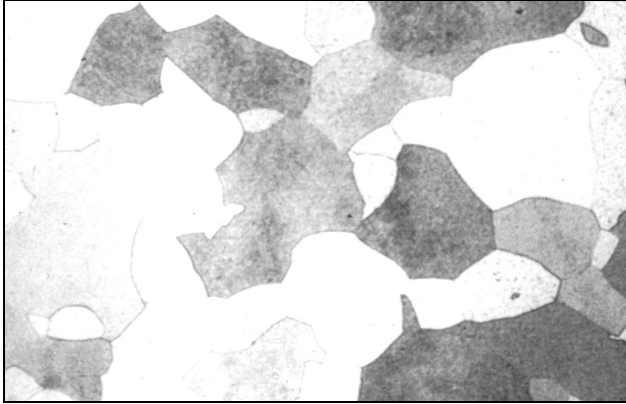


Fig. 14: Metallographic section of platinum-3% copper ring produced by traditional route (x180).

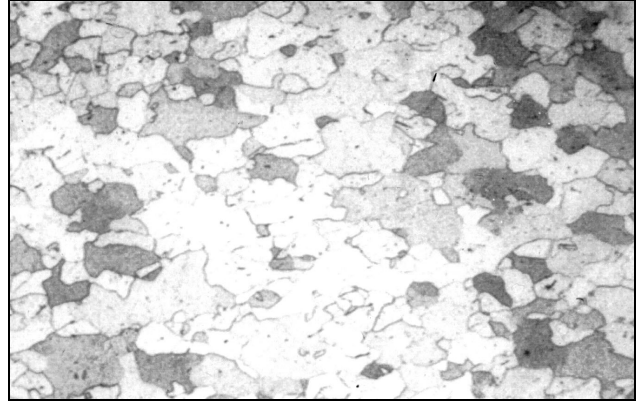


Fig. 15: Metallographic section of platinum-3% copper ring produced by powder route (x180).

ing trials, these powder-metallurgically produced rings behaved slightly differently to conventional rings, with some interruptions to the machined groove pattern which were postulated to be due to the presence of traces of porosity.<sup>(4)</sup> In Table 1, the ratio of sintering temperature to liquidus temperature is significantly lower for the platinum-ruthenium alloy compared with the other alloys and so a new batch of rings has been prepared in which a sintering temperature of 1575°C has been adopted. These rings are currently under evaluation.

The platinum-copper-cobalt alloy rings performed well although some slight oxidation occurred during sintering in air and so future batches will be sintered in a non-oxidizing atmosphere.

#### **BENEFITS OF POWDER METALLURGICAL PRODUCTION**

Based on 2 years production of platinum-copper rings in the UK clear technical and economic benefits have been identified and there seems every reason to believe these same benefits will apply to other platinum ring alloys including platinum-ruthenium and platinum-copper-cobalt.

#### **Technically**

The grain size of the new rings is significantly finer than that found in rings produced conventionally and this will give increased strength and wear resistance. The reasons for this fine grain size, which is commonly found in powder-metallurgical products, may be associated with the presence of very fine, sub-microscopic porosity which can stabilize grain boundaries and make them more difficult to move during re-crystallization.

The edges of the rings are easier to form during ring rolling and more uniform which, in turn, means less work at the finishing stage.

The rings are easier to size up to a larger finger size; in other words they exhibit improved ductility.

Engraved patterns are sharper.

#### **Economically**

The yield of powder after atomizing and sieving is close to 90% of the starting melt weight and virtually all this powder is converted into finished rings. This compares with a yield of 25% for conventionally-produced rings and leads to two major benefits. First, less metal is required to manufacture the rings leading to a reduction in metal financing costs. Second, material costs associated with segregating,

recycling and refining scrap alloy are dramatically reduced.

The manufacturing time for making rings is significantly shortened by the new process leading to further reductions in metal financing costs as metal spends less time in the factory.

Direct labor costs are reduced as both the number and time of the manufacturing operations have decreased.

#### **CONCLUDING REMARKS**

Having been initially developed for karat gold wedding rings, the press and sinter powder-metallurgical technique has now been successfully extended to the mass production of platinum alloy rings.

The technique, for which a patent application has been made, involves the water-atomization of alloy powder, pressing in an automatic hydraulic press and sintering at temperatures of at least 1450°C and leads to considerable economic benefits, largely as a result of yields of finished rings of close to 90%, although these benefits will be lessened if small volumes of different alloys and different ring sizes are processed. There are also significant technical benefits associated with the new rings, largely as a result of

the fine grain size of the new rings.

Other platinum products which could be candidates for a press and sinter approach in the future include coinage, medals and watch cases.

#### **ACKNOWLEDGEMENTS**

The author is pleased to acknowledge the work of many former colleagues at Engelhard-CLAL UK

where the process was first developed, in particular Terry Taylor, and is grateful to the management of Engelhard-CLAL, both in the US and UK, for permission to present this paper.

#### **REFERENCES**

1. D McDonald and L B Hunt, A History of Platinum and its Al-
2. P M Raw, Gold Technology No 27, 1999.
3. Engelhard-CLAL Ltd, International Patent Application No PCT/GB98/02733, 1998.
4. C Volpe and R D Lanam, Proc of 14th Santa Fe Symposium, Met-Chem Research Inc, 2000.

lied Metals, Europa Publications, 1982.