

## Twentieth General Assembly

The Twentieth General Assembly of the Tantalum Producers International Study Center was held on Wednesday November 2nd 1983 in the conference room of the International Association Centre, 40 rue Washington, 1050 Brussels.

Mr Robert Franklin of STC Components, Paignton, England, was elected to the Presidency for the coming year, in succession to Mr John Linden of Greenbushes Tin. Mr Carroll G. Killen, Sprague Electric Company, North Adams, Massachusetts, was elected to the Executive Committee. The other Committee members were re-elected to a further term of office, namely Mr Becker-Fluegel, Mr Conrad Brown, Mr Janson, Dr Korinek, Mr Linden, Mr Tolley and Mr Van Achter.

Two companies were elected to membership : I.T.T. Bauelemente GmbH of Nuremberg, West Germany, and Pancontinental Mining Ltd., Sydney, Australia. Four resignations were accepted. Total membership is currently 65, and 46 of these companies were represented at this meeting, which was attended by 60 delegates and guests.

The General Assembly approved the audited accounts for the six months ended June 30th 1983, and the budget projecting receipts and expenditure for the year to June 30th 1984. During the previous year a collection of information on the activities of the member companies had been started, which would become the basis of a library service. Also extended editions of this Bulletin, with eight and ten pages, had been published.

The Twenty-first General Assembly will be held on June 5th 1984 in Stockholm as part of a meeting from June 4th to 7th which will include plant visits to Sandvik and Seco Tools. Hosts for the meeting will be Sandvik, Seco Tools, Ekmans and Axel Johnson Ore and Metals.

Delegates were able to visit the office of the T.I.C. on the second floor of the International Association Centre, and also the other meeting rooms in the Centre.

Papers were presented to the assembly after the formal business of the association had been concluded :

- Treibacher — A unique enterprise, by Mr Otwin Pilgram, Treibacher Chemische Werke AG : A historical view of the origins and achievements of this company and its contributions to chemical research and interdependent commercial development.
- Chip capacitors, with emphasis on tantalum, by Dr. Werner Schnabel, Manager of Electrolytic Capacitor Development, Siemens AG : A review of the properties of new components manufactured in tantalum and other materials.
- Tantalum and its alloys as engineering materials for the 1980's, by Mr Reinhard Deil, Managing Director, and Mr Malcolm Salter, Marketing Manager, Murex Ltd. : The metallurgical work of Murex, wellknown for its fabrication of tantalum, among other metals, was described, and articles manufactured from tantalum were displayed, including a piece of tantalum jewellery.
- The role of the Metal Bulletin tantalite quotation, by Mr David Gilbertson, Editor, Metal Bulletin : Interest centred on the reporting and publication of reference prices in the trade press and the sources of information used.

These papers will be reprinted in the Bulletin.

### T.I.C. TWENTIETH GENERAL ASSEMBLY

The Twentieth General Assembly of the T.I.C. was held at 9.30 a.m. on Wednesday November 2nd 1983 at the International Association Centre, 40 rue Washington, 1050 Brussels, Belgium.

Mr John Linden completed his year as President and was thanked for his vigorous work on behalf of the association.

Mr Robert Franklin was elected President for the coming year. Mr Carroll Killen was elected to the Executive Committee, and the other members were re-elected for a further term of office.

Two new companies were elected to membership, and four resignations were accepted.

The audited accounts for the six months ended June 30th 1983 were approved. The budget for the year to June 30th 1984 was accepted.

Presentations were made by Mr Otwin Pilgram of Treibacher Chemische Werke, Dr. Werner Schnabel of Siemens, Mr Reinhard Deil and Mr Malcolm Salter of Murex and Mr David Gilbertson of the Metal Bulletin.

Further information on the T.I.C. may be obtained from the Secretary of the T.I.C., 40 rue Washington, 1050 Brussels, Belgium, telex 65080, telephone (02) 649.51.58.



## Letter from the President

The Twentieth General Assembly in Brussels on November 2nd gave members an opportunity to inspect the new T.I.C. office and also the conference facilities within the International Association Centre in which the office is housed. This Centre was honoured by the presence of the King of the Belgians for its official inauguration on October 25th. Our secretary, Mrs Wickens, represented the T.I.C.



King Baudouin, centre right, is welcomed to the International Association Centre by Mr Pierre Harmel, Minister of State, President of the Foundation of the Centre (right), Mr Georges Speeckaert (centre left) and the Director of the Centre, Mr Gellinck (left).

Our Assembly was the first such meeting to use the Conference Room. Whilst the room had many excellent features the facilities offered for the presentation of papers needed attention and a number of recommendations are being progressed with the Director of the Centre.

A start has been made on setting up a library within the office, concentrating initially on information provided by member companies, for which we thank those who have already supplied copies. If you have not already done so may we again ask you to send us product data, company reports and other informative papers concerning the organisation which you represent. Gradually we will extend the coverage of data together of course with means for disseminating it to members, but this will require more manpower. In order to achieve the expansion of services without substantial increases in fees attempts will be made to increase the Membership of the T.I.C. from the present 65 to more than 100. The increase in income would then allow a wider range of services to be provided for the members.

General Assemblies and the Bulletin are our main means for regularly updating members with the state of tantalum associated industries. Delegate members receive 5 copies of each Bulletin: may I ask delegates to review the circulation of them within their organisation to ensure that they reach all persons to whom the contents may be of value. Only in this way can we achieve the full purpose of the T.I.C.

Preparations for the next General Assembly in Stockholm on 4th - 6th June, 1984 are well advanced and invitations will be despatched to delegates late February or early March. The emphasis of the papers and plant visits will be on tantalum carbides, which is, of course, one of the major outlets for tantalum materials.

Finally may I express the appreciation of the T.I.C. to the outgoing President, John Linden, for his considerable efforts towards furthering the aims of the T.I.C. during his year of office. In spite of his heavy business commitments he has devoted much time and energy to the advancement of our common interests within the total tantalum scene.

R.W. Franklin



Inauguration of the International Association Centre, honoured by the presence of the King of the Belgians.

## Treibacher — a unique enterprise

(This article has been written from the presentation made to the Twentieth General Assembly by Mr Otwin I. Pilgram, Senior Executive Officer of Treibacher Chemische Werke AG, who is currently responsible for Carbides and Mischmetal, after 30 years with the company.)



Treibacher Chemische Werke.

I want to paint a picture of my company in — to a certain extent — an unusual way, so that you will know more about Treibacher. The title is taken from the Metal Bulletin, my friend Trevor Tarring created it when describing my company many years ago.

The name Treibach derives from Drei, meaning three, and Bach, which means small rivers, and the place has a very long and interesting history. 2000 years ago this area already had an important role connected with iron. Even Ovid spoke of the high quality iron from Noricum, and the Romans used to buy iron goods made in the area of Treibach. There were a number of iron works using the locally mined ores from Hüttenberg, although the grade was low by today's standards. 1610 was the first year in which iron made in Treibach was sold on an industrial basis. By 1720 Treibacher iron was considered to be one of the best in Europe for quality.

According to a report in 1780 the works in Treibach were the largest enterprise on the continent, producing 1,200 tons per annum. The bullets for the shot guns during the Napoleonic wars were made in Treibach. The highest quantity produced was 20,000 tons in 1870, but 1887 saw the end of the iron works, due to the introduction of the new process.

### DR AUER

Carl Auer von Welsbach was the son of the head of the state owned printing works. He began the study of chemistry in Vienna in 1878 and after about two years he continued his studies in Heidelberg. Professor Robert Bunsen was one of his teachers and became his friend. Back in Vienna he discovered that Didymium, which was considered as one element only, consisted of two, namely praseodymium and neodymium. Dr Carl Auer invented the gas light, and found that lanthanum oxide and zirconium oxide increased light output. He sold his patent for 1 million Guilders and gave away licences. He continued working on improvements, which resulted in the new incandescent mantle over the gas light, with thorium and cerium. With this invention Auer earned a good deal of money and bought Treibach and Rastendorf in 1893. Buildings were erected in 1898 and 1899 and people began working on Auer's ideas. By 1890 he had already patented the metal filament lamp. Edison's carbon filament lamp could not be used successfully, so Auer decided to use for the filament the metal which he believed to have the highest melting point, namely osmium, but he overlooked two other metals with higher melting points: wolfram and tantalum.

The osmium lamp was first introduced at the world Expo 1900 in Paris. Siemens and Halske came up with a tantalum lamp but Mr A. Lederer's tungsten lamp won, finally, as we all know today. And who was Mr Lederer? He was an assistant of Dr Auer! Dr Auer gave up all activities in metal filament lamps and continued to concentrate on his gas light. He had to buy thorium, which was very scarce and expensive: he heard of a new mineral containing thorium and rare earths — monazite. He was only looking for thorium, the rare earths were waste, but he did some research on the waste. Ytterbium was then considered to be one rare earth element only: using spectral analysis he proved that it was two elements, which in 1907 he named alabardarium and casiopeium. But Urbain, a French chemist, claimed to have discovered element no. 71 before Auer, Urbain called our casiopeium « luthetium ». According to today's status, both Auer and Urbain are considered to have discovered element no. 71.



Auer continued his research of cerites, these are the rare earth elements from lanthanum to gadolinium. The so-called heavy rare earths are called ytterbiums. Also Auer pursued his work in the electrolysis first used by Bunsen and improved by Muthmann.

Auer found that an alloy of iron and cerium sparked and could kindle gas : in 1903 he patented the flint stone, although corrosion was a problem in the ensuing years. In 1907 Dr Auer founded Treibacher Chemische Werke GmbH, making 300 kgs of flint alloys in 1908 and 8 tons in 1912. In 1910 lighters and flint stones were produced and in the same year a lighter factory was founded in Paris, although it was closed in 1914, and our works in New York were closed in 1917. During world war I the Treibacher works were closed for one or two years, but in 1916 we produced some tons of ferromolybdenum for Gebr. Böhler in Austria. Later the labour unions began to be active : there was a strike in 1923.

Due to the war, the flint business was not very profitable, so other products like synthetic jewels, clean molybdenum compounds and explosives were produced. In 1921 the basis was laid for our A1203 activities by buying a large area of a riding school.

In 1926 we supplied 15 tons of tungsten/ferro-tungsten to Böhler and increased the ferro-molybdenum production to 8 tons molybdenum content.

At this time we sold, with very good profits, georadium and a radioactive gypsum in the form of compresses, pastes, etc. Also, at the same period, we kept 200 cattle and 50 horses.

1929 was an eventful year : we received a large amount of money from the U.S.A. in payment for the expropriation of our flint works; Dr Carl Auer died, aged 71; Treibacher Chemische Werke AG was founded.

The moly business did not bring enough profit, so we produced the cleanest plant protection material. We made dichromates and chromic acid. In a pilot plant pure metals such as chromium, magnesium, vanadium and, last but not least, tantalum were produced.

In 1934 a company was founded in America, called Treibacher Chemical Works : we produced and sold flints and lighters at works at Niagara Falls.

Georadium and the profits from sales brought up the idea of going further into this field, especially as, in the U.S.A., there were radioactive materials on the shelf at low prices. In 1935 radium mesothorium and radio thorium were produced.

We erected a new plant in 1936 to work up a mixed salt from molybdenum, containing molybdenum and vanadium, but also tungsten, arsenic and phosphorus.

The following year we bought a large portion of shares in a French-Brazilian company with rare earth plants near Paris, a flint factory near Rouen and monazite plants in Brazil. After Austria was annexed to Germany more inland business was expected, but only the radium activities improved. We were a one-third partner in St Joachimsthaler Bergbau GmbH, and worked up the radium-containing pitchblende. Also an office was opened in Berlin.

## AFTER THE WAR

In 1946 all the radioactive materials were taken away by the British military government. We produced magnesium chloride for the production of soret-concrete. Also we began to produce the sparklers for Christmas trees which you saw reflected in the eyes of children in photos, but unfortunately they caused fires in the Christmas holidays, as they continued to sparkle even on the carpet !

We produced pure rare earths such as lanthanum, cerium, praseodymium and neodymium. Ferromoly could not be sold as the Austrian special steelworks were broken down, but we made ferro-chromium, ferromanganese with high carbon-content, some A1203 and calcium carbide.

Only in 1947 did the level of flint production reach again the level of 1938. Flints were highly priced on the black market : for the black market price of two cigarettes, about 20 schillings, you could buy one flint — whereas the price of one kilo of bread was 4 schillings !

This period saw the beginning of our activities in the chemical-pharmaceutical field, with the production of chemically clean magnesium oxide and magnesium carbonate.

By 1948 raw materials were scarce — we had to buy on grey markets. Brazil and India banned the export of monazite due to the thorium content : these countries wanted to work up the thorium for themselves. Dr Babha from the Indian government came to Treibach to negotiate about our know-how to do this, but S.T.R. Paris had the better wire.

At least a dozen horses were used in 1949 to transport products within the local area. In this year we produced :

- 9 tons of Mo in FeMo
- 50 tons of W in FeW
- 200 tons of FeCr
- 2,000 tons of  $Al_2O_3$
- 53 tons of MM

But competition in the lucrative flint business came up. Although we extruded flints in 1941 and had the extrusion press in April 1944, we still cast our flints, whereas Goldschmidt supplied extruded flints in 1950, with experience gained from us when they were shareholders of T.C.W. Our patents were infringed and many court decisions had to be made to enforce our rights.

Our far East business in flints was widened in 1951 when we bought the German Pyrophor Metallgesellschaft in Essen.

When the foreign armies left Austria in 1955, we opened our new ferro-alloy plant. We produced ferro-titanium and ferro-niobium, and our business with China was extensive. Microalloy production grew from 1,500 tons in 1955 to 4,700 tons in 1960.

A journalist found out that Treibach worked in radioactive products. Mr Karner, this was the journalist's name, published articles saying that Treibacher supplied the materials for Hitler's A-bomb and made a contribution to the A-bomb. It was not true — and when you think of the very few attempts to produce the A-bomb in Germany you will understand that they would not have succeeded, by comparing these few with the tremendous efforts and cost expended by the U.S.A. In December 1976 these articles made a lot of noise.

Among our products were activated radium-needles for hospitals and huge quantities of tooth-fillings, a kind of concrete, also Brom-uvan, a tranquilliser.

During all this time one man was in the spotlight — Dr Fattinger, General Manager, shareholder and driving force of the company. He was a kind of emperor : he was the leader of a private battalion, fighting the Yugoslavs for Southern parts of Carinthia. He was a unique individualist. Also a good friend of Mr Starck. He allowed the local hair dresser to cut his employees' hair during office hours, as the hair also grew during these hours. When he was beaten at card-playing by one of his employees he fired him — but engaged him again a few days later. He allowed skating during the winter when the river was frozen.

We have been working for a long while in the field of various glass additions, especially rare earth compounds for the optical industry — either for direct addition colouring or decolouring, and also for polishing purposes.

We also supplied tantalum oxide to this industry. A maker of hard metals approached us one day to sell him  $Ta_2O_5$ , in about 1959 : we did. Then he came and asked for a carbide : we made it, and sold it. Another came with the same request : we acted, and found out that, thanks to the high Starck prices, we could make money. So we entered this complicated, sensitive carbide market.

In our plants we can use all kinds of tantalum raw materials. We feed with low grade tin slags, high grade tin slags, struverites, tantalites, simpsonites, djalmits, wodginites, tapiolites and all kinds of scrap. What we buy depends on the price and availability only — and of course the quantity, one cannot buy 20 tons of slag or one ton of a stibiotantalite.

From the above you will note the flexibility demonstrated by Treibacher Chemische Werke over many decades. Currently, turnover amounts to \$ US 200 million annually (1982), 85 % is exported, well balanced between Western Europe (42 %), Eastern Europe (33 %) and Overseas (8 %). The company is organised in seven divisions :

**Ferroalloys :** Ferro Molybdenum, Ferro Vanadium, Ferro Boron, Ferro Niobium, Ferro Titanium, Ferro Nickel, Ferro Nickel Molybdenum, Ferro Tungsten, Tungsten Melting Base, HSS Premelts, GRAN-ALLOYS, Nickel Oxide, Nickel Salts.

**Mischmetal :** Mischmetal.

**Abrasives :** Aluminium Oxide ALODUR, Concrete Hardener DUR-MAX.

**Peroxides :** Sodium Perborate.

**Flints :** Flints.

**Refractory Carbides :** Tungsten Carbide, Tantalum Carbide, Titanium Carbide, Mixed Carbide, Tungsten Metal Powder.

**Rare Earths and Rare Earth-Polishing Compounds :** Cerium Polishing Powders TECEPOL, Glasscomponents, Rare Earth Compounds.

Subsidiary companies exist in Germany, Great Britain, USA, Japan, Italy as well as in Austria; of the latter some specialize in East-West trade.

Continuing the flexible policy, important investments have been made in widening the capability to use various raw materials, to ensure cost competitiveness and constantly improve product quality.

Thank you for giving me this opportunity of telling you about Treibacher.

## Tantalum and its alloys as engineering materials for the 1980's

(The following paper was introduced by Mr Reinhard Deil, Managing Director, and presented by Mr Malcolm Salter, Marketing Manager, Murex Ltd., at the Twentieth General Assembly of the T.I.C.)



TANTALUM has a unique combination of chemical and physical properties which fit it for use in arduous applications. It is available in all the normal forms of engineering materials, and it can be fabricated by the conventional techniques without undue difficulty. There are many proved applications, and new applications are being found by engineers in a variety of different industries.

## ELECTRON BEAM MELTING

At Murex we start our work with electron beam melting, a process which overcomes the disadvantages of sintering and arc melting, in that very large blocks of tantalum of high purity can be produced.

In this process the kinetic energy of beams of highly accelerated electrons is converted into heat when the beams are directed on to a small block of tantalum contained in a water-cooled crucible. Once the head of this block is molten, the feedstock is fed into the array of beams and drip melts into the crucible, the ingot being gradually withdrawn.

To obtain stable, controllable electron beams requires an operating vacuum of  $10^{-4}$  –  $10^{-5}$  torr and a high voltage power source operating at 10 - 20 kV. Feedstock in the form of compressed powder bars, tantalum capacitor pins and recycled sheet and rod clippings are generally used and normally two melts are carried out. During the first melt, which is carried out fairly slowly at 10 - 15 lb/h, the tantalum is purified under the influence of the high temperature — 3000 - 3200° C — and the high vacuum. Oxygen, hydrogen, nitrogen, and carbon are all substantially eliminated and metallic impurities, such as iron, copper, nickel, titanium are removed with equal facility. A second melt is carried out to produce a homogeneous block of good surface quality — an important feature when dealing with an expensive product. The second melt may be carried out much faster, say 30 - 60 lb/h.

Several types of electron gun have been described, but most commercial installations now use either the Pierce type gun as developed by Heraeus or the transverse gun as developed by Temescal Metallurgical Corporation and Degussa. The transverse gun is of very simple and robust construction and is used inside the melting chamber, sited in such a way that contamination is minimised. The simplicity of this gun means that spare units can easily be constructed and fitted by the operator, thus reducing furnace downtime to a minimum.

## COMPARISON OF TANTALUM CONSOLIDATED BY VACUUM SINTERING AND ELECTRON BEAM MELTING

A comparison of impurity levels in tantalum feedstock, vacuum sintered bar and electron beam melting ingot is shown in the table :

Element	Feedstock ppm	Vacuum sintered bar ppm	EBM ingot ppm
O <sub>2</sub>	2500	35	10
H <sub>2</sub>	-	1	1
N <sub>2</sub>	120	50	50
C	300	100	200
Si	250	100	15
Fe	150	100	30
Cu	-	-	5
Ni	-	-	5
W	100	100	30
Mo	100	-	30
Nb	500	500	100
Ti	30	100	20

Vacuum sintered bars are of fine grain size and are amenable to direct cold rolling, while the electron beam melted ingots are of coarse grain size and require cold forging prior to rolling. Electron beam melted tantalum is rather « softer », 60-70 H<sub>B</sub> against 90-100 H<sub>B</sub> for sintered material.

## PRIMARY FABRICATION

Tantalum can be readily cold worked in the annealed condition. Hot working should be avoided as reaction with gases such as oxygen, carbon monoxide or nitrogen could cause embrittlement. Vacuum sintered, arc melted and EBM tantalum can be cold worked to a considerable degree as the rate of work hardening is slow. However, alloys such as tantalum/10 tungsten work harden somewhat faster. During processing vacuum annealing has proved successful in increasing ductility of the work and the recrystallisation behaviour also shows the EBM tantalum to have improved ductility.

Vacuum sintered bar may be rolled to sheet or swaged to rod at room temperature, better results are obtained with heavy reductions at slow speeds allowing a steady metal flow, as higher speeds tend to tear the metal. Process annealing is carried out as required but reductions up to 90 % between annealings have been achieved. Sheet and rod is supplied bright or as-worked, depending on the ultimate requirement of the customer.

Arc cast and EBM ingots are three-dimensionally forged cold prior to rolling or swaging in order to create a finer grain structure, thus imparting greater ductility to the material. However, lower temperatures are preferred to lessen the effects of oxidation during forging, for example, 950 ° for Ta/10 W. For wire drawing an anodized coating is used which holds the lubricant in the formed oxide layer, the lubricant used being beeswax or a chlorinated hydrocarbon. This process requires slow drawing speeds and frequent inter-stage anneals preceded by removal of the anodizing with suitable etchants.

At Murex, we then continue with secondary fabrication, our welding and machining facility, with which we have some 40 years' experience.

## SECONDARY FABRICATION

### Welding

Because of the reactivity of tantalum, the methods of welding must be limited to those which prevent the molten weld metal or the hot parent sheet from coming in contact with any substance which will embrittle them, particularly gases in the surrounding atmosphere. In general, the practical methods are restricted to tungsten-inert gas and resistance welding, with the probability that electron beam welding will become a third. The properties of the weld metal, including the corrosion resistance, are the same as those of the parent material.

Information on the welding of alloys of tantalum is rather scanty, but no great difficulties have been experienced with the more common alloys with electron beam or tungsten-inert gas welding (t.i.g.). The conditions for Ta/10 W alloy welding are very similar to those for the pure metal, and the weld is equally satisfactory.

### Tungsten-inert gas welding

The most trouble-free method of welding tantalum is in a glove box, evacuated and back-filled with argon. A normal shielded tungsten-electrode torch is used with a light flow of argon. In order to give the best penetration, with a narrow molten pool, and to concentrate the heat in the weld, it is preferable to use a direct current source with the electrode negative.

If appropriate care is taken, tantalum can be fusion welded outside a glove box. A high flow of argon must be used and the back of the joint must be covered with argon as well. This is normally done with a jig having a channel 3/8 in. wide by 1/8 in. deep behind the joint, along which argon is passed.

With joints over 18 in. long it is advisable to have more than one argon supply lead. A trailer shield designed to supply an argon cover to the fresh weld metal is sometimes used, as well as the normal electrode shield which supplies argon to cover the weld pool. An alternative is to weld intermittently, allowing the fresh weld metal to cool under the argon flow between runs. With this technique, it is advantageous to weld with a series of disconnected short runs and subsequently to join these together with further short runs. This limits the thermal distortion as well as contamination away from the immediate argon cover by limiting the temperature rise of the parent material.

To prevent serious contamination, the jigs and holding down clamps should be designed to limit the temperature rise of the tantalum away from the immediate weld area. For the same reason, it is inadvisable to use a filler rod as this becomes oxidized outside the argon shield, before being melted. Where necessary, a filler can be tack welded into position before welding.

The fabrication should be so designed that welds are only made between thin sections in order to limit the power necessary and the thermal effects around the joint. The need for filler rod can be eliminated by weld design in some cases, so that a fillet can be melted down to form the joint.

Where the final fabrication is required in the annealed condition, the pieces to be welded should be previously annealed or the oxide skin on the weld will diffuse into the metal during annealing and embrittle it. This oxide skin, normally invisible, is caused by impurities in the argon or by air cooling if the weld is not cooled to 300 °C under the argon shield. Recrystallization and grain growth take place in the area adjoining the weld, and impurity segregation in the grain boundaries hardens this area as well as in the cast structure of the weld metal.

### Resistance welding

With sheet thinner than 0.020 in. argon arc welding is unsuitable and resistance welding is used. The surfaces to be welded should be degreased and acid cleaned as cleanliness is of great importance.

Spot welding in air, provided that the timing is held to one cycle, is satisfactory, but for multiple cycles the welding can be carried out under water or under argon shielding nozzles surrounding the electrodes, a new process developed this year.

### Sheet Metal Work

Tantalum can be worked at room temperature, but it is found advantageous to heat Ta/10 W to 100-200 °C, depending on thickness, for these operations.



## Spinning

Conventional spinning techniques can be used with steel formers and hardened and ground tool-steel tools. Tallow is used as a lubricant, with peripheral speeds of about 80 m/min or 300 ft/min. Because of the soft nature of the material, any imperfections in the former will be shown on the work. It is important to form the shape gradually with light passes, and to trim the workpiece periodically to remove the most highly stressed material. Intermediate annealing or stress relieving is normally unnecessary.

## Blanking

Blanking sheet is straightforward, with steel dies and punches kept well lubricated to prevent galling. If the « burr » must be kept to a minimum the clearance is very critical. A clearance of 0.0003 in. when blanking discs in 0.020 in. sheet for example will limit the burr to 0.001 in. to 0.002 in. maximum. Setting the punch and die with this clearance requires considerable care. The stamping procedures applicable to mild steel can be used with tantalum, after allowing for the fact that no « spring-back » will be encountered.

## Deep Drawing

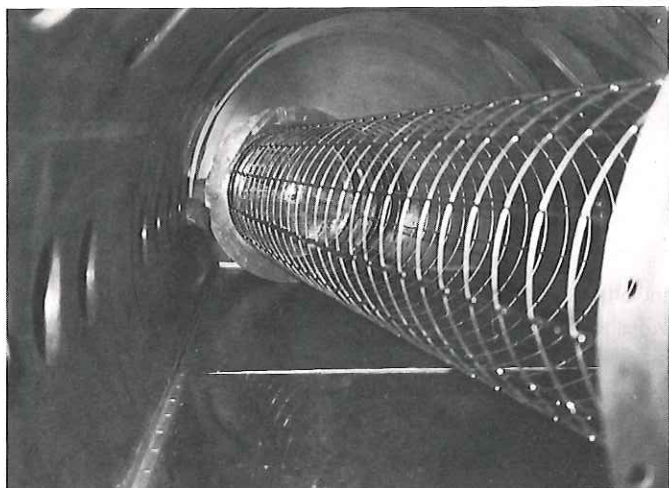
Annealed sheet, anodized to aid lubrication, should be used. For the initial stage, the depth to diameter ratio should be limited to 1 : 2, before drawing to the final size.

Galling occurs with steel, and aluminium bronze or « Narite » tools are preferable.

## Rivetting

Tantalum sheet can easily be riveted with tantalum rivets. The latter are made by cold upsetting annealed rod. The technique is seldom used, however, because of the good properties of welded joints.

### Chemical equipment fabricated from tantalum



## APPLICATIONS

### Chemical

A number of applications of tantalum are in the manufacture of chemical processing equipment, where the initial cost is balanced by unique corrosion resistance, ductility, thermal shock resistance, and ease of fabrication or repair.

A major use is in heat transfer systems, particularly heaters such as the bayonet heater. The tantalum pipes are sealed at one end and welded to a common tantalum flange at the other. Steam is introduced by means of a steel tube inside each tantalum tube, the condensate being exhausted from the steam chest. For steam pressures up to 150 lb/in<sup>2</sup>, 1.5 in. diameter seam welded tantalum tubes with a wall thickness of 0.013 in. are used, but for higher pressures, up to 250 lb/in<sup>2</sup>, fusion welded tubes from 0.020 in. thick sheet have been used. The working stress in the tantalum should be limited to 12,000 lb/in<sup>2</sup>, which gives a minimum safety factor of 4.

Heat transfer rates varying from 100,000 to 200,000 Btu/h ft<sup>2</sup> are achieved with 150 lb/in<sup>2</sup> steam, dependent on the presence or otherwise of scale. These rates will be unchanged over long periods of use, if no scaling takes place, and thus provide the justification for using tantalum.

Heat exchangers are constructed by similar methods. In the open-ended type, tantalum tubes normally pass through a cylindrical jacket, with tantalum flanges welded to each end of the tubes. To overcome the problem of differential expansion, hairpin type exchangers can be used where the corrosive medium in the tubes enters and leaves from

the same end of the jacket. With the correct selection of the material of the outer jacket, corrosive matter can be used outside the tubes also. Where the pressure is outside the tube, the wall thickness must be increased and the tube strengthened by ribbing.

Condensers, for acid vapours for example, are also made in tantalum. A tapered ribbed tube of the metal is fitted inside a water jacket, and tantalum flanges are welded to the central tube after assembly. Heat transfer rates of more than 100,000 Btu/h ft<sup>2</sup> have been reported.

A variety of dip pipes and sparge pipes in tantalum are in use, the latter being strengthened by ribbing or a web if high rates of steam throughput are used.

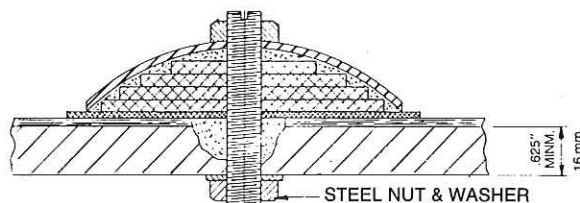
## Cladding

Because of the high price of tantalum, it is economic to consider a thin lining of tantalum for chemical equipment, backed by a cheap conventional material, which will protect the lining from physical damage. Another application for tantalum is in thermocouple pockets, since the thermal barrier of a thin-walled tube virtually free from oxide is negligible.

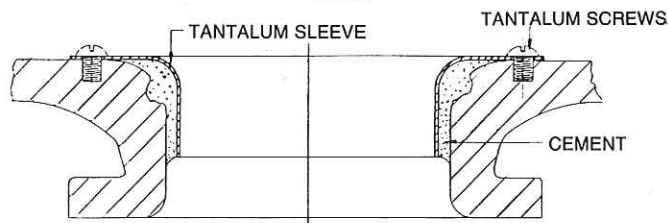
Since tantalum resembles glass in corrosion resistance, it is used extensively in the repair of glass-lined vessels. Where the lining is imperfect, exposing the metal wall, a disc of tantalum is bolted to the vessel with a tantalum stud and nut. Damage to ports is repaired by a tantalum sleeve fixed in position with screws of tantalum. The reliability of these pieces and the economics of their use is such that new vessels are delivered with repair plugs over any imperfections in the glass, to save the cost of relining.

Spun tantalum crucibles are used for a variety of purposes in chemical analysis.

### Tantalum repair disc for heavily damaged glass or enamel lined vessel



### Tantalum repair sleeve for damaged port in glass or enamel lined vessel



## High-temperature equipment

For the more complex furnace designs, tantalum, with its relative ease of fabrication and repair, and its stability at high temperatures, offers an economical substitute for tungsten or molybdenum, with the advantages of a somewhat higher maximum working temperature and a lower vapour pressure than molybdenum.

Tantalum capacitor anodes are sintered at 2000-2200 °C in tantalum furnaces to avoid contamination. Tantalum is used for the radiation screens, work trays, and heaters.

Tantalum and its alloys are being used experimentally in aerospace applications. It seems possible that they could replace niobium alloys above certain operating temperatures. As with the niobium alloys, it seems certain that they will need a protective coating.

## Miscellaneous

The physical and chemical properties of tantalum make it an ideal material for surgical implants. It is used as wire, gauze, braid and sheet. As it is non-toxic, tissue grows around the metal implant.

Tantalum spinnerettes are used in producing rayon and acrylic fibres, being much cheaper than the precious metal types. As yet there are no reports of use being made of the ductility of tantalum at very low temperatures.

In conclusion, Mr Deil confirmed that there were still many possibilities for new applications and he encouraged all those concerned with tantalum to look at new areas for its use, his company was always interested in widening the scope for the use of tantalum.



Mr Salter then displayed a number of tantalum components and demonstrated a set of tantalum darts, coloured by anodising, both efficient and comfortable to hold. Mr Deil and Mr Salter presented the Secretary of the T.I.C. with a handsome tantalum pendant which she wore for the rest of the meeting and will show again at future assemblies.

## T.I.C. tantalum production and shipments

The T.I.C. data for the production and shipment of tantalum-bearing concentrates and tin-slugs, taken together, for the third quarter of 1983 are :

(figures given in lbs. Ta<sub>2</sub>O<sub>5</sub> contained)

1983 - 3rd quarter	Total of slags and concentrates
Production	478 608
Shipments	216 587

For this quarter 24 of the 27 companies reported figures.

### PROCESSORS' SHIPMENTS

Data for shipments made by processors during the first and third quarters of 1983 are :

(figures gives in lbs. tantalum contained)

1983 - 1st quarter	368 773
1983 - 3rd quarter	529 280
1983 - total for first three quarters	1 340 886

For the first quarter 16 out of 19 companies reported, and for the third quarter 18 out of 19.

## G.S.A. purchases tantalite

In July 1983, the General Services Administration (G.S.A.) announced that it would purchase 305,250 lb. of tantalum pentoxide in natural mineral concentrates for the U.S. National Stockpile. (See issue no. 35 of the T.I.C. « Bulletin ».) G.S.A. specified that bids were to be submitted on the basis of separate lots each consisting of 61,050 lb. Ta<sub>2</sub>O<sub>5</sub>.

After several extensions of the deadline for receipt of bids, G.S.A. opened the bids on September 15th. Eleven suppliers made offers as follows :

Company	first lot	second lot	third lot	fourth lot
Greenbushes Tin	\$ 29.85*	\$ 31.25*	\$ 34.40	\$
Norore	31.64*	43.25		
Bomar Resources	33.23*	34.27		
Amalgamet	33.9631	35.8911	39.0515	42.4910
Phibro	33.989			
Metallurg	34.60			
Hermann C. Starck	36.75	36.75		
Atomergic Chemical	39.50			
Talmine Trading	44.00			
Samincorp	46.25	47.50		
Pacer Corp.	69.90			

Awards were made for four lots (marked « \* »), two lots to Greenbushes Tin and one lot each to Norore and Bomar Resources.

The fifth lot, which had been set aside at the request of the Small Business Administration to be reserved for a small domestic producer, was not ordered. The only bid meeting this condition was received from Pacer Corp., a developer of tantalum resources in South Dakota, U.S.A. The bid made by Pacer was considered by the G.S.A. to be too high at \$ 69.90 in view of the general market price level. The G.S.A. has indicated that they will probably request further bids to obtain this last lot of material.

## Published reports

The following articles have been recently published or have been presented at meetings and are expected to be published in the near future :

1. « Tantalum, Mineral Commodity Profiles 1983 », by Larry Cunningham, Physical Scientist, Division of Ferrous Metals, Bureau of Mines, United States Department of Interior.
  - A complete resumé of the supply situation and the market requirements for tantalum including projections to the year 2000. (Will be summarized in the T.I.C. « Bulletin »)
2. « Columbium and Tantalum », a preprint from the 1982 « Bureau of Mines Minerals Year Book », Bureau of Mines, United States Department of Interior.
  - A review and summary of the tantalum and columbium supply and consumption in the United States during 1982, including a World Review and a section on new technology.
3. « Control of Electron Beam Melting Furnace Covering both the Power Sources and the Micro Processor Aided Beam Performance », G. Vock, F.W. Thomas, J. Petzoldt, E. Zilg, all of Leybold-Heraeus, Hanau, West Germany, a paper presented to Electron Beam Melting and Refining State of the Art Symposium in Reno, Nevada, in November 1983, to be published as a part of the transactions.
  - A report of the state of the art in 1983 covering high voltage power supply units, beam current feedback controls, electron optical beam control, programmable beam deflection and scanning and microprocessor controlled beam deflection parameter storage.

4. « Electron Beam Power Supplies », Emmett R. Anderson and Robert W. Fisk of Energy Research Associates of Campbell, California, U.S.A., a paper also presented at the symposium in Reno, Nevada, in November 1983.

— The evolution of the electron beam power supply during the past twenty-five years is reviewed. Most recent developments are discussed in detail, as well as an overview of the solid state devices which have been successfully applied to electron beam power supplies being described and discussed.

5. « Physical Metallurgy of Electron Beam Melted Tantalum and Columbium », Victor T. Bates of Fansteel, Inc., North Chicago, Illinois, U.S.A., a paper also presented at the symposium in Reno, Nevada, in November 1983.

— The paper is presented in this issue of the « Bulletin ».

## Physical metallurgy of electron beam melted tantalum and columbium

The following article has been obtained from a presentation made by Mr. Victor T. Bates, Research Director of the Metals Division of Fansteel, Inc. at the Electron Beam Melting and Refining State of the Art 1983 Symposium in Reno, Nevada, U.S.A. from November 6th to 8th, 1983.

### INTRODUCTION

Electron beam melting is an indispensable process for purifying and consolidating both tantalum and columbium metals. In combination



with chemical purification processes, such as liquid-liquid extraction and crystallization, with other consolidation processes such as consumable-electrode arc melting, and often when used by itself, electron beam melting offers an attractive way of economically producing the broad range of metallurgical properties required by the many industries served by both metals.

For the tantalum capacitor industry, chemical processes predominate. In particular, tantalum powder for making sintered capacitor anodes is manufactured directly by sodium reducing the salt,  $K_2TaF_7$ . In some cases, especially to serve the high voltage, high reliability capacitor market segment, electron beam melting is almost exclusively used to purify further the sodium-reduced powder. The resultant ingot is subsequently hydrided, crushed, classified to various narrow particle size distributions, dehydrided and thermally agglomerated to achieve physical properties such as flow, green strength and thermal stability of the powder's surface area.

For industries such as aerospace, chemical, nuclear, sodium-vapor lamp, and military, the application of tantalum and columbium are dictated by unique physical, electrical, electronic, mechanical, corrosion-resistant, and thermal properties.

However tantalum and columbium possess, in varying degrees, propensities toward over-purification when electron beam melted, resulting in unacceptable wrought products.

## OVER-PURIFICATION

There are many indefinite and arbitrary definitions of « high purity ». Here we define high purity as the highest level of purification which still allows successful manufacture of mill products (primary metalworking) and fabricated components (secondary metalworking) for an end-use application. The most frequent problems encountered in making components from electron beam melted tantalum and columbium are « orange peeling » and non-uniform elongation, manifested by excessive localized metal thinning. The mill products used in such cases exhibit extremely large grains. There are four possible methods to overcome exaggerated grain growth caused by over-purification :

- (1) Optimize the primary and secondary metalworking steps.
- (2) Control the melting process.
- (3) Add grain growth inhibitors by micro-alloying.
- (4) Modify the metal more dramatically by macro-alloying.

## METALLURGICAL OPTIMIZATION

Although the metallurgy of tantalum and columbium is relatively simple, processing costs are high. Neither metal undergoes any phase transformation, and their properties are almost exclusively dependent upon cold work and recrystallization. Some alloys of these two metals are responsive to solution heat treatments and aging. However, the unalloyed metals do not respond to such treatments. Solution heat treatments are generally employed to improve the fabricability of an alloyed ingot for primary metalworking. Heat treatment is carried out using high vacuum, cold-wall furnaces, temperatures typically being 1600 °C for columbium alloys and 1700 °C for tantalum alloys, respectively. There are some instances when solution heat treatments of highly alloyed metals at the mill product and final component stage are practised to improve creep and stress-rupture properties.

On the other hand, in the case of unalloyed metals, where over-purification is a particular problem, the metal producer is limited to practising the basic rules governing cold working and annealing of metals. The grain size is reduced during mill product manufacturing using moderate-to-severe incremental cold reductions of 50 to 95 % between annealing steps. However, the total reduction is restricted by the upper practical limit of ingot diameter that can be processed using conventional steel metalworking equipment. Not to be over-looked is the benefit of utilizing frequent, in-process anneals to refine the grain size. The benefit of in-process annealing is related to the degree of cold working that is subsequently employed.

Optimum final annealing time and temperature are usually based on pilot data and depend on purity, percentage of cold work, and the cross-sectional thickness of the product. The metal producer selects the lowest temperature for recrystallizing the metal to produce the finest grain size possible, and yet obtain 90 % or more recrystallization. In the case of columbium, the temperature and time is usually 1000 °C to 1250 °C for one hour and for tantalum, 900 °C to 1050 °C for one hour.

If the product is very pure, the recrystallization temperature is lowered. A point is soon reached where there are insufficient nuclei to initiate the formation of grains, and adequate recrystallization occurs only if the annealing temperature is higher. The microstructure that develops from using higher annealing temperatures is unacceptable because abnormal grain growth occurs. The choice of annealing temperatures is the last variable the metal producer has to correct for over-purification. If unsuccessful, the problem must be solved earlier in the process by altering melting practice, micro-alloying or macro-alloying.

## CONTROLLING THE MELTING PROCESS

Tantalum and columbium differ in their rates of purification during electron beam melting. That is, the metals must be held molten for different times to achieve the same degree of purification. With increasing melt time, tantalum ingots are purified relatively quickly and approach the base line hardness of 60 to 65 BHN. Further melting does not affect hardness appreciably but does remove trace elements which act as grain-refiners.

On the other hand, columbium is more slowly softened by electron beam melting since nitrogen, the significant hardener in this metal, is only slowly removed. Nitrogen hardens columbium four times more than the same weight percentage of oxygen and is removed by melting at only one-fourth the rate. The formation of the volatile  $CbO$  species and the slow removal of nitrogen, which is rate limited by the probability of two nitrogen atoms colliding and forming molecular nitrogen at the melting point of columbium, seem the most reasonable explanation.

Columbium requires extensive melting to bring the metal to its base-line hardness of 36 BHN unless special low nitrogen feed material is used. As the hardness falls below 60 BHN, the purity rapidly approaches the point where there are no grain refinement characteristics remaining. At 36 BHN, the ingot is so pure, the grain size so coarse, that many products are difficult if not impossible to fabricate. The relationship of hardness to nitrogen content is :

Nitrogen Content* (ppm)	BHN (500 kg - 30 sec.)
10	40
20	50
30	55
40	60
60	65
75	70
100	75
200	95
300	112
400	128
500	143
600	157

\* For  $O_2$  - 100 ppm; C - 25 ppm

To produce acceptable products from columbium, ingot hardness must be between 60 and 75 BHN. Within this range, the ingot generally possesses the inherent grain refinement properties to be quite fabricable and meet the most stringent specifications for chemistry and mechanical properties. For this reason, columbium, unlike tantalum, is usually not deliberately micro-alloyed.

## MICRO-ALLOYING

The metal producer is often faced with the situation that high purity is almost always specified. Justification for high purity is apparently self-evident, but is often not supported by performance. This has been clearly demonstrated in the titanium metals and semiconductor industries which now control purity by back-doping. In these industries, similar difficulties arose when over-purification became a problem in meeting desired properties. Since over-purification is a tendency in electron beam melting tantalum, micro-alloying is a logical approach to design and control properties.

Many years ago, Fansteel recognized the need to micro-alloy. Observations were made that mill products such as sheet behaved unsatisfactorily with respect to grain size when made from electron beam melted, high purity, capacitor grade powder, and yet behaved satisfactorily when melted from recycled scrap. The difference in behavior was related to trace levels of columbium and tungsten found in ingots made from scrap, which had been inadvertently contaminated. As a result of this observation it was found that a preferred quality, fine-grained mill product can be produced by controlling the sum of (Cb + W) as shown :

$\Sigma(Cb + W)$	ASTM Grain Size
< 200 ppm	0 to 4
200 ppm	~ 4
450 ppm	~ 5
850 ppm	~ 6
1350 ppm	~ 7

(0.018" thick sheet identically processed).

A micro-alloy of tantalum with desired metallurgical and mechanical properties can be produced by simply keeping the sum of these two elements, as well as their individual contents, in a « window » between the ASTM specification (Cb - 500ppm max. and W - 300ppm max.) and specifications for capacitor grade product (Cb - 50ppm max. and W - 25ppm max.). Primary and secondary metal working are enhanced by



doping with these trace elements. As a matter of interest, Fansteel has been using columbium and tungsten micro-alloying of tantalum for over ten years.

Before continuing, it is informative to consider the purity attained by triple electron beam melting capacitor-grade, sodium-reduced powder. Almost every element, except columbium, tungsten and silicon, is less than 1 ppm. The first two elements are indigenous to the ore and are not easily removed by either chemical means or by electron beam melting. Although silicon has a relatively high vapor pressure, it obviously has a lower activity coefficient in tantalum. However, silicon can be removed by employing excess oxygen in the feed stock so as to form the more volatile compound, SiO.

Actually, trace levels of silicon are not undesirable as the element provides another way to control tantalum's properties. By keeping the silicon content between 25 and 50 ppm, ingots can be produced for making mill products with acceptable grain sizes. Silicon is a powerful micro-alloyant, and retained silicon at 150 ppm raises the recrystallization temperature of tantalum from 1800 °F to 2400 °F, the yield strength from 28,000 to 39,000 psi, the ultimate strength from 39,000 to 56,000 psi, improves the ASTM grain size from 5 to 8, and yet only lowers the tensile elongation from 50 % to 40 %.

Silicon micro-alloying is not generally practised in columbium. Fansteel does not intentionally use silicon as a micro-alloyant in electron beam melted tantalum products; however, a powder metallurgical tantalum product, trade named TPX, is made using this approach. In this case, silicon, retained at 100 ppm in mill products, markedly imparts oxygen-embrittlement resistance and greatly improves the service life of tantalum furnace hardware.

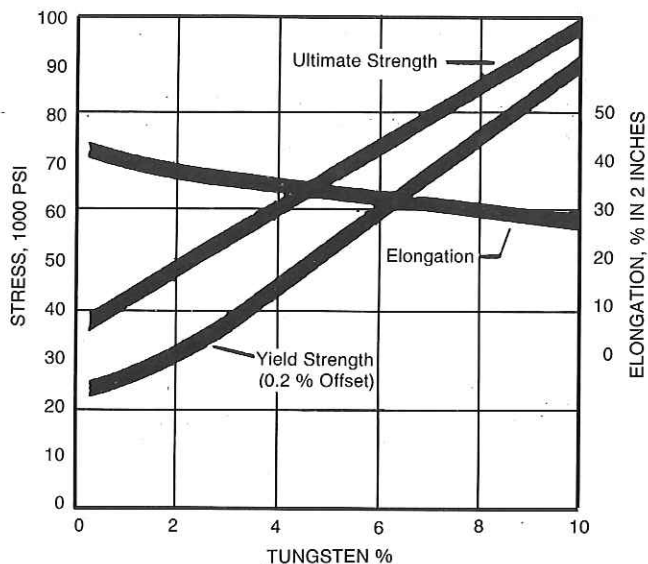
There are other ways to micro-alloy tantalum to facilitate electron beam melting, generally a more desirable process than arc melting since losses from « hot-tops » and « sidewall-scarfing » are less. Additions of zirconium and hafnium at 50 to 100 ppm and 150 to 300 ppm, respectively, have been used by Fansteel to achieve specific properties. Allowances for the vaporization of ZrO and HfO, as in the case of silicon, must be made by stoichiometrically adding an excess of each element as dictated by the oxygen content of the melt stock.

The last notable example of micro-alloying is the addition of rare earth elements such as yttrium. Research work done by the U.S. Air Force and others clearly demonstrated the potency of the rare earth elements as grain refiners. Only five ppm retained yttrium can have an extraordinary effect on the properties of both tantalum and columbium. Recrystallization temperatures are increased and other properties improved. Secondary recrystallization or grain growth is retarded resulting in excellent high temperature performance. However, rare earth additions must be carefully practised to prevent centre-line segregation in welds.

Micro-alloying represents a powerful technology to control metallurgical and mechanical properties in tantalum and columbium. The essential characteristics of the unalloyed metals are retained. However, when higher strengths are needed, macro-alloying offers some economic advantages because of the greater strength-to-weight ratios possible.

## MACRO-ALLOYING

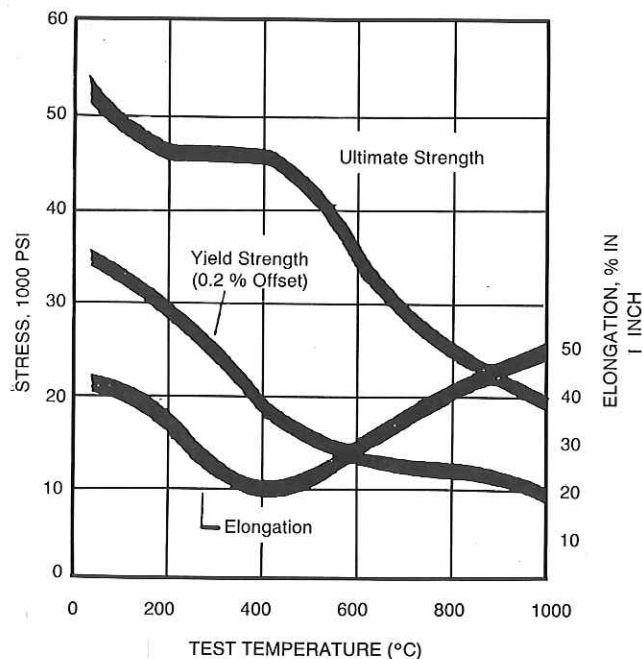
Tungsten is a powerful alloying agent for tantalum. The metals have comparable density and vapor pressure. Tungsten provides excellent



Room temperature transverse tensile properties of 0.020" recrystallized sheet of tantalum - 0 to 10 % tungsten alloys.

solid solution strengthening, and the corrosion resistance of alloys is equal to and sometimes better than, unalloyed tantalum. Fansteel developed such an alloy in 1967 and produces it under the trade name Tantaloy 63. This alloy contains 2 to 3 % tungsten and 500 to 5000 ppm Cb. The alloy was designed to provide the strengthening from tungsten, yet not elevate strength or hardness where primary metalworking requires high working temperatures, as is necessary in forging or pressing Ta-10 % W. The change in properties of Ta-W alloys as tungsten content increases from 0 to 10 % follows graphically :

For the chemical industry, technical properties at 200 °C are of prime importance, for example, in applications such as sulphuric acid concentrators. These properties as a function of temperature for Tantaloy 63 are :



Elevated temperature longitudinal tensile properties of 0.020" recrystallized Tantaloy 63 metal sheet.

For comparison, at 200 °C, unalloyed tantalum has only 35,000 psi tensile strength, 15,000 psi yield strength and 38 % elongation in a one inch gauge specimen. Without the high strength properties possessed by Tantaloy 63, heat exchangers would have to be made from tubing of much thicker wall, or smaller diameter, either of which would greatly increase cost per unit of heat transfer surface area. A further refinement in Tantaloy 63 incorporated the observation that the yield strength at 200 °C was further improved without losing primary metalworking properties by additions of columbium from 500 to 5000 ppm.

Columbium is equally amenable to macro-alloying. Many alloys including Cb-1Zr and Cb-10 %Ta-10 %W are made exclusively by electron beam melting. In general, the alloys that are required by the aerospace industry mandate a duplex melting process, electron beam followed by arc melting. Nevertheless, the electron beam melting process is invaluable in making electrode remelt stock. Alloys such as Cb-27 %Ta-10 %W-0.9 %Zr (FS85) and Cb-10 %Hf-1 %Ti-0.7 %Zr (C103) are typical of macro-alloys widely used in aerospace programs such as the Space Shuttle where the former alloy is used for rocket engine nozzles and the latter for other hardware exposed to high temperatures.

## SUMMARY

Over-purification is somewhat unique to unalloyed tantalum and columbium because of their high melting temperatures and low vapor pressures. However, the selective volatilization of alloying agents during electron beam melting of other metals, such as titanium based alloys, is analogous.

Despite this short-coming, electron beam melting is, and has been, unequalled in importance to the refractory metal producer. The growth of the tantalum and columbium industries has been tied hand-in-hand with the introduction and utilization of this melting process. In fact, all major producers of tantalum and columbium metal own electron beam melting furnaces.



## CLASSIFICATION BY INDUSTRY SECTION AND PRODUCT TYPE

In issue no. 35 we published a classification of some companies listing their tantalum activities. Further replies to our questionnaire have been received since this issue was published, and a summary of the activities of some other companies follows.

### Members

Charter Consolidated	x	x				x																								x
Datuk Keramat Smelting						x																								x
Ekmans	x																													x
GfE/Metallurg group																														
Malaysia Mining																														
Mepco/Electra																														
Minas Gerais Mozambique	x																													x
Mitsui Mining & Smelting																														
Montanisa	x																													
Murex																														
National Resources Trading																														
Nigerian Mining																														
S.A. Minerals	x	x																												
Showa-KBI																														

### Non-member

Pratt & Whitney

## The role of the Metal Bulletin tantalite quotation

When John Linden asked me to make a presentation to this conference, I was very happy to accept. Not since 1978, I think, has Metal Bulletin given a paper to the tantalum industry on our role in reporting prices. Many things have changed dramatically since then — not the least being the price of tantalite — but I believe I can say with honesty that the principles and practices followed in assessing the MB quotation have not altered. As publishers of reference prices, we are mindful of the need for good historical comparability between our quoted prices, so we always prefer to err on the side of conservatism rather than radicalism.

The practices which we follow in forming free market reference prices hold good over the wide range of non-ferrous commodities. Of course there are differences from price to price but these tend to relate more to structural differences between the industries or to the application made of our quotations by those industries. We work in much the same way on each assessed price.

Broadly, the prices quoted by the Metal Bulletin fall into three categories. The first of these is terminal market prices, where we simply report the prices which come from the terminal exchanges as the by-product of their main business, the trading of metal warrants. Plainly, at MB we play no active role in these prices.

The second major group of prices we quote are the producer list prices across the full range of non-ferrous metals and ores. These prices have generally taken something of a beating over the past three years but we follow a policy of continuing to post list prices for reference purposes where they have been maintained in any form by the producers, even if only on their books. A large number of contracts continue to be written on producer prices "as quoted in Metal Bulletin". We have in the past carried producer prices for tantalite, and when any are reinstated we will be very pleased to carry them again.

At present it is generally thought that producer prices are unlikely to regain their former importance. In recent years the rise of numerous new suppliers in metals such as molybdenum, cobalt and vanadium has enabled merchants to gain a very big price foothold in those markets at the expense of producer prices. Also the advance of the terminal markets in the last five years has apparently displaced some long-standing producer benchmark prices such as the Alcan aluminium price or the Inco nickel price. Personally I do not think that producer prices will remain out of favour and I doubt that the future belongs entirely to the free market. Although the days of the

unwavering, inflexible producer price have probably gone, I believe that in 1983 we are witnessing a move in many commodities back to traditional producer-consumer connections, only with a more sensitive pricing base. As many non-ferrous prices have begun to stabilise after three years of decline, free market activity among merchants has declined in many areas.

Thirdly, there are the MB assessed free market quotations, including tantalite: in these prices we perform an active function. We spend the most time on them, they are the most productive in information generation (if not cash generation) and they cause us the most headaches. Typically, the metals involved are those in which no terminal market contract exists, and significant business is transacted on a basis other than in direct reference to an official producer price.

We do our best to ensure that the prices in which we do play an active role accurately reflect market conditions. Our success can only be judged by our readers, but our reputation is built on a professional application to the job. I must tell you that we can not offer any guarantees on our price assessments. I think we are better than the sum of the information we are given, but ultimately we depend on the integrity and co-operation of those actively involved in the industry.

We do not promote the application of our prices in pricing contracts. We are in business to carry information on the metals industry and this is our prime purpose. If you do see fit to use the tantalite price indication for the purpose of period contracts, that is for you to decide. From our point of view we cannot allow that to influence us.

The important thing is for our prices to be as transparent as possible. It is for the industry itself to decide whether to use a particular reference price, but it is our duty to make clear how that price is formulated so that any decisions about making use of the price are made in full knowledge of the facts.

### TANTALITE

To assess the tantalite price, we contact raw material producers by telephone or by telex and seek reports of any market transactions carried out. Also we hold regular conversations with producers, traders and consumers about conditions in the industry and from a central vantage point we are usually able to build up some reasonable picture of market developments and prevailing price trends.

Under this system, we apply an element of judgement — an important feature — and we are not slaves of the numbers reported to us. We use our wider knowledge to assess what is representative of the market as a whole. No mathematical calculations are involved, there is



no elimination of the highest or lowest prices reported to us. The quotation reflects only business with consumers and aims to be an historical record of the prices of representative quantities of material of the specified grade bought by consumers in the recent past.

The price is quoted on a cif Europe basis, but the tantalite market is so small and the application of the quotation so widespread that clearly it would be quite wrong for us to insist that European business alone can be taken into consideration.

With a price such as the MB tantalite quotation, which is widely used for contract purposes, there is some temptation for market participants to attempt to distort the price. This is a danger to which we are alert in all our free market price assessments. While no-one could say we are entirely safeguarded against distortion, I believe the system evolved over many years is reasonably well regulated and protected in a variety of ways. Editorial judgement is one safeguard against disfigurement of the price. As there are no mathematical calculations, no individual operator can calculate with any precision what he needs to do to influence the quotation. Obviously there is no compulsion upon the trade to give us correct, wholly truthful information, so we try to check the price information we receive, firstly with the consumer to whom the supplier claims he has sold, or vice versa. Most market participants internationally can see that in the long term a representative quotation is in their interest, and, consequently, most are willing to co-operate with us in confirming transaction reports. If we feel confirmation is necessary but this cannot be obtained, we reserve the right to call in the contracts. This is not often necessary but such verification has been carried out on occasion.

Over time we believe we have not been too far out in reflecting tantalite prices. Any single price, particularly in today's painfully thin market conditions, might possibly be questioned in the light of a single participant's particular experience. But our real aim is to provide some historical guide, a market price in perspective, rather than a hard, precise description of buying and selling at any given moment. I must stress that we take the long view on prices and price relationships over time. We regard our prime role as tracking, for example, the movement in tantalite prices from \$ 122 per lb. to \$ 22. Reference prices provide a yardstick for historical comparability. In this light, it is unfortunate that most of the comment we receive on our prices relates not to how effectively we have charted movements over a period but to vehement debate as to whether the \$ 22 price quoted on one particular day should be \$ 22.5. We cannot and do not guarantee pinpoint accuracy at a given moment.

We face, of course, peculiar problems with tantalite. Recently volumes have been so low and consumer business so infrequent that the job of

sustaining a "live" and realistic quotation has been made doubly difficult. A further major problem is assessing how "representative" of the market as a whole any one particular transaction may be. There are no easy answers to that. Frankly in conditions like these, that decision comes down to "gut feeling".

There is no minimum lot size for our acceptance of a business report for the quotation. I believe that price distortion may occur if we discount reports of bona fide business, in such a thin market. Every report helps us build up an impression of the overall price picture, and from this impression the quotation is formed.

Another problem peculiar to tantalite is that we often find it particularly difficult to explain price changes to those in the market either in written or spoken word. Business reports are given to us in confidence and often the price moves on one or two parcels, so we tread a very fine line in giving people comment on price adjustments. As journalists we make our living from promoting information flow so that is a situation which is alien to us. But, sadly, until market volumes improve, there is little we can do about it. We do like to make things transparent, but at times we are simply not free to give detail.

Currently the Metal Bulletin quotes a 60 % and a 30 % price. The volume of 30 % material is small, the volume of 60 % material is still smaller. Additionally, there has been no real premium for higher grade material of late. The combination of those two factors leads me increasingly to the view that the 60 % price is unsustainable and should be dropped, and I should appreciate your comments on this quotation. (\*)

Finally I should like to appeal to you for price information. It is quite clear that the more sources contribute price information, the more representative the published price quotation will be. Metal producers worldwide are realising the truth of this and beginning to take serious note of prices on the exchanges. The same is true of metals such as tantalite which takes its prime reference price from a publication. It seems to me that the MB price is of importance to many of you and it is therefore in your interest to ensure that it represents market conditions. I feel that the MB is not receiving information on all free market transactions in tantalite, and the onus must be on the participants in tantalite deals to inform us of the price levels so that the MB tantalite quote continues to reflect the market. Already this market is very small.

(\*) On November 4th 1983 the Metal Bulletin announced that it was dropping its 60 % tantalite quotation, as a result of discussions at the T.I.C. meeting.

#### NEW MEMBERSHIP

The following two companies were elected to membership by the Twentieth General Assembly :

**ITT Bauelemente GmbH,**  
Platenstrasse 66,  
Postfach 4756,  
D-8500 Nürnberg,  
West Germany.

**Pancontinental Mining Ltd.,**  
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#### FOUR COMPANIES RESIGNED FROM MEMBERSHIP :

Mineracao Canopus  
Industrial Fluminense  
Metallgesellschaft  
Pratt & Whitney