

T.I.C. Activities

THIRTEENTH GENERAL ASSEMBLY

This Assembly was held in Torquay, Devon, a location chosen to allow participants to visit the capacitor manufacturing plant of ITT Components Group at nearby Paignton, and also Billiton Minerals' tin concentration plant at Mount Wellington in Cornwall.

The meeting took place in the Imperial Hotel in the seaside resort of Torquay, a beautiful site overlooking Torbay and sheltered by surrounding hills. Most delegates arrived on Monday afternoon for a civic reception in the evening by the Mayor of Torbay, Councillor Leonard Howard, in Torre Abbey Mansion.

The formal Assembly was convened at 9 a.m. on Tuesday. In addition to the election of six new members, bringing total membership to forty-five companies representing all facets of the tantalum industry, the General Assembly voted to sponsor a new study of the tantalum business to be carried out by Emory Ayers Associates of New York. This study will update the former 1976 T.I.C. study « World Tantalum Outlook to 1980 » and will assess changes which have occurred in the interim and which will affect the future market situation up to 1985. Since the tight supply situation in the past few years has resulted in a dramatic increase in tantalum material prices, it is believed by the members of the T.I.C. that significant changes are occurring in the pattern of consumption of tantalum. A thorough assessment of the trends now being established in both supply and demand is of vital importance to producers and consumers alike in planning their future policies.

PAPERS PRESENTED

After the General Assembly three papers were presented, followed by general discussion :

- « Future Rate of Tantalum Usage — U.S. Managements' Views of the Key Issues » presented by Thomas C. Barron, Emory Ayers Associates,
- « Some Trends in U.S. Cutting Tool Development Affecting Tantalum Carbide Demand » presented by Graham B. Brown, Technical Adviser to the T.I.C., co-authored by Edmund F. Baroch, Metallurgical Consultant,
- « The Tantalum Capacitor Market — Today and Tomorrow » presented by Carroll G. Killen, Senior Vice President, Sprague Electric Company.

Mr Barron's paper covered some early findings in the work by Emory Ayers Associates in relation to the new world-wide study which they are making. A survey of the U.S. cemented carbide industry has revealed management decisions made with respect to the usage of tantalum carbide which will have significant impact on the future demand for tantalum.

The paper presented by Mr Brown appears in this Bulletin in condensed form, and a shortened version of Mr Killen's paper will be printed in the next issue.

Copies of the Proceedings of the First International Symposium on Tantalum are still available at a price of \$ 25 US each; orders should be sent to the Secretary of the T.I.C., 1 rue aux Laines, 1000 Brussels, Belgium.

T.I.C. THIRTEENTH GENERAL ASSEMBLY

The Thirteenth General Assembly of the Tantalum Producers International Study Center was convened in the Imperial Hotel, in Torquay, Devon, on Tuesday, May 6th 1980, chaired by Mr Brian Reynolds, President of the T.I.C. Thirty-eight of the thirty-nine member companies were represented. In all, 120 people from twenty countries attended the open meeting after the Assembly.

The General Assembly conducted the business of the T.I.C., which included a decision to sponsor a further world-wide study of the tantalum industry and a survey of the prospects for the coming five years.

Six new members were elected, bringing the total membership to forty-five (see p. 4).

After the formal Assembly, the meeting was joined by delegates from applicants for membership, and by invited guests. Three technical papers were presented, describing the current status of consumption of tantalum in the production of cemented carbide products and electronic capacitors.

In the afternoon, participants from producing and processing companies visited the solid tantalum capacitor plant of ITT in nearby Paignton. An official banquet was held in the evening for delegates and their ladies. The assembly was addressed by Mr K.A. Gilbert, Managing Director of Geevor Tin Mines, Pendeen, Cornwall, the current President of the Cornish Chamber of Mines.

On Wednesday, May 7th, a group of delegates visited the Mount Wellington tin tailings treatment plant of Billiton Minerals UK Ltd., near Truro, Cornwall.

The Fourteenth General Assembly will be held in Brussels on Wednesday, October 29th 1980.

T.I.C. Visit to the ITT Capacitor Plant

BACKGROUND

From the earliest days ITT has maintained a strong position as a capacitor manufacturer. As needs changed, new styles of capacitors have been evolved and performance has been improved. Shortly after the tantalum capacitor was developed in America, the ITT factory at Paignton was set up for the manufacture of a metal-cased version for military and other professional markets. In the early 1960's it became clear that a substantial consumer market existed for a capacitor with performance similar to the metal-cased capacitor but which would sell at a fraction of the price. To meet this market, ITT developed the resin-dipped capacitor, the universally accepted way of achieving a low-cost unit. To reduce costs further, manufacturing methods were improved to allow considerable automation of the more than thirty costly actions by extensive mechanisation and by handling groups of capacitors rather than individual ones.

PRODUCTION

Various grades of tantalum powder are used, depending on the type of capacitor and the voltage rating. Prior to pressing into an anode, the powder is mixed with a binder which reduces the friction between the tantalum particles to obtain greater uniformity of density, lubricates the punches and dies to increase their life, and provides strength to the anode prior to sintering. Although some rectangular anodes are made, the majority are of cylindrical shape with a tantalum wire pressed into the powder as an electrical connection.

After pressing, the binder is removed under vacuum in presinter furnaces. Then the anodes are sintered at temperatures up to 1600-2100 °C. in the main sinter furnaces. These furnaces consist of a main chamber in which there is a table which can be rotated, a loading and unloading lock, and a heating zone. All hot parts of the furnaces are made of tantalum. Each furnace is capable of sintering several million anodes per week. When sintered, the anodes are mechanically strong and have a porosity of about 50 to 60 %.

A capacitor consists of two conductors separated by an insulator. The tantalum is one conductor. The insulator must be produced by changing the surface layers of the tantalum to its oxide by anodisation. To do this, the anodes are welded on to carrying strips which are then connected together to make a self-contained pallet holding several thousand anodes. These are immersed in an aqueous electrolyte and a constant current is applied which changes the tantalum surface to oxide. After anodisation, the anodes are brightly coloured, the colour being controlled by the thickness of the oxide insulator.

The second conductor must make intimate contact with all of the surface oxide in order to develop full capacitance. In the solid capacitors, this conductor is produced by immersing the anodes in manganese nitrate and then decomposing the nitrate by heat to form manganese dioxide, a black, solid conductor. The step is repeated many times and, where possible, is carried out by specially designed automatic machines. Since the repeated thermal cycles degrade the insulation, it is reformed by a process similar to anodisation but at a lower voltage.

The device is now a capacitor, but it must be made suitable for use in electronic circuitry. It requires leads to carry current and encapsulation to protect against humidity and mechanical damage. To make a connection to the manganese dioxide conductor, the outside of the anode body is coated with graphite and then a solderable metallic layer by dipping in suitable dispersions. For the connection to the tantalum conductor, a nickel or iron wire is

welded to the inserted tantalum wire. The welding operation is carried out on machines designed by ITT.

Encapsulation in resin is performed by a robot which carries out the operations of fluxing, soldering and resin-dipping. It then places the capacitors in a conveyor oven where the encapsulant is cured. After the printing of the capacitance and the voltage on the body of the capacitor, it is automatically tested for capacitance, dissipation factor, leakage current and impedance.

There are many support functions also at the Paignton plant: incoming material inspection, piece part manufacture, Materials Preparation Laboratory, Chemical Laboratory, Development Laboratory and a Tool Room for maintenance and for construction of new equipment. There are also an Electrical and Electronic Department and a fully approved Test House for customer, national and international specification approvals.

Some trends in U.S. cutting tool development affecting Tantalum Carbide demand

(The following paper, written by Graham B. Brown, T.I.C. Technical Adviser, and Edmund F. Baroch, Metallurgical Consultant, was presented at the Thirteenth General Assembly of the T.I.C.)

The cemented tungsten carbide industry, facing a myriad of material problems, has reacted by accelerating development work to change its products. Trends being established will, within a year or two, show significantly as the users of cemented tungsten carbide (CTC) tools adopt the resulting new and modified products.

In the United States there seems to be a common objective among the CTC tool producers: the elimination of as much tantalum from their product as possible. On a cost basis alone, adequate motivation exists. The CTC producers definitely believe that the tantalum shortage will become worse and the day would arrive, if they did nothing, when there would not be enough tantalum to meet their needs.

The programmes aimed at decreasing reliance on tantalum range from relatively minor decreases in use to total elimination of tantalum from the products. Some of those schemes have not been primarily aimed at tantalum. Other economic considerations, such as the price of tungsten and the price and availability of cobalt, will also result in conservation of tantalum. Similarly, technological break-throughs in recycle processes have led to lower costs, higher yields and better quality of material to be fed back in to the system. Several changes are already evident in the processing and composition of CTC products and there are others which will be in place in the near future:

1. Niobium Carbide Substitution.

It has been common practice in Europe to use mixed tantalum carbide/niobium carbide instead of straight tantalum carbide. However, in the United States, this use has been negligible. The reduction in use of expensive tantalum by less expensive niobium is significant. Allowing for the density difference between tantalum and niobium, and assuming a price ratio of 5:1, a 40 % molecular substitution of niobium carbide for tantalum carbide will result in a cost-reduction of about 50 % for this component of CTC. The transition is currently underway and has reached about 5 %.

2. Reduced Proportions of Tantalum Carbide.

When tantalum is used, whether it be for grain refinement or to enhance performance, common practice has been to over-add as insurance. Improvements in production techniques, control of

blending, control of sintering-temperatures, and improvements in analytical techniques have decreased the need for large comfort margins. The overall care being exercised today to optimize costs for all materials has, in itself, resulted in conservation of tantalum use. The gains in this direction are not large in terms of pounds of tantalum, but they are nevertheless significant in terms of cost.

3. Coated Tools.

The last decade has seen an explosive growth in the use of coated tools, especially in the steel-cutting grades in which tantalum is used extensively. Coatings extend the tool life by a factor of two to five times.

The use of coated tools has increased by five times during the past five years and further increases are coming. With the development of new coatings now being introduced and with the extensive experience in the use having been obtained, the proportion of coated cutting tools can soon reach an estimated saturation point of about 80 %. Considering that these tools with an average of about 4 % tantalum carbide in the substrate are being used in place of tools which contained from 6 % to 12 % tantalum carbide, the effective reduction of the use of tantalum carbide is already being realized. To date there has not been much compositional shift in the CTC substrates, but current work on the substrate will provide a further large reduction in the use of tantalum carbide.

4. Recycled Material.

Used CTC cutting tools have always been recycled to some extent. But, because of limitations of the processes used for recovery, most of the recycled material has been down-graded in use and has not gone into new cutting tools. Two recent developments, however, in the recovery of CTC have altered the use pattern dramatically: the contamination-free attrition method, and the zinc recovery process. With the high increase in the prices of virgin materials, there is now adequate incentive to collect used material properly so that these new processes can be used to full advantage.

The Coldstream process, devised and operated by Metallurgical International, provides powder of any particular composition for direct reuse in making new CTC tools of any grade. The tantalum content is preserved and provides its benefits in the new tools.

The zinc recovery process is somewhat newer. In the process, molten zinc alloys with the cobalt binder generating internal stresses which permit crushing. Following crushing, the zinc is vacuum-distilled and recovered. Recent improvements in the control of the process have allowed use of 100 % zinc recovered material without degradation in performance.

Several of the large CTC producers surveyed advised that they are installing the zinc-recovery process for recycling their own in-house scrap and worn tools purchased back from their customers. Smaller CTC producers use the toll-service provided by Teledyne Wah Chang at Huntsville, Alabama, and Metallurgical International. Two producers are now recycling about 55 % to 60 % of their material needs.

The output quality is related to the quality of the starting scrap and particular emphasis is placed on sorting by composition grades. The total volume currently being recycled by these methods is estimated to be about 20 %, but a disproportionate share of that is the tantalum-containing grades.

5. Hafnium-Niobium Carbide.

In the past, commercialization of hafnium-niobium carbide has been hampered by lack of field test data, apprehension concerning the availability of hafnium, and the relatively minor price differential between hafnium-niobium carbide and tantalum carbide.

These concerns have evaporated. Extensive testing has demonstrated that in the C-5 and C-7 steel-cutting grades particularly, alloys using hafnium-niobium carbide were superior to the commercial grades containing tantalum carbide. The availability of hafnium is of no greater concern to the CTC producers than the

availability of tantalum. The current price of the hafnium-niobium carbide is only \$ 40 per lb., about one-fourth of the price of tantalum carbide. Considering the weight-usage ratio, about \$ 30 worth of the double carbide will replace about \$ 150 worth of tantalum carbide.

Only the conservative approach of cautiously testing every new product has prevented a more rapid switch to hafnium-niobium carbide. But testing has been going on for at least one and a half years now and much more widespread use can be expected quickly. One CTC producer surveyed is using hafnium-niobium carbide as a grain refiner and already has switched his total requirement to this material from tantalum carbide.

It is expected that during 1980 the sales of the hafnium-carbide will not quite reach 100,000 lb., a rate triple the level of a year ago.

6. New Material Systems.

Most of the major developments of the tungsten-titanium-cobalt system, whether of a process or of a compositional nature, have been more evolutionary than revolutionary. Developments have involved step-by-step minor improvements in the then-current state of the art. This evolutionary tendency has become more institutionalized as the systems became more complex and the applications became more specialized.

Now, however, the recent rapid changes in cost and assured availability of various materials have inspired many organizations and individuals to engage in fundamental, generic studies of the system and of other systems which will provide wear and abrasion resistant products. This basic research includes the use of ceramics, cermets, molybdenum substitution for tungsten, nickel substitution for cobalt, systems based upon nickel, molybdenum, and carbon rather than cobalt, tungsten and carbon. While many of these areas are conceptually very old, their potential has never been fully explored.

One system, worthy of note as a possible model for what may occur in other systems in the future, is the system based upon Ti-Mo-C-Ni. A fairly recent development now allows introduction of a significant amount of nitrogen into this system without undergoing the loss of ductility usually associated with the nitrides. A spinodal decomposition occurs in which a nitrogen- and titanium-rich phase is completely surrounded by a molybdenum- and carbon-rich phase, precluding formation of the low-wettability boundary between the nickel binder and the nitride. This system is a generic one, and some formulations in the future might contain significant quantities of tantalum.

Also, in the past, CTC has replaced tool steel in many applications. But tool steel development, with emphasis on increased carbide content in the steel, is such that a general convergence is occurring such that the boundary between tool steels and CTC will become more historical or definitional than real. To the extent that these tool steel materials intrude into the CTC area, tantalum usage will decrease since it does not play a significant role in any of the tool steels. This area warrants serious consideration when evaluating long-range trends.

SUMMARY

Although these things have been said before, they have been a threat of what might happen to tantalum carbide demand if prices were to go too high. Today, these things are no longer a threat, they are reality. It is not possible to predict how much tantalum usage will decrease, but the decrease will be significant. The 1979 U.S. shipment statistics show a large increase in the amount of tantalum carbide being shipped by the primary producers. But a survey of some of the principal scrap dealers shows that the use of tantalum scrap to produce tantalum carbide has virtually disappeared. The increased scrap demand for use in high-performance alloys and the reuse of good, clean scrap to produce various tantalum metal products has jumped the scrap price to a level that has made

the use of scrap to produce carbide economically unfeasible. Thus, there has possibly been some real reduction in the volume of tantalum carbide used. A very sizeable reduction can be expected in 1980, partially due to economic conditions, but also due to the factors described here.

Tantalum carbide will never be totally eliminated, but usage will settle down to a lower level for some time to come. The pursuit of changed technology in the U.S. CTC industry will probably swing the pendulum for several years beyond the point where it will ultimately settle down. Right now there is a strong drive to eliminate tantalum carbide and, once initiated, many of the substitutions and modifications will stay in place for a long time. But ultimately economics will govern and the continually changing costs in all areas can well lead to a time when cost-performance relationship will again be favorable to an increased use of tantalum carbide.

1979 U.S. shipments of tantalum and columbium products

The 1979 shipments of tantalum and columbium products by U.S. processors, along with comparative data for 1975 through 1978, are as follows: (1,000 lb. units)

PRODUCT	1975	1976	1977	1978	1979
Tantalum					
Oxides and salts	127.4	55.4	62.8	38.2	35.4
Alloy Additive	8.5	13.2	12.2	4.4	23.7
Carbide	106.5	93.3	113.5	116.9	190.1
Powder and					
Anodes	436.6	759.0	759.2	840.0	928.2
Ingot	1.0	7.7	8.0	7.2	6.6
Mill Products	172.2	238.5	292.4	321.9	365.2
Scrap	13.0	130.7	168.3	184.1	151.0
Other	—	—	2.0	2.1	—
Total	865.2	1,297.8	1,418.4	1,514.8	1,700.2
% Change	(48.5)	50.0	9.3	6.8	12.2
Columbium					
Compounds	930.8	791.8	872.4	1,611.0	1,627.8
Metal	112.7	101.6	189.3	223.7	329.5
Miscellaneous	21.2	41.0	16.6	12.5	64.2
Total	1,064.7	934.4	1,078.3	1,847.2	2,021.5
% Change	(36.9)	(12.3)	15.5	71.3	9.4

Once again the shipments data for tantalum do not indicate any effect of the expected reduction in demand with increasing product prices. Carbide shipments increased 62.6 % reaching the highest level ever and exceeded the previous peak of 1973 (173,400 lb.). This increase was disproportionate to the 1978-1979 increase in cemented carbide product shipments estimated to have been only 15 %. It would appear that the known substitution of other materials for tantalum carbide in cemented carbide products would have to have been at the expense of other sources, not from the basic virgin material processors.

Capacitor powder also reached a peak equal to the shipment level of 1974 (929,400 lb.). Inadequate information at this time precludes any analysis of trends in the capacitor business. The sales of

tantalum capacitors have obviously grown faster than the ability of the industry fully to capitalize on the higher-capacitance powders being offered. The rate of increase of tantalum powder shipment from 1978 to 1979 was 10.5 %, almost identical to the rate of increase from 1977 to 1978.

Shipments of mill products reached an all-time high continuing the upward trend and attaining double the level of 1975. Scrap sales were down from 1978 amounting to only 9.0 % of the total tantalum shipments as compared to 12.2 % in 1978.

Based on the reported shipments of products, an estimate can again be made of source material usage allowing for unrecoverable losses and scrap purchased by the processors for recycling. Calculation provides the following estimates of the tantalum and columbium content of ores and slags consumed each year by the processors (1,000 lb. units):

Year	lb. Ta ₂ O ₅	lb. Nb ₂ O ₅	Ta ₂ O ₅ : Nb ₂ O ₅
1975	1,160	1,700	0.68
1976	1,740	1,490	1.17
1977	1,910	1,720	1.10
1978	2,040	2,950	0.70
1979	2,260	3,220	0.70

The latest information available indicates that the 1979 production of tantalum source materials was in the range of 2.6 to 2.8 million lb. Ta₂O₅. Assuming that consumption outside the United States increased by about the same proportion as the increase in the U.S., it appears that once again inventories supplied at least 250,000 lb. contained Ta₂O₅ and possibly as much as 450,000 lb. The continued usage of columbites as a source of tantalum is evident from ratio of tantalum oxide contained to columbium oxide contained. The increasing demand for columbium products and the relatively high prices of these products makes the use of more lower ratio columbites attractive to the basic tantalum processors.

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