TANTALUM PRODUCERS INTERNATIONAL STUDY CENTER

QUARTERLY BULLETIN ISSUE No 23 SEPTEMBER 1980 THIRD QUARTER

T.I.C. Activities

The Fourteenth General Assembly of the Tantalum Producers International Study Center will be held in Brussels on Wednesday October 29th 1980 to carry out the formal business of the association.

The T.I.C. is currently sponsoring a world-wide study of the tantalum industry and Mr Thomas C. Barron will make a presentation to the meeting on the results of his work. Delegates will have the opportunity for general discussion of the study and its findings.

The Assembly will also be addressed by Mr John Linden on the production prospects for the tantalite orebodies of Greenbushes Tin NL in Western Australia.

SYMPOSIUM PROCEEDINGS

Copies of the Proceedings of the First International Symposium on Tantalum, at $ 25 each, may be ordered from the Secretary of the T.I.C., rue aux Laines 1, 1000 Brussels, Belgium.

T.I.C. FOURTEENTH GENERAL ASSEMBLY

The Fourteenth General Assembly will be held at 9.30 a.m. on Wednesday 29th October 1980 at the Sheraton Hotel, Place Rogier 3, 1000 Brussels.

AGENDA

1. **Presidential Address.**
2. **Minutes of the Thirteenth General Assembly.**
3. **New membership.**
4. **Report of Executive Committee.**
5. **Study of tantalum industry, third phase.**
6. **Report on quarterly Bulletin.**
7. **Production statistics : 1979 and first and second quarters 1980.**
8. **Statutory elections.**
9. **Fifteenth General Assembly : date, place.**
10. **Other business.**

Mr Thomas C. Barron of Emory Ayers Associates will make a presentation on the world-wide study of the tantalum industry.

Mr John Linden, Managing Director of Greenbushes Tin NL, will make a presentation on « Tantalite orebodies and their future production potential of Greenbushes Tin NL ».

Mount Wellington Plant - Cornwall - Billiton Minerals U.K., Ltd.

On May 7, 1980, the members of T.I.C. and their guests, in conjunction with the Thirteenth General Assembly held in Torquay, Devon, U.K., visited the Mount Wellington Tin Mine Tailings Concentration Plant in southwestern Cornwall. A brief description of this plant follows.

The Carnon River Valley in central Cornwall has been the site of tin mining for centuries, before the days of the Roman Empire. As a result the valley has a tremendous accumulation of tailings, much of which has been reworked before to extract residual tin. But as technology has developed, these tailings can again be reworked to remove even more tin. The Mount Wellington Plant, built originally to treat tailings, has been recently acquired by Billiton Minerals U.K., Ltd. and is once again in operation to recover further tin.

At present the plant is processing the old Wellington tailings and the sand tailings from the Bissoe concentration plant located in the valley below the Wellington Plant. Currently, it is designed to handle 600 tons per day of these materials but the capacity will be increased in 1981 to 1200 tons per day when the source of materials is switched to the settled deposits in the Carnon River.

The feed is pumped from the Wellington tailing pond and trucked from the site of the Bissoe sands. The feed is slurrified, screened to remove all trash including stones, heather and peat over 1000 microns, and well mixed before being pumped into the mill at 30 % by weight solids. To ensure this consistency, a storage thickener is used before processing begins in the mill.

The material is divided into three fractions

— plus 44 micron size, containing mainly locked-in tin, to be treated by grinding and gravity methods,

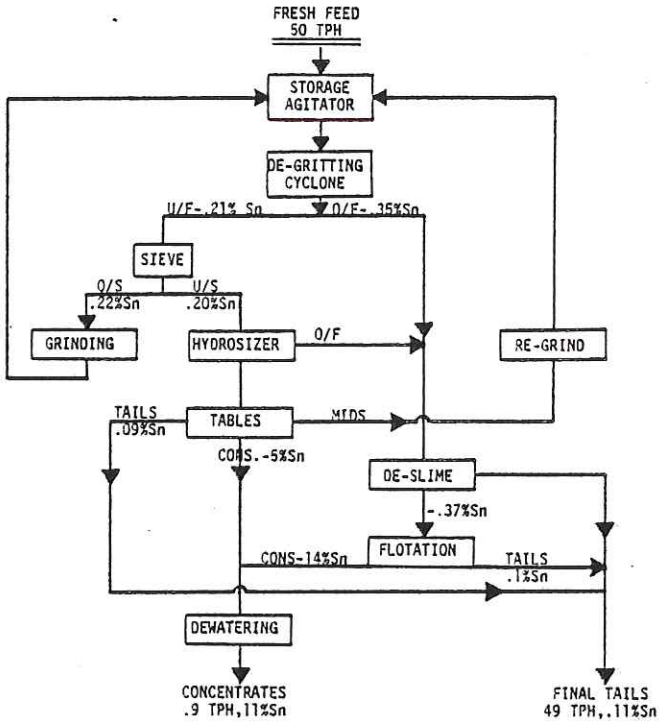
— the 10 to 44 micron mid-range to be treated by flotation, and

— the minus 10 micron size, too fine for flotation, to be discarded.

The plus-44 material is again separated by sieving, the most coarse, over 250 microns, being ground in a closed circuit with spiral concentrates returning to the storage. The balance goes through a Cyclone to a Hydrosizer to tables, except for the smallest particles which join the flotation circuit. The output of the tables provides concentrates for smelting, fines which are discarded, and midlings which are reground and fed back to the thickener.

The feed to the flotation circuit passes into a storage agitator which acts as a surge capacity buffer and provides a constant feed to the desliming circuit. In order to assure optimum recovery but also to prevent slimes that are too fine from affecting the flotation, a three stage process of cyclones is used. After sulphide scavenger flotation in which the sulphides are removed to the tailings, passing through a rougher, the concentrates pass through five stages of counter current cleaning and emerge as final concentrates.

The combined concentrates yield a recovery of 1.8 Kilos per tonne processed, 60 % recovery. With an initial feed averaging 0.3 % and the final concentrates averaging 10 %, an approximate 30 : 1 concentration has been effected.



Tantalum capacitor market — Today and tomorrow

This article is a condensation of a presentation made by Mr. Carroll G. Killen, Senior Vice President of the Sprague Electric Company, at the Thirteenth General Assembly of the Tantalum Producers International Study Center on May 6, 1980, at Torquay, Devon, England.

The Sprague Electric Company is involved in the manufacture and sale of electronic and electrical circuit components, producing capacitors, resistor networks, hybrid circuits, transistors, integrated circuits, etc. It is the largest manufacturer of capacitors in the United States and one of the largest in the world. In the manufacture of its products, it processes many materials including plastic film, ceramic, silicon, aluminium, tantalum and various chemicals. Sprague has been in business since 1926 and was the first company to offer solid tantalum capacitors. Sprague is the largest consumer of tantalum products in the world, powder, foil, wire and mill stock.

Every electronic circuit requires capacitance. A capacitor consists of two electrodes separated from each other by a dielectric material, i.e. a material which is capable of storing electrical energy, such as mica, glass, oil impregnated paper, film, aluminium oxide, tantalum pentoxide, and various types of ceramics. These materials compete with each other for use in electronic circuitry. A design engineer, in making a selection, considers the electrical properties of each dielectric, its size, reliability and cost.

The solid tantalum capacitor became important with the invention of the transistor because it was small, stable, reliable and had good electrical properties and, until recently, its price was competitive with capacitors made with other dielectric materials. Although it has some shortcomings, such as limited voltage range, inability to stand high surge and excessive reverse currents, its excellent properties more than offset these factors. Tantalum capacitors are used in electronic equipment produced for every major market including defence, industrial communication, office and store (computers) instrument and control and consumer products. Two-thirds of all refined tantalum is consumed by the electronics industry.

1979 was an excellent year for the tantalum capacitor industry. 899 million units were shipped by U.S. manufacturers compared with 637 million units in 1977. Unfortunately, the price of tantalum ore has increased so much that, by the time these increases are passed from the mine to the powder manufacturer to the capacitor manufacturer to the equipment manufacturer, tantalum capacitors are no longer cost competitive with other types of dielectrics. There is a breaking point and tantalum capacitors are rapidly approaching this point.

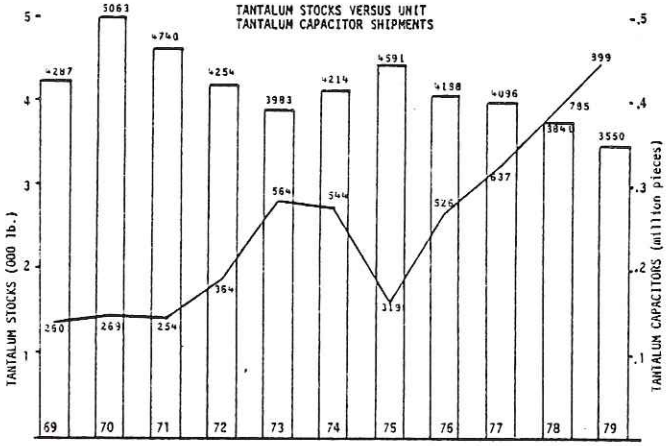
The points of a summary which Mr. William E. McLean, Executive Vice President — Sprague Electric Company, made to your group in May 1978 are still valid today :

1. Tantalum capacitors have reached a declining portion of their life cycle. Engineering choices will move increasingly to more competitive capacitor families.
2. Tantalum ore pricing is contrary to other basic capacitor raw materials.
3. Tantalum ore and powder costs violate the cost reduction pattern for semiconductors that determine primary circuit costs.
4. Tantalum usage is extremely cost sensitive and higher material costs give competitive capacitors cost advantages for increasing applications.
5. Irresponsive ore price increases will substantially reduce tantalum capacitor usage in the coming years.
6. Increasing costs for tantalum capacitors will result in the loss of tantalums to aluminiums. Tantalums will not replace aluminiums, but rather will be replaced by aluminiums.

What has happened to force the tantalum ore price up out of proportion to the increase in other types of materials ? The April 11 issue of « Metal Bulletin » stated :

« The seeds of today's problems were sown when two U.S. companies, KBI and Fansteel, established long-term contracts for the supply of tantalite contained in tin slags from the south-east Asian dumps, mainly Thaisarco's. The slag is now considered high grade, at 7-9 % Ta_2O_5, but at the time it was the lowest grade material being processed in the industry. KBI and Fansteel, as two of the largest consumers of tantalite, thus injected an element of inventory drawdown into the tantalite market which has dominated it since. Normally, this need not have been a problem, except that tantalite markets have an unusually high ratio of formula contracts. Until something happened to disturb the inertia of self-perpetuating price levels then the classical price reaction to a shortage would fail to appear. That something was a combination of merchant activity and the role played by Greenbushes. Thus by a series of auctions on to the free market the Greenbushes' sales identified a rapidly increasing price which was independent of the formula contracts. »

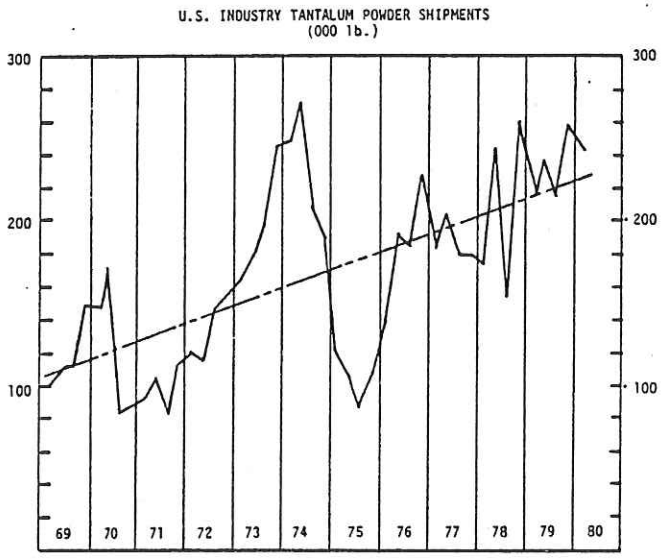
From our vantage point, I will simply state that the tantalum metals price explosion was caused by a continuous reduction in ore stocks while the market for finished devices grew. (Chart I)



Ore stocks reached a new low by the end of 1979 while finished tantalum capacitor shipments reached an all time high. Everyone, of course, knows that tantalite is scarce but there also may have been some poor management of ore stocks during this period. Certainly, there was ore available in 1976, 1977 and perhaps 1978 as well, that would have allowed powder manufacturers to maintain their stocks at higher levels. The value of ore stocks increased from less than $ 100 million at the end of 1975 to roughly $ 350 million for smaller quantities at the end of 1979. It is most ironic that a miscalculation or misunderstanding of the finished device market could precipitate the beginning of the decline in demand of an ore which has contributed so much to the fortunes of so few.

The trend line for U.S. powder shipments increased by 7 % annually between 1969 and 1979, lower than the 12 % estimate often cited. Even at 7 %, the annual growth rate for powder was higher than the corresponding rate of increase for end equipment in which capacitors are eventually used. This historic growth rate for tantalum powder shipments cannot be sustained with the prevailing

cost of metal. In an independent study, the U.S. Bureau of Mines projected future growth at only 3 % annually for overall tantalum metal consumption. (Chart II)



Powder shipments swing widely above and below electronic end equipment shipments and these swings reflect changes in powder inventory held by capacitor manufacturers and by end equipment houses in the form of raw materials or finished capacitors. For the most part, powder shipments dropped after they reached their historic peak in mid-1974 and they did not recover until late in 1978. Over correction of powder stocks by capacitor manufacturers and finished goods inventory held by end equipment houses probably encouraged powder manufacturers and others to reduce their ore stocks. Better inventory management by all concerned might have averted the present pricing crisis.

Since May of 1978, powder prices have more than quadrupled to over $ 225 per pound and still higher prices are expected later this year. This price explosion means that tantalum capacitors and powder usage will be hurt more severely and sooner than was indicated in 1978.

Several dielectric systems offer the design engineer alternatives to tantalum and such are becoming more attractive. For several years, monolithic ceramic capacitors have taken the bulk of the growth in the small CV ranges that otherwise would have gone to tantalum. This trend has begun to accelerate. We are now facing an increasing number of direct replacements of tantalum capacitors by aluminium electrolytic capacitors, some of which can be inserted in the same socket without any change in lead spacing. Aluminium capacitor manufacturers are taking steps to increase their aluminium business at the expense of tantalum.

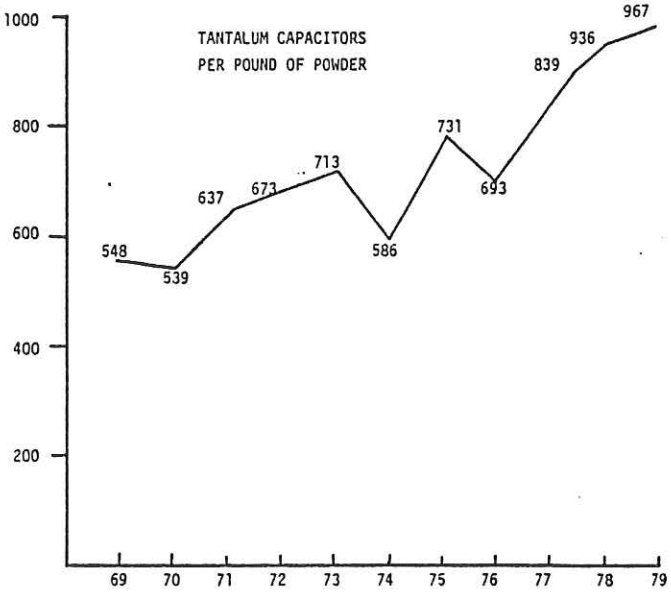
The result of dielectric substitution will become even more acute to tantalum capacitor manufacturers as customers accelerate their efforts to replace tantalum capacitors in their equipment. The results of this effort will not be as evident in existing equipment as it will be in new designs. However, one large manufacturer of automobile radios and engine control devices has reduced by two-thirds its use of tantalum capacitors by substituting 5 and 6 millimetre aluminium electrolytic capacitors. Another customer replaced 400,000 47 mFd. 35v hermetically sealed solid tantalum 150d capacitors per year at S 2.80 per unit with a miniature metal case aluminium electrolytic capacitor at a price of 25 cents per unit.

A comparison of the weighted average unit prices of various styles of tantalum capacitors with prices of similar aluminium capacitors follows :

Category	*Tantalums*	*Aluminiums*
Radial leads	Dipped @ 57 c	Metal case @ 15 c
Axial leads	Hermetic @ 61 c	Metal case @ 15 c
Axial leads	Resin sealed @ 24 c	Metal case @ 15 c

Since 1977, powder shipments have not matched the growth of unit capacitor shipments as higher CV powder allowed capacitor manufacturers to produce more pieces per pound than was previously possible. Even though the increase in gain helped to offset some of the increased powder cost, it was not sufficient to prevent some customers from reducing or eliminating their usage of tantalum capacitors, a trend particularly apparent where higher capacitance values are required. This cost pressure is accelerating and the net result will be a major reduction in tantalum powder shipments over the next five years.

Growth in the number of capacitors manufactured per pound of powder for the ten year period 1969 through 1979 is shown in Chart III.



MARKET TRENDS

The trend for total capacitors per dollar of end equipment shipments has tended to be flat since 1965. For the future, the number of capacitors is projected to increase in direct proportion to the growth of end equipment shipments in constant dollars, as it has been in the past. The usage rate is increasing for some capacitor families while decreasing for others, but the ratios for most tantalum capacitor types have not matched the growth of end equipment markets.

a. *Foil Tantalums* — Except for military equipment, very few foil tantalum capacitors were designed into new equipment during recent years. Less expensive extended range aluminium electrolytic capacitors were used instead. Since 1970, except for a short period during 1975 when there were technical problems with some extended range aluminium capacitors, the market for the extended range unit has grown faster than the market for tantalum-foil capacitors.

b. *Wet Tantalums* — Despite the recovery of the military market and some new automotive applications, the market trend for wet tantalum electrolytic capacitors is also down. Relatively few wet tantalum capacitors were designed into new equipment because less costly alternatives were available, i.e. metal case solid tantalums and extended range aluminium electrolytics. Wet tantalum capacitors are also large CV devices where inflated powder costs sharply reduce their economic efficiency.

c. *Metal Case Solid Tantalum* — The usage trend for metal case solid tantalum capacitors is also down, some replaced by less expensive moulded or dipped solid tantalums. Many of these units are being replaced by extended range aluminium and monolithic ceramic capacitors. Hermetically sealed tantalum capacitors were the backbone of the capacitor industry, but they peaked about 5 years ago and are being supplanted by the non-metal case types.

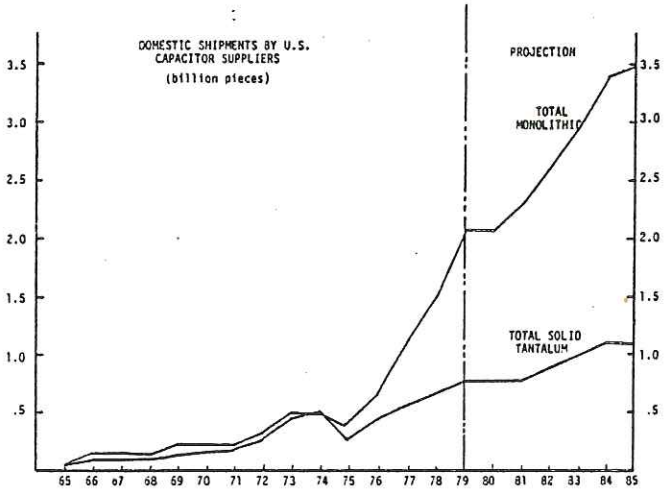
d. *Non-Metal Case Solid Tantalums* — The major growth in tantalum capacitor usage has been in dipped and moulded devices. While this trend is expected to continue, the pace is likely to decrease as a result of inroads made by competitive dielectric systems. Dipped and moulded tantalums are usually smaller CV devices. Higher growth rates for dips and moulded parts account for much of the shift in mix toward smaller CV devices and increases the number of devices that can be manufactured per pound of powder. However, this growth will not materialise if present tantalum powder prices prevail.

MONOLITHIC CERAMIC CAPACITORS

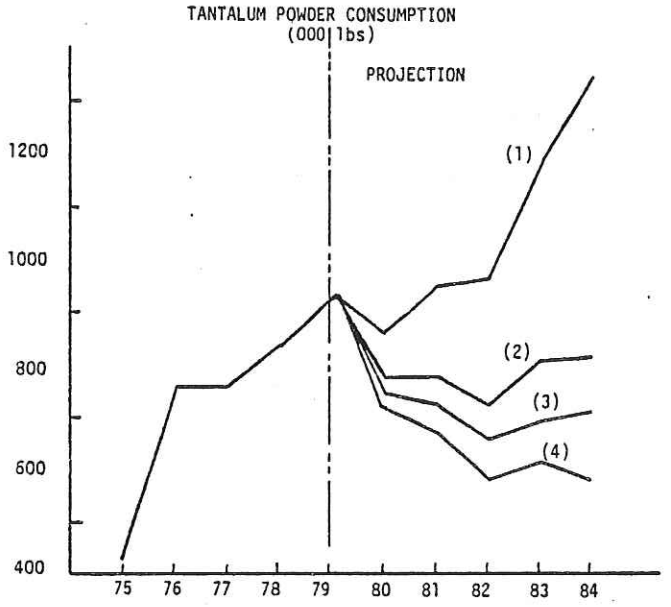
The number of monolithic ceramic capacitors per thousand dollars of electronic equipment was almost « zero » in 1965 and now is nearly five times larger than the ratio for dipped and moulded solid tantalums. Cost trends favour monolithic capacitors when the CV product is comparable for unit volume. Much of the future growth in monolithic capacitors will come at the expense of the tantalum capacitor.

U.S. DOMESTIC SHIPMENTS

The result of the changes projected in end equipment usage rates and the significance of the price advantages now held by monolithic ceramic capacitors is dramatic. (Chart IV)



If tantalum metal prices are maintained at present levels, powder shipments will not increase but will decrease dramatically by 1984. (Chart V)



The top line (1) on the chart is the amount of powder required through 1984 to meet capacitor shipment projections if a continuation of the 1978-1979 powder prices with no CV improvement is assumed, the historic 7 % average annual increase. The next line (2) is this amount of powder reduced by wider usage of higher CV powder, allowing for more units produced per pound of powder. The third line (3) is the effect of further reduction due to the mix of capacitor ratings, a higher percentage of smaller ratings. Finally, the bottom line (4) shows the displacement of tantalum capacitors by lower cost monolithic, aluminium electrolytic and metallised film capacitors.

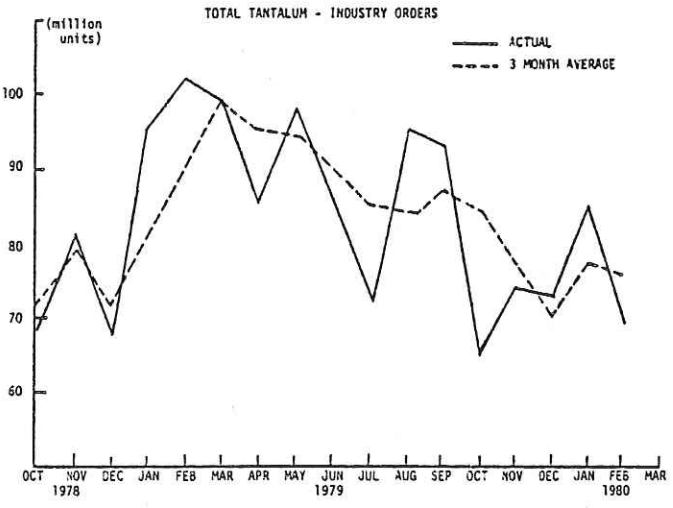
The cumulative overall reduction in powder requirements by these three causes could easily reduce powder shipments from 900,000 plus pounds in 1979 to somewhere between 500,000 and 600,000 pounds by 1984.

Tantalum ore prices have spiralled since 1974 while the wholesale price index of 13 raw materials first declined and then resumed a long range upward trend. The price index for these 13 materials is slightly above the 1974 peak while the tantalum ore price index is nearly seven times the 1974 peak. Also, between 1974 and 1977, the wholesale price index of the 13 raw materials was relatively stable while the price of tantalum ore surged, then accelerated and finally exploded.

I really do not expect powder shipments to drop to the 500,000 to 600,000 pound level indicated because I do not believe that the present $ 200 to $ 265 powder price will prevail any more than the recent $ 850 gold price and $ 50 silver price prevailed. Perhaps the oldest maxim among commodity traders is that nothing will cure high prices as much as unreasonably high prices. Tantalum metal prices long ago were high enough to encourage the acquisition of additional ore from marginal sources. Farmers and workers in Thailand are digging what were once marginal grade ores out of roadbeds to make a quick profit. This development was impressive and roughly akin to Americans cleaning their attics to sell old silver at the top of the silver boom. There is every reason to believe that the rapid increase in ore prices has increased the amount of ore that is moving through the pipeline to market and that this increase will continue.

Certainly, there is something wrong with the economics of the tantalum industry when it is more profitable to sell finished devices for scrap to metal processors than to sell these devices for use in electronic circuits. My expectation is that a combination of larger quantities of material, which are becoming available, coupled with a reduction in requirements for powder will cause prices to fall sharply. I am aware that non-electronic uses for tantalum are increasing, nonetheless, electronic applications still account for two-thirds of overall tantalum usage and the economics of the tantalum metals industry will continue to be driven by the electronic market.

The decline in orders for tantalum capacitors has already begun. Unit orders passed their peak in February 1979 at roughly 100 million pieces per month. One year later, unit orders were down to 70 million pieces per month and our industry is continuing to experience further decreases. (Chart VI)



The April 11 « Metal Bulletin » article, previously mentioned, stated : « Forecasts made only a year ago that the market would collapse if prices reached $ 100 have proved unfounded. If demand has held up, therefore, there will inevitably be questions about the necessity of a new measure of stability in the market. If demand is failing, then stable prices will help preserve whatever is left. The key to success is in the timing of any new move. Simon Hicks, Ferer and, now, Nelson Bunker Hunt all had this problem. Will tantalite markets add a new name to the list ? »

I forecast that tantalite will be added to the list.

As a representative of the world's largest user of tantalum powder, I urge sanity and restraint in the pricing of ore and metals to prevent irreparable damage to both your industry and ours. You who are here today have the power to save or destroy the tantalum capacitor industry.

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PRINTED BY PUVREZ
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