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TIC

TANTALUM-NIOBIUM INTERNATIONAL STUDY CENTER

PRESIDENT'S LETTER

Friends,

This past quarter we have seen some rather dramatic announcements regarding the tantalum industry that will have implications for many years to come.

In early April, H.C. Starck GmbH & Co. KG of Germany announced the acquisition of controlling interest in Thai Tantalum Co., Ltd. of Thailand in order to gain improved access to the Far East market for tantalum.

In early May, Gwalia Consolidated, Ltd. announced that it had acquired 100% of the Wodgina tantalum project in Western Australia from Goldrim Mining Australia, Ltd. This acquisition included the 50% interest previously owned by Pan West Tantalum Pty Ltd.

Finally (again in early May), Vishay announced that a partnership formed by Vishay and the Eisenberg Group of Companies of Israel has signed a Cooperation Agreement with China National Non-Ferrous Metals Industry Corp. for the comprehensive development of the tantalum industry in the People's Republic of China. This includes the mining and refining of tantalum ore and the production of tantalum capacitors in China through several joint ventures.

These announcements come on the heels of a recent softness in the tantalum capacitor business driven largely by the slowdown in the rate of growth in personal computers. It is not clear at this point the impact this will have on overall tantalum demand for the future.

The plans for the General Assembly continue and you will be receiving invitations to the meeting during the summer. Please make sure you mark your calendar for October 20th to 22nd.

Have a safe and healthy summer, and I will see you all in October.

Yours sincerely,
R.S. Barron, President

NEWS OF MEETINGS - SEE LAST PAGE

SUMMARY

RECYCLING OF TANTALUM

This paper was presented to the Third International Symposium on Recycling of Metals and Engineered Materials, held in Point Clear, Alabama, November 12th-15th, 1995. It was written by Dr Axel Hoppe, H.C. Starck GmbH & Co KG, and Dr George Korinek, Technical Adviser to the T.I.C. We should like to thank TMS, The Minerals, Metals & Materials Society, organisers of the conference and publishers of the Proceedings, for permission to re-print it here.

ABSTRACT

Although tantalum is not usually regarded as a precious metal, its pricing structure is very similar to that of silver. Unlike precious metals, tantalum has only **industrial** applications, and its use is about 1000 metric tons per year. The intrinsic value of tantalum has already in the past been a driving force for its recycling. Based on these facts, the tantalum industry world-wide is approaching the closed-loop concept of its recycling. A detailed material flow of tantalum processing as well as recovery of residues and used products will be discussed.

A. GENERAL OVERVIEW

Since tantalum may not be so well known to the participants in this conference, we would like to start with a short general overview of the properties of tantalum, followed by a description of its processing and economics.

A.1. Properties

Tantalum is a member of the refractory metals group and is characterized by the properties shown in table 1.

• Very high melting point	2 996° C
• High density	16.68 g/cm3
• Affinity for interstitials (oxygen, nitrogen, hydrogen, carbon)	
• Excellent corrosion resistance	
• Good ductility	

Table 1: Properties of tantalum metal

In view of its very high melting point and affinity towards the interstitials, all thermal treatment processes of metallic tantalum are performed either under high vacuum conditions or in a noble gas atmosphere. Melting of tantalum is restricted to either electron-beam (EB) or arc-melting in high vacuum or to plasma-melting in noble gas atmosphere. These processes not only require relatively expensive equipment but are also cost and energy intensive.

On the other hand the same properties are the basis for major applications of this metal:

- the formation of a dense, pore-free and adhesive oxide-layer is responsible for its unique corrosion resistance towards all acids with the exception of HF;
- formation of a controllable anodic oxide layer is the key for its application in electrolytic capacitors;
- the good ductility and machineability of tantalum also permit production of fairly complex shapes.

The excellent resistance to acids, however, complicates the extraction process for tantalum, and HF is the only acid capable of bringing tantalum into solution. As a result the application of the highly corrosive HF limits severely the materials of construction for the equipment in tantalum processing plants and complicates the general handling of the intermediate materials.

A.2. Processing

Tantalum is closely associated with its sister element, niobium, which is separated during the chemical processing.

The simplified flow sheets in figures 1, 2 and 3 give an overview of the most important processing steps during the chemical extraction (figure 1), metal production (figure 2) and capacitor processing (figure 3) [ref. 1].

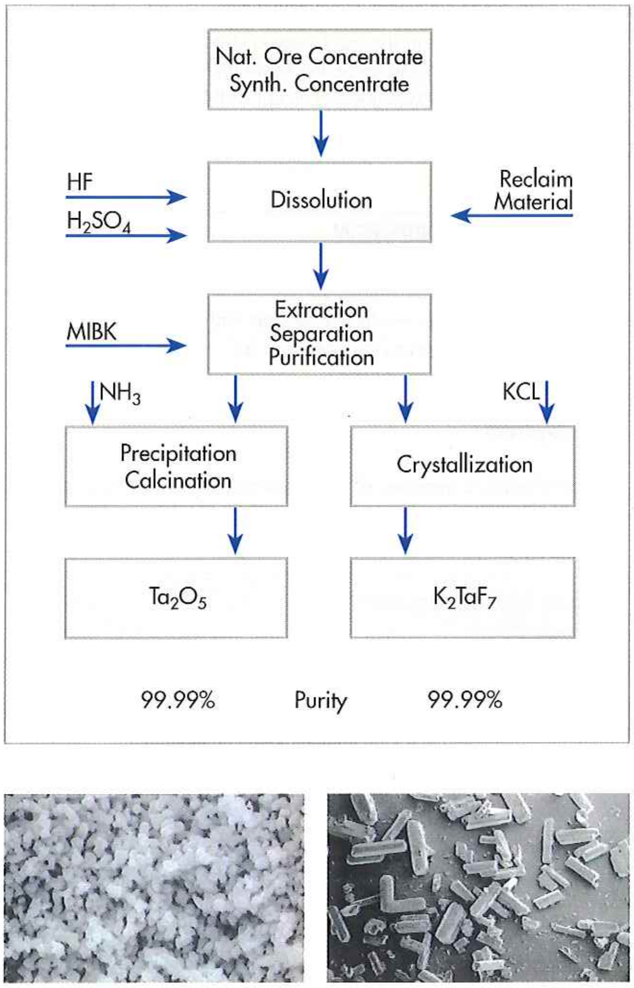

Figure 1 : Tantalum processing : chemical extraction

A.3. Economics

The main tantalum-bearing minerals are tantalite and columbite (table 2). The concentration of Ta_2O_5 in the major raw ore deposits hardly ever exceeds 0.1 % Ta_2O_5. Because of the fairly expensive chemical treatment, these ores have to be concentrated to approx. 20-45% Ta_2O_5 by mineral dressing techniques. As can be further seen from table 2 the major tantalum producing countries are also major tin producers.
In some cases the tantalum minerals are so closely interconnected with cassiterite that a separation by mineral dressing techniques is not possible. That is why the tantalum values from such tin raw materials collect during the tin smelting in the slag. These slags, as well as natural ore concentrates, have always been an important source as tantalum raw materials.

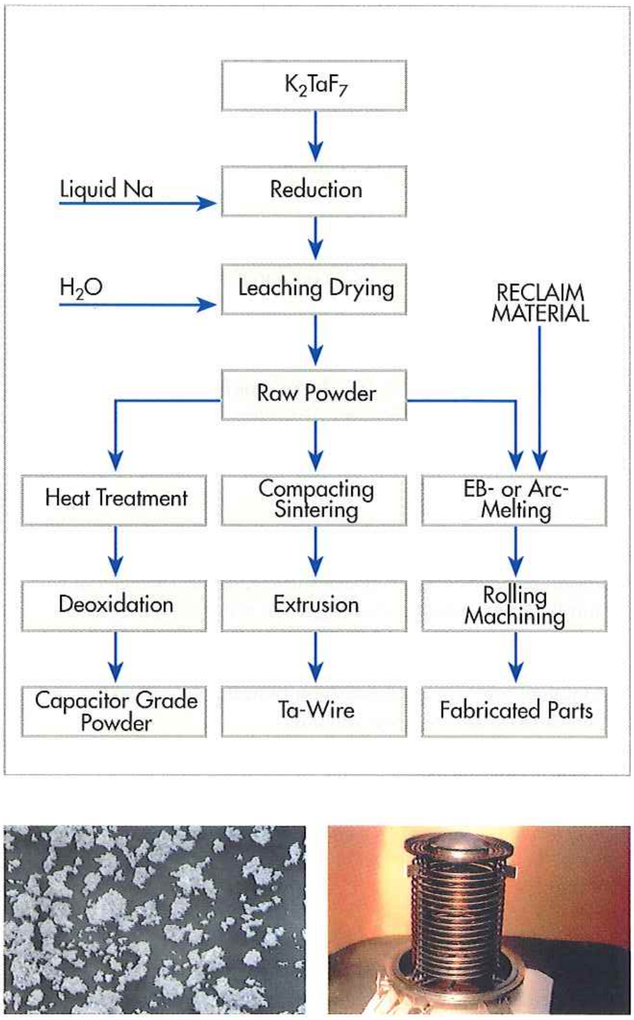

Figure 2 : Tantalum processing : metal production

In view of the low content of Ta_2O_5 in the raw ore or in the tin slags, and the relatively limited size of the tantalum deposits, which are not suitable for large scale mechanized mining, the price of tantalum concentrates is relatively high as shown in table 2.

The world market of tantalum products in all its forms was relatively stable over the last few years and was in the order of 2 MM lbs tantalum per year. Around 65% of the above quantity is utilized in the electronics industry, followed by cemented carbides (about 20%) and miscellaneous applications like fabricated parts, super alloy additions and others [ref. 2].

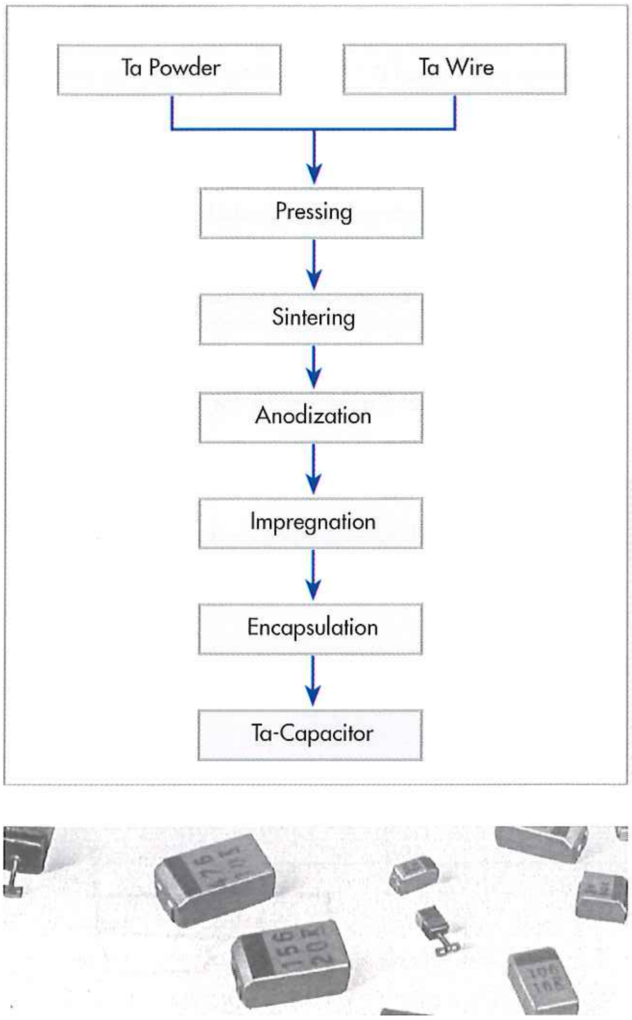

Figure 3 : Tantalum processing : capacitor manufacturing

Mineralization	Tantalite, columbite Tantalite and columbite usually connected with cassiterite ⇨ Tin slags
Raw ore	Ta_2O_5 content approx. 0.1 %
Ore concentrate	20-45% Ta_2O_5 Price \$ 26-40/lb Ta_2O_5
Ore deposits	Australia Canada Brazil Africa Southeast Asia
World demand	approx. 2 MM lbs Ta
Average selling prices	
Ta-powder	\$ 100-180/lb Ta
Ta-oxide	\$ 40 - 90 /lb Ta_2O_5
Ta-carbide	\$ 45 - 60 /lb TaC
Ta-wire	\$ 170-250/lb Ta
Ta-sheet	\$ 100-150/lb Ta

Table 2 : Economics of tantalum

As mentioned before, the relatively high price for concentrate and the complexity of manufacturing results in tantalum metal prices which are equivalent to or higher than those of silver.

Therefore, the above-mentioned economic considerations have been the leading driving force for recycling of tantalum since the early fifties.

B. INTERNAL RECYCLING ROUTES

Figure 4 shows in a comprehensive way the material flow from the raw material to the final product groups as well as the internal recycling at tantalum processing companies, as it is performed at HCST.

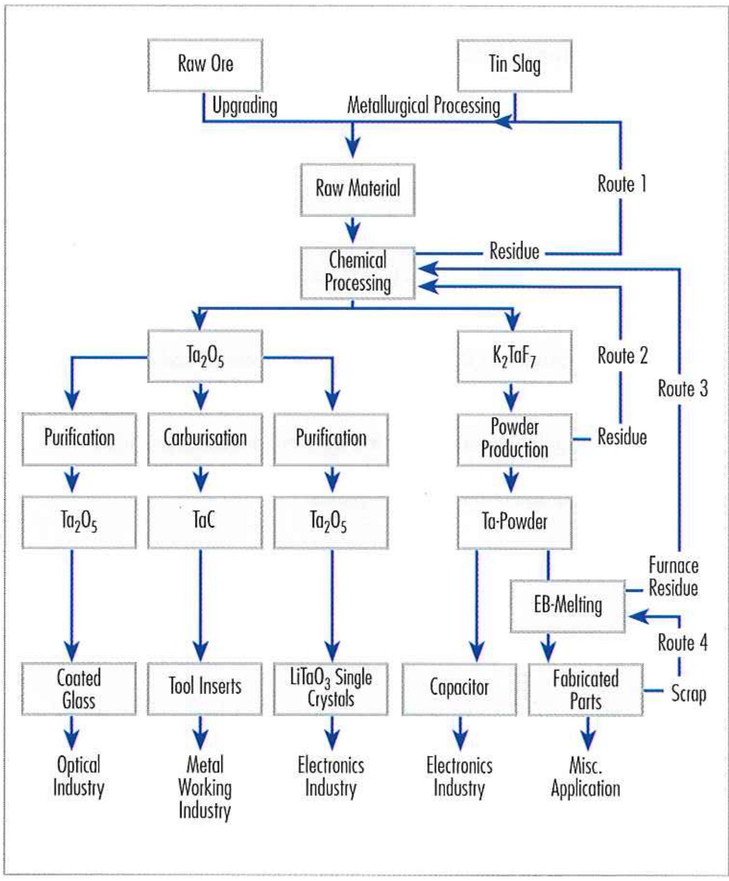

Figure 4 : Internal recycling routes

Recycling route no. 1 is dealing with leaching residues after the extraction of the tantalum values from the concentrate. Since not all the tantalum can be dissolved or extracted, approx. 2-5% remains in the residue. Because of the high intrinsic value of tantalum, these residues are recycled and added to the tin slags and subjected to a subsequent metallurgical upgrading process. This step reduces the actual tantalum losses during extraction to less than 0.5%.

Recycling route no. 2 is dealing with residues generated during the reduction of K_2TaF_7 to tantalum powder. These residues mainly consist of partly oxidized extra-fine tantalum powder which are collected during the leaching steps. They contain about 50% tantalum and are re-dissolved along with natural and/or synthetic concentrates.

During EB-melting a certain amount of the metal is deposited on the cold wall of the furnace. This deposit is removed during the cleaning operation from the furnace, and after an oxidizing step is added to the feed material for the extraction process (recycling route no. 3).

Recycling route no. 4 is dealing with metallic scrap generated during the fabrication process, such as skinning, rolling, extrusion, cutting etc. This scrap, which basically is high grade tantalum, is used as additional feed-stock for the EB-melting operation.

These recycling routes at tantalum processors reduce the overall losses to approx. 2-4% of the input raw materials. To achieve these yields consistent improvements in the operations of the processing industry were required over the years.

C. EXTERNAL RECYCLING ROUTES

C.1. Electronics Industry

The main products delivered from the processing plants to the electronics industry are shown in table 3.

The total quantity is about 1.3 MM lbs tantalum. By far the largest consuming sector is the capacitor industry which uses about 1.25 MM lbs tantalum mainly in the form of powder (about 1 MM lbs), wire (about 0.18 MM lbs), and furnace parts (about 0.07 MM lbs).

Approximately 0.05 MM lbs tantalum contained is being used in the production of $LiTaO_3$ wafers for SAW-applications.

During the production of the above-mentioned products (capacitors and wafers) the following reclaim materials are collected at the manufacturing plants:

from capacitors
- blow powder
- sintered anodes
- wire pins
- capacitors in all forms
- furnace parts

These reclaimed products are being re-delivered directly or indirectly to the processors for further treatment as shown in table 3

from wafer plants
- cuttings of $LiTaO_3$ single crystals
- turnings and grinding powder from wafers

They also are re-delivered to the processors for chemical processing.

Input products	Ta-powder		for capacitors
	Ta-wire		for capacitors
	Ta-fabricated parts		for furnace hardware
	Ta-oxide		for tantalate single crystals
Input quantity	1.3 MM lbs Ta		
End products	Ta-capacitors		
	$LiTaO_3$-wafers		
Reclaim materials from capacitor production	Powder	→	Chemical processing EB-melting
	Anodes	→	EB-melting
	Pins	→	EB-melting
	Capacitors	→	Chemical processing and EB-melting
	Furnace Parts	→	EB-melting
from wafer production	Cuttings	→	Chemical processing
	Turnings	→	Chemical processing
Reclaim quantity	0.3 MM lbs Ta		

Table 3 : External recycling routes : electronics industry

The total quantity of tantalum which is generated from the electronics industry during processing and which is re-delivered to the processors is about 0.3 MM lbs tantalum. This represents the largest portion of the externally recycled tantalum.

C.2. Cemented Carbide Industry

About 0.4 MM lbs contained is delivered to the cemented carbides industry mainly in the form of TaC and TaNbC (table 4). These carbides are added to the hardmetal mixture to improve the high-temperature characteristics of the cemented carbide cutting tools. These cutting tool inserts contain on average about 3% tantalum.

The reclaim material is generated by the insert producers and users in two ways:
- as grinding sludge or powder scrap
- in the form of used tool inserts

Sludges are treated chemically in order to extract W and Co values first. The remaining tantalum values are then added to the feed material at the tantalum extraction plants.

Input products	Ta-carbide		
	TaNb-carbide		
Input quantity	0.4 MM lbs Ta		
End products	Cutting tool inserts approx. 3% Ta contained		
Reclaim materials	Grinding sludges	→	Chemical processing
	Used inserts	→	Chemical processing or zinc process
Reclaim quantity	0.25 MM lbs Ta		

Table 4 : External recycling routes : cemented carbides industry

Used tool inserts can be treated in the same manner, but in addition a zinc recycling process is used. In this process, zinc metal is added to the insert bits in a vacuum furnace at elevated temperatures. This results in a break-down of the hard metal structure and allows conversion into powder. After removal of the zinc by distillation, this powder can be directly used in a blend with virgin carbides to manufacture cemented carbide parts for non-critical applications.

The total amount of tantalum reclaimed from the cemented carbide industry is about 0.25 MM lbs tantalum, out of which approx. 0.14 MM lbs are re-delivered to the processing companies.

The tantalum which is recycled via the zinc process is not included in the 0.4 MM lbs tantalum contained which is delivered as virgin material to the cemented carbide industry.

Besides these two major applications, tantalum is used to a smaller extent in the chemical industry as corrosion resistant structural material, as additive to superalloys mainly for the jet engine industry and in the optical industry as coatings. The amount of reclaimed tantalum from these industries is about 50 000 lbs on average per year.

D. CONCLUSION

Figure 5 gives a complete overview of the main material streams and recycled quantities. As can be seen, the internal recycling by the processors and the external recycling from the industrial users is developed to a high degree, and reflects itself in minimum tantalum losses in these areas.

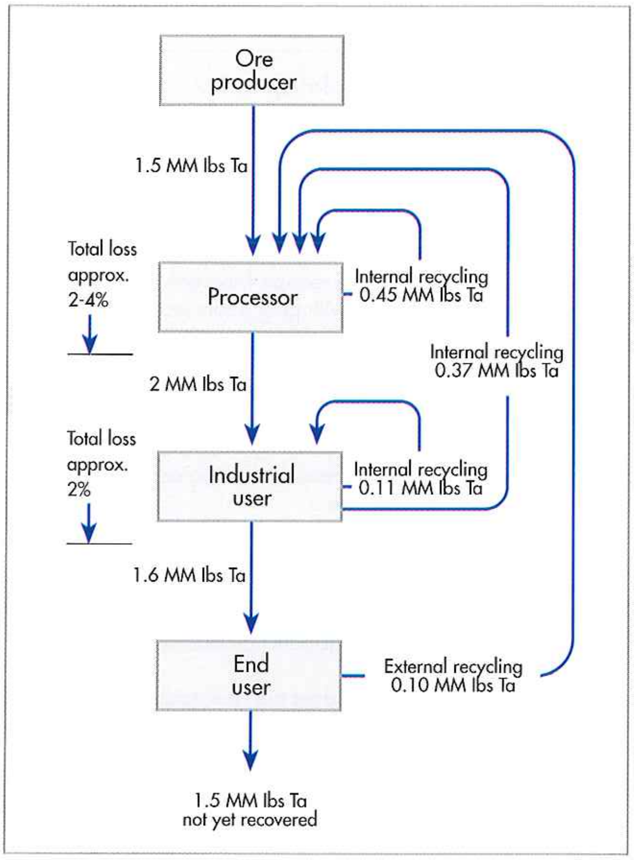

Figure 5 : Material stream for tantalum

The recycling of tantalum from finished electronic equipment is developed so far only to a very small degree and therefore represents a major potential for tantalum reclamation in the future.

Whereas the tantalum which is reclaimed by industrial users occurs in relatively concentrated form, this is not the case for the electronic equipment sector. As a consequence any tantalum recycling effort from this area will have to be done only as a part of a total recycling concept for electronic equipment.

This will require time and major effort and cooperation between the tantalum industry and the electronic equipment recyclers.

References

1. P. Borchers, George J. Korinek, Extractive Metallurgy of Tantalum, Proceedings TMS-AIME Chicago, Ill.; February 22-26, 1981.

2. George J. Korinek, TIC Bulletin, Nr. 80, December 1994, Brussels, Belgium.

TANTALUM RAW MATERIAL SUPPLY

A paper presented by Mr John Linden, Gwalia Consolidated Ltd., at the International Symposium on Tantalum and Niobium, September 1995.

Tantalum raw material supply and availability have undergone significant changes over the past seven years since the last time I addressed this subject in Orlando in 1988.

The changes that have developed include an almost complete elimination of tantalum bearing slags as a by-product from tin-smelting operations, the development of significant new hard rock primary tantalite mines in Australia, the significant increase in recycling of tantalum units by the processing industry and changes in the supply and demand balance in the CIS and China.

Supply from unsophisticated operations in Africa and Brazil is difficult to quantify but is a significant proportion of total supply to processors.

Inventories of low grade slags and synthetic concentrates continue to make up the primary supply and demand imbalance.

SUMMARY

Tantalum supply has been in excess of demand for the majority of the past 20 years, the significant exception being in 1980 when a perceived shortage lead to a real price increase resulting in a significant over-supply for the next 10 years.

Tantalum demand has been remarkably consistent and steady over a long period of time with no real growth in demand since 1980. Fluctuations in demand due to world economic conditions have generally seen demand vary from a low of 2.0 m lbs Ta to a high of 2.6 m lbs of Ta in all end product forms.

Peaks in demand occurred in 1980, 1984, 1988 and now 1995.

The supply side of tantalum has gone through major structural changes during this period and it is necessary to understand the reasons for these changes.

Traditionally tantalite has been produced as a by-product or co-product from tin mining and tin smelting and as a collector mineral from a large number of diverse small operators in developing countries.

Until relatively recently, there was no dedicated capital invested in primary production infrastructure and no large mining companies were involved in the business.

This situation existed until 1990 when, as a result of 10 years of declining tantalum production as a by-product from tin mining and smelting, a significant capital expenditure was undertaken by Gwalia to ensure a long term base load production of tantalum from a large hardrock resource.

This commitment to capital expenditure could be undertaken because Gwalia, together with two of the major processors, entered into long term contracts to underwrite the development and stabilise the primary production side of the industry.

The strategy adopted has been successful, with tantalum raw material prices remaining remarkably stable during the past 5 years.

The tantalum industry has seen a surge in demand during the first half of 1995 related to the growth in the electronics industry. The extra demand required by this industry is now working its way down the supply line to the raw material producers. Additional production capacity will need to be brought on stream during the next several years if this demand increase is sustained.

PROCESSOR DEMAND

Demand for tantalum units is recorded and published by the T.I.C. as tantalum industry statistics on a quarterly basis. The statistics for demand are considered reliable and reflect real usage because all processors are members of the T.I.C. and report shipments of finished products to customers.

The consensus among all reporting companies is that total T.I.C. reported processor shipment statistics now accurately reflect the industry demand.

The processor shipments are reported in lbs Ta metal content in various product categories.

Processor shipments are reported in 1994 to be 2.3 million lbs Ta and shipments for 1995 are expected to be up sharply at 2.6 m lbs Ta.

While there is some chance that processor shipments may incorporate some end user and pipeline inventory build-ups or rundown, the figures presented in this paper reflect reasonably the actual supply and demand relationship for the industry from 1993 to 1995.

	1993	1994	1995(e)
Ta_2O_5/K_2TaF_7	288	140	214
TaC	218	255	313
Ta Powder	1039	1086	1184
Mill Product	375	430	460
Ingot Metal	358	332	380
Totals	**2278**	**2243**	**2551**

Table 1 : Processor shipments (000's lbs Ta)

The higher Ta_2O_5/K_2TaF_7 shipments in 1993 include deliveries to the Defence Logistics Agency in the USA under its procurement programme.

The 1995 estimates are arrived at by annualising the first quarter's T.I.C. statistics. On indications from second quarter demand, this estimate is expected to be on the low or conservative side for the year.

Since 1993 one processor in China and one in Kazakhstan have become members of the T.I.C. and the Chinese company is reporting both Processor Receipts and Shipments.

MARKET SHARE

The Industry Demand of 2.3 m lbs Ta in 1994 is estimated to be divided among the processors according to Table 2. China and countries of the CIS have been excluded because reliable data for domestic consumption in those countries is not available. The market shares of the carbide and mill product categories are reasonably well defined with industry experts estimating the powder/anode and melt stock categories.

Tantalum raw materials are processed by Starck, Cabot and Thai Tantalum into K_2TaF_7 and Ta metal powders and Metallurg and Mitsui have small tantalum oxide production facilities.

Processor	Powder/ Anode	Mill Product	Melt Stock	Carbide Oxide/K_2	Total
H.C. Starck	400	150	120	250	920
Cabot	600	150	130		880
VMC/Plansee		100	52		152
Thai Tantalum	50				50
China	36				36
Metallurg				30	30
Treibacher				50	50
Mitsui				65	65
Ulba		30	30		60
Total	**1086**	**430**	**332**	**395**	**2243**

Table 2 : Processor market share by product, 1994 (000's lbs Ta)

PROCESSOR RECEIPTS

Processor receipts are recorded by the T.I.C. statistics and include incoming Ta units by all processors. The categories reported cover the primary raw materials such as tantalite concentrates, columbites, struverites, tin slags and synthetic concentrates, and secondary materials including recycle, scrap, residues, tantalum pentoxide, K-salt and metal products.

The T.I.C. statistics for these receipts have only become reliable in the past 12 months with prior years incorporating many mis-reportings and inaccuracies.

The first and cheapest units available to the processing industry are recycle materials generated internally during processing, followed closely by scrap generated by other sections of tantalum manufacturing industries and returned to processors as part of new delivery contracts.

Ta units are generated by all processors in the normal course of production of various tantalum products. These units are recycled internally to earlier parts of the process stream and add to available input units for new product production.

In addition, scraps and residues are generated from other product manufacturers such as capacitor producers, superalloy producers and hard metal scrap reprocessors.

It is estimated that approximately 25% of processor shipments are returned as recycle raw material input to processors.

The next most available Ta units to processors are the K-salt and oxides derived from China and the CIS from either conversion contracts or sale.

The conversion of struverite sourced in Malaysia and Thailand by Chinese processors has been going on for some time and continues to add to the processor supply base.

Recycle Materials	• Processor internal • Scrap returns • Residues
Secondary Materials	• Ta_2O_5/K_2TaF_7/Metal
Primary Materials	• Tin slags • Columbite/Struverite • Tantalite concentrates
Inventories	• WIP stocks • Synthetic concentrates

Processors source tantalum containing raw materials based on the lowest cost. Under normal circumstances, cost of raw materials to processors increases as the tantalum content of the starting material decreases.

Increasing Cost ↓

Recycle
Scrap
Secondary materials
Columbite/Struverite
Tin slags
Alluvial tantalites
Synthetic concentrates
Hard rock tantalites

From Recycle and Secondary Materials

Processor demand is all measured in units of Ta contained in product. Processor receipts, however, come as units of Ta in recycle and secondary materials and units of Ta_2O_5 in primary raw materials.

The receipts in the form of Ta can generally be incorporated into other products without significant processing losses.

Primary tantalites and tin slags come in the form of Ta_2O_5 and incorporate a processing loss and recovery factor which is assumed to be 95%.

	Unit	1993	1994	1995
Processor Demand	Ta	2278	2243	2551
Less:				
Recycle -				
Capacitor powder scrap	Ta	240	240	250
Mill product scrap	Ta	60	70	80
Residue (hard metal)	Ta	100	120	120
Intermediates -				
K-salt China	Ta	50	50	50
Oxide China	Ta	50	50	30
Oxide Russia	Ta	50	80	50
Oxide Brazil	Ta	50	60	80
Total		600	670	660
Required from primary sources	Ta	1678	1573	1891
Equivalent to	Ta_2O_5	2148	2013	2420

Table 3 : Processor receipts from recycle and secondary materials (000's lbs)

From Primary Materials

Receipts of tantalum raw materials should be divided into those with >10% Ta_2O_5 which can be used in direct feed to solvent extraction plants and those with less than 10% Ta_2O_5 but more than 2% Ta_2O_5 which need to be smelted to form a synthetic concentrate.

The direct feed raw material consists of tantalite concentrates, columbites, high grade tin slags and synthetic concentrates.

The feed for synthetic concentrate production consists essentially of low grade tin slags containing less than 10% Ta_2O_5 and struverites containing less than 15% Ta_2O_5 .

Available production statistics do not separate between direct feed and low grade slags so the information must be obtained from various countries' import and export statistics.

	1993	1994	1995(e)
Required from primary sources	2148	2013	2420
Less:			
Africa	250	220	200
Australia	540	590	700
Brazil	130	155	150
Canada	40	40	50
China	30	90	20
Kazakhstan	10	17	20
Thailand	160	200	200
Other	50	50	50
Total receipts	1210	1362	1390
Required from inventory	938	651	1030

Table 4 : Processor receipts from primary materials (>10%Ta_2O_5) (000's lbs Ta_2O_5)

From Inventories

Synthetic tantalum concentrates are produced by Starck at their Laufenberg operations and can be produced by Metallurg at Weisweiler, both in Germany.

The synthetic concentrates are produced from low grade tantalum-containing tin slags and struverites containing from 2 to 15% Ta_2O_5 .

The two stage smelting process produces a tantalite containing a minimum 25% Ta_2O_5 which is then used as normal feed to the solvent extraction process.

Production of synthetic concentrates is contributing some 500 000 - 700 000 lbs Ta_2O_5 per annum to processor receipts. The production capacity is limited by the size of the operating furnaces and by the grade and availability of the low grade slags required as feed.

Current production of low grade tantalum-containing tin slags has stopped in the Malaysian smelters because of the unavailability of the tantalum-containing tin concentrates.

Production of synthetic concentrates continues from previously produced and stockpiled quantities of low grade tin slags.

Identified resources of low grade tin slags include :

1. Straits Trading Company, Malaysia

   20 000 tonne of 3.0% Ta_2O_5 containing 1.3 m lbs Ta_2O_5
   20 000 tonne of 2.0% Ta_2O_5 containing 0.8 m lbs Ta_2O_5

2. Paranapanema, Brazil

   40 000 tonne of 1.8% Ta_2O_5 containing 1.6 m lbs Ta_2O_5

3. Processor Inventories

   10 000 tonne of 3.5% Ta_2O_5 containing 0.75 m lbs Ta_2O_5

4. Singapore, Thailand, Malaysia landfill dumps of low grade slags.

The issues involved in production of synthetic concentrates are essentially economic.

As lower and lower grades of tantalum-containing tin slags need to be processed, the tantalum recovery decreases and the energy consumption increases per unit of production.

Production capacity of existing facilities also becomes an issue.

Production of low grade tantalum containing tin slags now occurs only in Brazil from tin concentrates mined by Paranapanema at the Pitinga deposit and smelted at company-owned facilities in Sao Paulo.

	1993	1994	1995(e)
Required from inventory	938	651	1030
Less:			
Synthetic concentrates	500	600	700
Inventory reduction	438	51	330

Table 5 : Processor receipts from inventory reduction (000's lbs Ta_2O_5)

TANTALUM RAW MATERIAL SUPPLY

The T.I.C. primary production statistics have been understating the production and availability of tantalite raw materials for the past 20 years.

While the statistics include production numbers from all producer members of the T.I.C., the problem is that a large percentage of production comes from non-members.

Specifically, the production from African countries collected from a large number of small producers and sold to traders is not included in the T.I.C. production statistics.

The same is true for a proportion of the production from Brazil and also for Thailand and Malaysia for material sent to China for conversion.

Tantalum raw material supply comes from recycle, intermediates, new mine production, synthetic concentrates and inventory drawdown.

Table 6 shows the relative contributions of the different sources to the total supply base.

Contribution from recycle has been reasonably stable but is scheduled for a significant increase with the establishment of residue pond recycling facilities by major processors.

These residue recycle operations have the potential to supply from 200 000 to 400 000 lbs Ta per annum for the next 5 years.

Intermediate products are likely to continue to increase but probably at the expense of concentrate exports or only as a result of increased conversion business.

Synthetic concentrate production will continue to be a major contributor to the supply base while low grade slags and other raw materials remain available.

With current production of these products decreasing, synthetic concentrates are now being produced from inventoried low grade slags.

New mine production is increasing and will continue to increase to meet the requirements of the processing industry. As the easiest to mine alluvial deposits are worked out, the industry has developed more hard rock sources of tantalite.

The Tanco mine in Canada was the first development, followed by Metallurg's operation in Brazil. PanWest invested new capital in a hard rock processing plant in Australia in 1988 and Greenbushes followed with its major expansion in 1992.

Since then, only Ethiopia has established new production capacity on a pilot plant basis.

Tantalum Mine Production

Africa — **Actual 250 000 lbs Ta_2O_5**
Capacity 335 000 lbs Ta_2O_5

Tantalite is produced from low cost alluvial and eluvial mining operations in Rwanda, Burundi, Zaire, Zimbabwe and Nigeria and from hard rock mining in Ethiopia, Zaire and South Africa.

It is difficult to tell where the material is actually produced because it will be transported across borders and exported from whichever country has the best access.

The material is collected by traders and sold to major processors. The main trading companies are A & M Metals & Minerals and Sogem.

Production statistics show annual total production at some 150 000 to 200 000 lbs depending on politics, riots and weather conditions. The resource base is large and could sustain higher production levels if investment was forthcoming.

Australia — **Actual 700 000 lbs Ta_2O_5**
Capacity 850 000 lbs Ta_2O_5

Between Gwalia and PanWest Tantalum, annual production is running at approximately 700 000 lbs Ta_2O_5 per annum in concentrates and high grade tin slags. There are a number of potential resources that could be developed if prices justified the development costs.

Brazil — **Actual 150 000 lbs Ta_2O_5**
Capacity 350 000 lbs Ta_2O_5

The Metallurg owned Mibra mine produces 80 000 lbs Ta_2O_5 per annum in the form of tantalite concentrates and 50 000 lbs per annum in the form of high grade tin slags. Garimpero activity contributes a further 100 000 lbs.
A significant part of Metallurg's production is further processed in Brazil and exported as the oxide.

Country/ region	Recycle	Inter-mediates	Primary Production			Synthetic concentrates	Total supply	Potential capacity 3-5 years
			Concentrates	Tin slags	Other			
Australia			600	100			700	850
S E Asia			50	100	50		200	300
Africa			200		50		250	350
Nth America	250		50				300	700**
Sth America		80	150				230	350
Europe	250		10			500*	760	760***
CIS (Exports)		100					100	200
China (Exports)		80	50				130	100
Total	**500**	**260**	**1110**	**200**	**100**	**500**	**2670**	**3610**

* *From low grade slag Inventories*
** *Will increase by 200 000 lb/y from 1997 from processors' residue ponds*
*** *Will decrease when low grade slags run out for synthetic concentrate production*
Potential capacity is subject to capital expenditure

Table 6 : Tantalum total supply (000's lbs Ta_2O_5 content)

The potential of Brazil is probably a sustainable 300 000 lbs Ta_2O_5 per annum.

Paranapanema produces a tin slag and mixed columbite concentrate both with low Ta_2O_5 and high radioactivity. Total annual production contains some 100 000 lbs of Ta_2O_5 which is currently not being used and is uneconomic and therefore not included in current production statistics.

Canada — **Actual 50 000 lbs Ta_2O_5**, **Capacity 250 000 lbs Ta_2O_5**

The Tanco mine owned by Cabot is currently producing only from tailings at 40 000 lbs Ta_2O_5 per annum.

When mine production starts up again, sustainable production will be at the rate of 200 000 to 250 000 lbs per annum for a period of 5-10 years.

Malaysia — **Actual 50 000 lbs Ta_2O_5**, **Capacity 50 000 lbs Ta_2O_5**

There is no current on-going production of 3% Ta_2O_5 tin slags due to a decline in the Malaysian tin industry. On the depletion of current low grade slag stockpiles, on-going feed for Starck's Laufenberg synthetic concentrate production may become a problem unless the high radioactivity slags in Brazil can be utilised.

Struverite is still produced from the retreating of Amang at an annual rate estimated at 50 000 lbs of Ta_2O_5 per annum.

Thailand — **Actual 150 000 lbs Ta_2O_5**, **Capacity 250 000 lbs Ta_2O_5**

Thailand produces natural tantalite concentrates from some small primary mines as well as tantalite and struverite from Amang treatment operations.

Annual production is estimated at a sustainable 100 000 lbs Ta_2O_5.

The Thaisarco smelter produces tin slags containing 15-20% Ta_2O_5 but total annual production has dropped significantly to a current sustainable level of 100 000-150 000 lbs per annum. All of Thaisarco's production is processed in Thai Tantalum's facilities at Map Ta Phut.

China — **Actual Exports 65 000 lbs Ta_2O_5**, **Export Capacity 50 000 lbs Ta_2O_5**

China has at least 5 producing tantalite mines and at least 7 processing facilities located in different provinces throughout China.

China both exports and imports tantalite concentrates, depending on the level of local production and internal demand.

Total mine production is estimated at 250 000 lbs of Ta_2O_5 per annum and in 1994 exports amounted to 65 000 lbs. In future years, China is expected to become a net importer of tantalum raw materials but may continue to be an exporter of tantalum intermediates and finished products.

CIS

Kazakhstan has some tantalite mine production but production is small and exports non-existent.

The CIS exports some intermediate and finished tantalum products but is not expected to be an exporter of tantalum raw materials.

Other — **Actual 20 000 lbs Ta_2O_5**, **Capacity 50 000 lbs Ta_2O_5**

There is some production from Portugal and Venezuela and production could be increased, especially in Venezuela and Bolivia, with a concerted exploration and development effort.

Potential Supply

Mozambique

Production from Mozambique stopped almost 15 years ago because of political instability. There is a resource that could be developed into production.

Ethiopia

Production from the Ethiopian Mineral Resources Development Corporation is included in the production statistics from Africa. Investment is currently being sought to increase capacity. It is estimated that the resource base can probably substantiate a production rate of 100 000 lbs per annum, up from the current 50 000 lbs Ta_2O_5.

Africa

The countries of Rwanda, Zaire, Burundi and Zimbabwe have large identified resources of near surface eluvial tantalite deposits. The resources have not been fully explored and delineated and have not been developed.

	1993	1994(est)	Capacity
Africa			
Burundi	35 000	50 000	50 000
Ethiopia	40 000	40 000	60 000
Namibia	5 000		
Nigeria	40 000	20 000	30 000
Rwanda	100 000	50 000	50 000
South Africa			10 000
Uganda			5 000
Zaire	30 000	10 000	30 000
Zimbabwe		50 000	100 000
Australia			
Gwalia	330 000	390 000	600 000
PanWest	180 000	170 000	200 000
Prima	30 000	30 000	50 000
Canada			
Tanco	40 000	40 000	250 000
China	30 000	90 000	
CIS			
Kazakhstan	6 000	10 000	50 000
Russia	2 000	5 000	
Estonia	2 000	2 000	
South America			
Brazil	130 000	150 000	300 000
Venezuela		5 000	50 000
Thailand			
Thaisarco	100 000	150 000	200 000
S A Minerals	40 000	40 000	50 000
Traders	20 000	10 000	30 000
Other	50 000	50 000	50 000
Synthetic concentrates			
Starck	350 000	400 000	500 000
Total	1 560 000	1 762 000	2 665 000

Table 7 : Primary raw materials supply (lbs Ta_2O_5)

This situation has been in existence for the past 20 years.

Development funds are not available because of the inherent political and country risk problems for any foreign investor.

South America

Resources have been identified in Venezuela, Bolivia and Brazil and limited development work commenced on some deposits.

COST OF PRODUCTION

The cost of production of tantalum raw materials has been increasing steadily over the past 15 years.

As a greater percentage of the required units have to be sourced from hard rock tantalite mines rather than from tin mining and smelting, and as the near surface alluvial deposits become depleted, this trend will continue.

Tantalum supply from hard rock mining now accounts for almost 50% of total primary production and almost 25% of total supply.

The first hard rock tantalite mine was Tanco in Canada, followed by Metallurg in Brazil and then the Australian operations of PanWest Tantalum and Gwalia Consolidated Ltd. The most recent operation to come into production was in Ethiopia.

The cost of production of hard rock tantalite mines depends largely on the grade of tantalum in the ore and the mining method employed.

Underground operations are generally more costly than open cut but higher grades can off-set this. Typical grades for producing mines are Tanco 1000 ppm, Metallurg 700 ppm, PanWest 600 ppm, Gwalia 400 ppm. The hard rock mines in China operate at levels of 150 ppm Ta_2O_5.

Other factors that influence cost are the recovery levels achievable, the co-products available and the inherent associated impurities in the orebody and the final product.

As processor demands increase for higher quality concentrates so the degree of processing and cost of production increases.

Radioactivity is probably the single most important impurity from a cost of production point of view. As international transport regulations and domestic waste disposal regulations become stricter, these costs will continue to increase.

Cost of production from hard rock tantalite mines has risen from the USD30 per lb level to nearer the USD40 per lb level over the past 5 years and will continue to increase as lower and lower grade resources need to be developed.

TANTALUM INVENTORIES

Primary Producer Stocks **0.2 m lbs Ta_2O_5**

Tantalite Concentrates

Current stocks of tantalite concentrates in the hands of producers are at normal levels, with most significant producers having entered into term contracts which require continuous deliveries.

Some build up of stocks has occurred during the last 6 months in Africa because of physical transportation problems due to civil unrest.

Trader activity has increased somewhat and some stocks would be in traders' hands.

Total of all producer and trader inventories above normal working levels is estimated at 200 000 lbs Ta_2O_5.

Low Grade Tin Slags **3.5 m lbs Ta_2O_5**

Straits Trading Company owns a stockpile of low grade tin slags located at Butterworth in Malaysia. The slags were accumulated during the late seventies and early eighties.

The stockpile contains some 30 000 to 40 000 tonnes, with grades ranging from 2-3% Ta_2O_5.

Paranapanema in Brazil has a stockpile of low grade tin slags located at its Sao Paulo smelter. The smelter is still producing low grade slags and accumulated stocks now amount to some 40 000 tonne.

The estimated grade is less than 2% Ta_2O_5 with higher levels of Nb_2O_5 and some radioactivity content.

Processor Stocks **2.5 m lbs Ta_2O_5**

Major processor inventories are generally kept at the level of 6 to 9 months' requirements.

The exceptions to this position are the low grade tin slags which are required for synthetic concentrate production and the high grade tin slags produced by Thaisarco in Thailand.

The low grade tin slags have been accumulated by Starck for its Laufenberg operations over the past several years. Current stocks are estimated to be sufficient for at least 2 years' synthetic concentrate production.

The higher grade slags produced by Thaisarco have been accumulated by Thai Tantalum for use in their Map Ta Phut K-salt production facility. At the time of acquisition, there were some 500 000 lbs of Ta_2O_5 and significant levels of stock remain.

Other smaller processors, such as Metallurg, Mitsui Mining and Smelting and Treibacher, carry sufficient stocks for between 6 and 12 months' production.

Government Stockpiles **2.5 m lbs Ta_2O_5**

The US Government Defence Logistics Agency carries an inventory of 2.5 m lbs of Ta_2O_5 in the form of tantalite concentrates and a further 1 m lbs Ta_2O_5 in the form of intermediate and finished products.

Historically, the DLA has had a goal of more than double actual stocks. No acquisitions have been made in recent times and no disposals have been made for a very long time. Recent publications suggest that USA strategic stockpiles are no longer required and that all stockpiled materials will be sold.

Russia also carries a tantalum strategic stockpile but quantities and disposal or acquisition policies are unknown.

Manufacturer Stock

Stocks of finished products in the hands of manufacturers are estimated to be below desirable levels. This situation has arisen as a result of demand increasing during 1995, resulting in lengthening delivery lead times.

Owner	Product	Contained lbs Ta_2O_5
Straits Trading Co	3% slag	1.3 m
Straits Trading Co	2% slag	0.8 m
Paranapanema	1.8% slag	1.6 m
Thai Tantalum	17% slag	0.5 m
Starck	3.5% slag	1.0 m
Processors	30% conc	1.6 m
DLA	25% conc	2.5 m

Table 8 : Inventory summary

FUTURE SUPPLY

Current levels of supply are sufficient to sustain a tantalum industry with an annual demand of 2.3 to 2.5 lbs Ta in finished products.

Sustained demand at levels of 2.8 lbs Ta or higher will require the development of new and additional resources to increase the supply base.

Already identified inventories and production flexibilities are sufficient to supply the industry needs in the immediate and short term.

(The information included in this report has been sourced from the T.I.C. statistics, various countries' import and export statistics and from personal communications between the author and members of the industry. The author takes sole responsibility for the accuracy of all figures presented.)

The Executive Committee at work
(Photo courtesy of Mr Takekuro and Mr Oka)

MEMBER COMPANY NEWS

H.C. Starck and Thai Tantalum

H.C. Starck has acquired a majority holding in the Thai Tantalum Company.

After several months of negotiations, H.C. Starck GmbH & Co KG of Goslar, Germany, a wholly-owned subsidiary of Bayer AG, Leverkusen, Germany, acquired a majority holding in the Thai Tantalum Company Limited (TTA), whose headquarters are in Map Ta Phut, Thailand. The agreement which was recently reached with the remaining Thai shareholders was announced in Bangkok on March 28th 1996 by Dr Manfred Schneider, Bayer Chairman, and Mr Peter Kählert, Chairman of the Executive Board of H.C. Starck, known to the T.I.C. as the immediate past Present of our association.

The acquisition includes a facility for the production of potassium fluorotantalate and tantalum metal powder in Map Ta Phut, an industrial park some 180 km southeast of Bangkok. About 170 people are employed at the 220 000 m^2 site, which is equipped with infrastructure and environmental protection in line with the latest technological developments.

With the acquisition of Thai Tantalum, H.C. Starck gains a second location for chemical production, in addition to its Goslar plant, and improves access in Southeast Asia to both raw materials and markets for its products.

Gwalia, Goldrim and Pan West

Gwalia Consolidated Ltd has announced that it has entered into agreement with Goldrim Mining Australia Ltd to acquire 100% of the Wodgina Tantalum Project, including the 50% interest previously owned by Pan West Tantalum Pty Limited. Gwalia is purchasing the assets of the Wodgina Project as well as other additional mining tenements, including those at Strelley and Tabba Tabba, held by Goldrim in the vicinity of that Project, together with the benefit of various product sales agreements.

The Project comprises an open cut tantalite mine and plant, campsite and equipment situated at Wodgina, approximately 100 kms south of Port Hedland. (A group of T.I.C. delegates visited the site in November 1990, and were very impressed.) The mine is currently producing about 170 000 lbs of tantalite concentrate per annum.

The acquisition of Goldrim's 50% interest is subject to approval by Goldrim shareholders and it is understood that a meeting of the shareholders is about to be called so that settlement may be completed by June 30th 1996.

Applications

We are pleased to welcome applications from **Matsushita Electronic Components, Capacitor Division** and **Osram Sylvania.**

Changes of name

The names of two member companies have recently been changed: the membership of Southern Prospecting has been transferred to Lydenburg Exploration, and Tan Ceramics has become Lev Gubenko.

SYMPOSIUM PROCEEDINGS

The Proceedings are now available in a hard cover book: please send your order to the T.I.C., 40 rue Washington, 1050 Brussels, Belgium, accompanied by a cheque for $US150, or by a request for an invoice. This price includes postage and packing.

MEETINGS

MEETING IN BRUSSELS

On April 23rd 1996 the Executive Committee met in Brussels. The members discussed the administration and financial situation of the T.I.C., and plans for the next General Assembly. The annual fee was maintained at the level of 1995-96 for the next year, ending June 30th 1997.

Another fourteen delegates joined the Committee members for lunch, and were given a summary of the work carried out in the morning.

GREENVILLE, OCTOBER 20th-22nd 1996

The Thirthy-seventh General Assembly will be held on October 21st 1996 at the Hyatt Regency Hotel in Greenville, South Carolina, as part of a meeting from October 20th to 22nd. The conference will open on Sunday with registration and a cocktail party. On Monday October 21st the General Assembly will be followed by a full programme of technical presentations, and the day will close with a gala dinner hosted by Kemet Electronics. On the morning of Tuesday October 22nd Kemet will offer a plant tour of its capacitor facility at Greenville.

Invitations will be sent to the delegates of member companies. Other people who would like to attend should contact the T.I.C. at 40, rue Washington, 1050 Brussels, Belgium.

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