

April meeting of T.I.C.

The informal meeting held on April 27th 1990 in Brussels was attended by more than thirty delegates and guests who took advantage of this opportunity for discussion and exchange of views. Although no formal business was enacted, the President of the Tantalum-Niobium International Study Center reported to the assembled delegates on the decisions taken by the Executive Committee members during their meeting in the morning, and gave a general review of the affairs and activities of the association. Changes were made to the collection of tantalum statistics, and arrangements for the next General Assemblies were announced. The annual membership fee for the coming year will remain unchanged from that in 1989-90 as the financial situation is satisfactory.

THIRTY-FIRST GENERAL ASSEMBLY

The Thirty-first General Assembly will be held in Perth, Western Australia, on November 6th 1990 as part of a four-day programme of meetings and tours.

The group will stay at the Observation City Resort Hotel, where the formal sessions and social function will also take place. On Monday November 5th delegates will register, and are invited to a cocktail party in the evening. Following the formal Assembly to conduct the business of the T.I.C. on November 6th, there will be a programme of technical presentations and the day will close with a formal dinner to which all participants are invited as guests of Greenbushes, Pancontinental Mining and Goldrim Mining. Plant tours are planned for Wednesday and Thursday. Should the number of papers become too great to be presented on Tuesday, a further technical session will be added on the afternoon of Monday. A ladies' programme including visits to Underwater World and the Atlantis Marine Park is being arranged for Tuesday and ladies may choose to visit Greenbushes on Wednesday if they wish. Details of the arrangements and participation fees will be available shortly.

Invitations will be sent to the voting delegates of member companies, others interested in attending this meeting should contact the Secretary General of the T.I.C., at 40 rue Washington, 1050 Brussels, as soon as possible.

TECHNICAL PROGRAMME

The provisional programme includes the following presentations; this list is subject to revision and it is likely that more papers will be added :

- The Pan West Tantalum Project, by Mr Tony Grey, Chairman, Pancontinental Mining;
- Mount Weld and Brockman rare earths deposits, by Dr Don Zimmerman, Managing Director, Carr Boyd Minerals;
- Prospects for tantalum, niobium and non-ferrous metals in Japan, by Mr Yoshiharu Nozawa, Managing Director, Vacuum Metallurgical Company;
- Pollution controls in tantalum/niobium chemical processing, by Dr Wolf-Wigand Albrecht, Hermann C. Starck Berlin/NRC;
- Commercial aspects of tantalum capacitor production, by Mr William Millman, AVX;
- Availability of tantalum from low-grade tin slags, by Mr Yoot Eamsa-Ard, Thaisarco, and Mr Rod Tolley, T.I.C. Technical Adviser;
- Overview of supply and demand by Mr L.S. O'Rourke, consultant;
- Niobium alloys in superconductivity, by Mr William K. McDonald, Teledyne Wah Chang SC.

PLANT TOURS

Wednesday November 7th : Departure by coach for Greenbushes mine site; tour of mine and facilities; lunch; return by coach to hotel in Perth. No charge to delegates, all expenses will be borne by Greenbushes.

Thursday November 8th : Departure of flight to Port Hedland; journey continues by coach to Wodgina mine site; tour of iron ore mine, ship loading facilities, and salt production; lunch; return to airport by coach for flight to Perth and return to hotel. Cost to delegates : airfare from Perth to Port Hedland; all expenses of coach transfers and lunch will be covered by Pancontinental Mining.

GENERAL ASSEMBLY IN 1991

This Assembly will be held in Philadelphia on October 24th 1991 as part of a three-day meeting from October 23rd to 25th, including a tour of the Cabot Corporation plant at Boyertown, by kind invitation of the company.

T.I.C. STATISTICS

The gathering of statistics from the industry has always been an important (and well-publicised) feature of the T.I.C.'s activities, and the Executive Committee at its meeting on April 27th considered ways in which the tantalum and niobium figures could be improved. In both cases there is an apparent anomaly: for tantalum, processors' shipments regularly exceed the primary production, whereas for niobium processors' shipments appear to be far less than the raw material produced. It was agreed that (i) in the case of tantalum a better picture of tantalum availability to the market would be given by a figure for processors' receipts and (ii) the secretariat would work with the producers and the statistics-gatherers to try to reduce discrepancies in the niobium figures.

With regard to tantalum, this means that effective January 1st 1990 the quarterly published figures will consist of primary production (tin slags and concentrates), processors' receipts (tantalum in all forms), and processors' shipments (by type).

It was agreed that we would continue to provide tantalum production estimates at various price levels (presently \$ 30, \$ 40 and \$ 50 per pound Ta₂O₅). These are calculated by five persons with particular knowledge of the tantalum industry in different parts of the world, and they estimate what the effect would be on tantalum output in the following five quarters if the price were to be at, or to change to, the price given. In many areas, output is not price-sensitive, in others it is appreciably so (e.g. primary mines), or even completely so (e.g. by-product struverite from tin mining), so the overall figure given is a composite world-wide.

President's letter

On April 27th the Executive Committee of T.I.C. met in Brussels in the morning and, after a lunch with the members and guests, we had a short informal meeting in the afternoon.

The Executive Committee spent a major part of the meeting discussing future General Assemblies, the financial situation of T.I.C. and collection of tantalum and niobium statistics.

I am pleased to report that the preparations for the Thirty-first General Assembly are proceeding very well. We will have at least seven or eight presentations on the timely subject of tantalum and niobium with visits to the Greenbushes operation and the Pan West Tantalum project at Wodgina.

We also firmed up the date for the Thirty-second General Assembly of T.I.C. in Philadelphia, October 23-25 1991, connected with a visit to Cabot's tantalum/columbium operation in Boyertown.

Furthermore, I am pleased to report that financially T.I.C. is in very good shape and that the financial problems we had two years ago seem well resolved.

Rod Tolley, our Technical Adviser, is addressing the issue of statistics in a separate column in this Bulletin.

T.I.C. statistics

TANTALUM

PRODUCTION AND SHIPMENTS

(quoted in lb Ta₂O₅ contained)

1st quarter 1990

Tin slag (over 2 % Ta₂O₅)
Tantalite (all grades), other

Total

Note :

18 companies were asked to report. The companies which report include the following, whose reports are essential before the data may be released :

Datuk Keramat Smelting
Greenbushes
Malaysia Smelting
Mamoré Mineração e Metalurgia
Metallurg Group
Tantalum Mining Corporation of Canada
Thailand Smelting and Refining

QUARTERLY PRODUCTION ESTIMATES

(quoted in lb Ta₂O₅ contained)

LMB quotation :	US \$ 30	US \$ 40	US \$ 50
2nd quarter 1990	263 500	391 500	425 000
3rd quarter 1990	256 500	393 500	450 000
4th quarter 1990	246 500	393 500	450 000
1st quarter 1991	243 500	391 500	445 000
2nd quarter 1991	233 500	391 500	445 000

Note :

The quarterly production estimates are based on information available, and do not necessarily reflect total world production.

PROCESSORS' SHIPMENTS

1st quarter 1990

Product category	lb Ta contained	lb Ta ₂ O ₅ equivalent
Ta ₂ O ₅ , K ₂ TaF ₇	37 725	50 929
Alloy additive		
Carbides	112 114	151 354
Powder/anodes	221 940	299 619
Mill products	71 286	96 236
Ingot, unworked metal, other, alloy additive and scrap	63 889	86 250
Total	506 954	684 388

Notes :

1. 15 companies were asked to report, and all 15 replied. Reports by the following companies are essential before the data may be released :

Cabot Corporation, Electronic Materials and Refractory Metals
Fansteel
W.C. Heraeus
Kennametal
Metallurg Group
Mitsui Mining and Smelting
NRC Inc.
Showa Cabot Supermetals
Hermann C. Starck Berlin
Treibacher Chemische Werke
Vacuum Metallurgical Company
V Tech

2. Reports were made in lb tantalum contained.

Capacitor statistics

EUROPEAN TANTALUM CAPACITOR SHIPMENTS

(thousands of units)

4th quarter 1989 149 495

(Data from ECTSP)

JAPANESE TANTALUM CAPACITOR PRODUCTION AND EXPORTS

(thousands of units)

	Production	Of this, exports
4th quarter 1989	918 766	243 857

(Data from JEIDA)

There has been a good attendance at the informal meeting of the membership with the Executive Committee in the afternoon and we will decide in Perth if we should repeat the meeting in this form in the spring of 1991 in Brussels.

I hope you are all making preparations to participate in the Thirty-first General Assembly of T.I.C. in beautiful Western Australia on November 5th-7th 1990.

George J. Korinek
President

Tantalite tender

The U.S. Government, through the Defense Logistics Agency, recently invited offers of 200 000 pounds of Ta_2O_5 in high-grade tantalite in two lots of 100 000 pounds each. The closing date was April 24th, and the tenders submitted were:

	\$ per pound Ta_2O_5	
	Lot One	Lot Two
Greenbushes	\$ 45.00	\$ 45.00
Metallurg	\$ 42.00	\$ 40.78
O'Dell	\$ 37.00	\$ 47.00
Sassoon (i)	—	\$ 40.92
(ii)*	\$ 38.73	\$ 38.73
Sogem	\$ 49.42	\$ 36.62
Speegaffs Nigeria	\$ 39.90	\$ 39.63

* Conditional on both lots being won.

The result has to be announced no later than June 23rd, but it would appear to be certain that O'Dell Construction will succeed in Lot One with its tantalite promised from a domestic source, subject to satisfying the authorities of the mine's viability. It is located in Rockford, Alabama, and is operated by Coosa Mining Ltd. Sogem would seem to be the winner of Lot Two.

The prices quoted gave some encouragement to the primary producers: the London Metal Bulletin price for spot lots of tantalite hardened and currently (end May) stands at \$30-35 per pound.

Mechanism of the HF test for tantalum powder assessment

by R.W. Franklin, AVX Ltd. Paignton.

During the T.I.C. International Symposium in 1988 a radically new method for comparing the quality of capacitor grade tantalum powders was presented (H. K. Schmidt & R. Capellades, Proc. T.I.C. Intern. Symp. Tantalum & Niobium, Nov. 7-8 1988, p. 509-519 (1)). This method has since been trialled in several locations and confirmation has been obtained showing that differences in behaviour can be consistently detected. The object of the present article is to provide an interpretation of the findings and to suggest improvements in technique which could enhance the repeatability of the test.

The concept behind the test is that two anodised sintered slug anodes are immersed in a buffered hydrofluoric acid solution and the rate of dissolution of the oxide estimated from capacitance measurements (Figure 1). The plots of reciprocal capacitance are assumed to be equivalent to the tantalum oxide thickness remaining after partial dissolution in the fluoride solution.

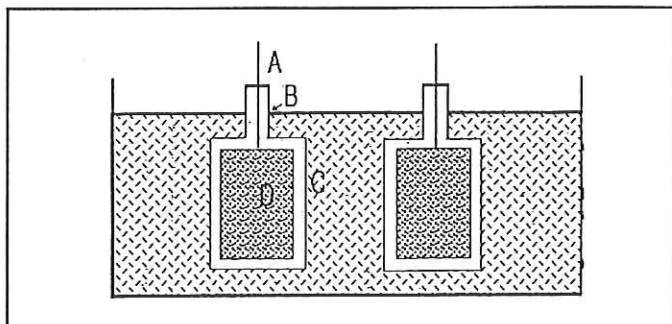


Figure 1
Two anodes immersed in fluoride solution
(letters A-D explained in text)

(1) See also Perfil de los Propiedades Dielectr. en capas finas de oxido anodico de tantalio, F. Climent, R. Capellades, E. Garcia, J. Gil, An. Quim. 84B 231 (1988).

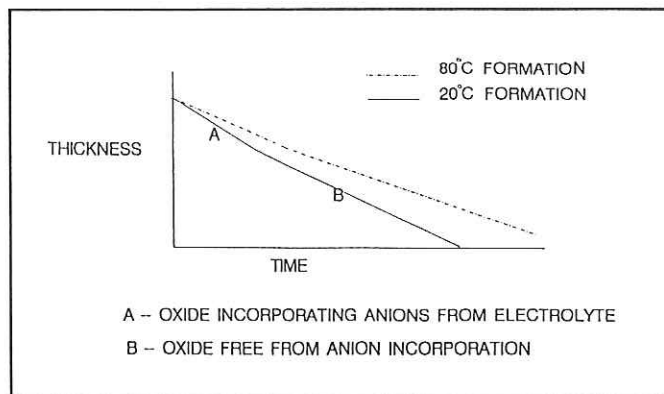


Figure 2
Dissolution of oxide on foil electrodes

Some 34 years ago D.A. Vermilyea determined the rate of dissolution of tantalum oxide on foil anodes using the colour of the film as a guide to its thickness. The dissolution rate (Figure 2) was found to vary depending on the temperature of anodisation (higher temperatures gave lower rates) and on the incorporation of anions from the electrolyte (rate increased by the inclusion of phosphate ions). Annealing the oxide also reduced the rate, probably by increasing the degree of covalency in the tantalum to oxygen bonds.

The steady dissolution of the tantalum oxide found with foil anodes must also apply to sintered anodes, except that the rate inside the anode might be slower because of depletion of fluoride in the narrow pores. Therefore the sudden apparent drop in thickness observed in the new test must require a different explanation. In the paper by Schmidt and Capellades an equivalent circuit as A in Figure 3 was suggested as representing the behaviour of the two anodes in the fluoride solution. This simplifies to circuit B which can be readily analysed using a standard capacitance meter. It is the burden of this article that the use of this equivalent circuit leads to false conclusions and that the behaviour needs to be interpreted as in circuit C.

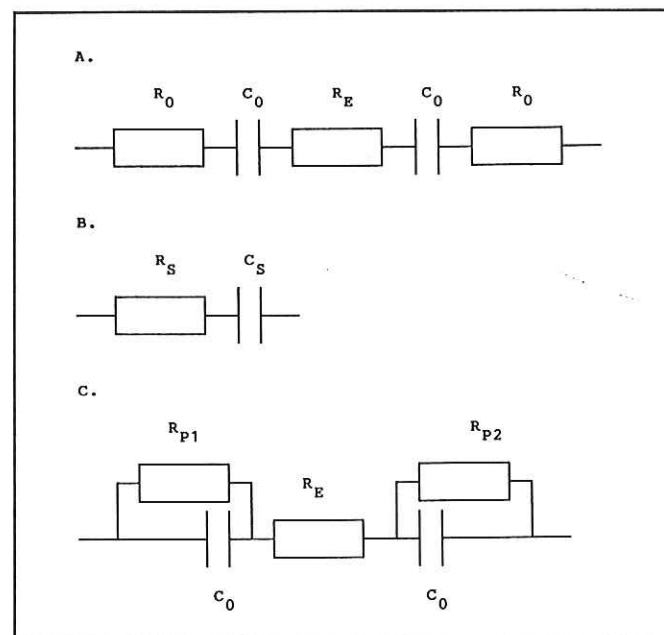


Figure 3
Equivalent circuits:
A. As given in paper by Schmidt and Capellades
B. As assumed during capacitance measurement
C. As suggested in this article

The additional resistors in parallel with the capacitors represent the leakage paths generated when the fluoride etches holes through the oxide. Such preferential etching has negligible effect on the overall colour and so were not a factor in the previous work with foil.

The measuring equipment cannot interpret the electrical behaviour of circuit C directly and has to present its data as a simple combination of a capacitor and a resistor in either series or parallel orientation. Usually for tantalum capacitors only the series combination is used to express the results i.e. circuit B is assumed.

The effect of the preferential etching can be calculated assuming different values for the resistance at the holes. In the following table the two anodes are taken to have a true capacitance of 10 μF each and

the resistance through the etched holes is assumed to be identical at both anodes. The value of the resistance of the fluoride does not affect the present calculations. The calculations are based on a frequency of 120 Hz as is normal for tantalum capacitors. As the resistance decreases the apparent capacitance increases and so the thickness of oxide appears quite erroneously to decrease. This apparent change comes about purely because the equipment is taking the values from circuit C and reporting them as though it is working with circuit B.

Hole resistance (ohms)	Apparent capacitance (μ F)	Apparent thickness (%)
infinity	5.00	100
1000	5.35	93
100	40.2	12.4
10	3525	0.14
1	352000	0.0014

Thus it can be seen that a sudden apparent decrease in oxide thickness can be indicated by the capacitance measurements when no actual change has occurred over the majority of the area. The way the measurement is carried out is indicating a change of capacitance whereas what is happening is a change in the resistance in parallel with the capacitance.

Under the electron microscope the nature of the low resistance regions can be observed. It appears that the fluoride penetrates at a few isolated sites and then spreads out sideways affecting the bonding between the oxide and the tantalum causing small flakes of oxide to break off. As this happens sudden drops in resistance will occur with the apparent change in total thickness. The exposure of the tantalum substrate to the solution, especially when under the influence of the electrical measurement signal, causes the metal to go into solution. This dissolved tantalum is unstable and readily hydrolyses to produce cauliflower shaped deposits around the original hole. Under some conditions this can partially block off the current so increasing the resistance of the hole and giving a partial recovery of the apparent thickness.

Once these aspects are understood it is possible to go back to the original procedure to improve certain aspects and so achieve better reliability and also to suggest an alternative measurement sequence which, although it is more involved than the simple capacitance measurement, will tell the true story of the effects being investigated.

Referring to Figure 1, four areas need special attention to avoid complications; these are indicated by the letters A-D and are described below.

A. Creepage of solution up the wire to contact welds etc. This can lead to low parallel resistance even without any attack on the main oxide film. The wire should be coated with a water repellent material (e.g. wax or silicone grease) to prevent creepage.

B. Preferential attack at the air/solution interface. This is a common feature of corrosion and again can be eliminated by coating the wire at this interface as in A.

C. Effect of currents and voltages from the measuring equipment. If a bias voltage is used for the capacitance determination, fluoride ions will be rapidly driven through the oxide at the positive electrode and so give enhanced attack at the tantalum to oxide interface. No bias may be used and the level of the a.c. signal must be kept as low as practical. The test signal should only be applied for the minimum time necessary to take a reading.

D. Slower rate of dissolution within the anode due to restricted availability of fluoride etchant. It is difficult to eliminate this problem and so any comparative tests of powders should be made with the same physical size of anode and the same porosity; then the effects should be comparable.

The modified method for obtaining electrical data is as follows:

- set the equipment to read series resistance and capacitance;
- measure initial equivalent series resistance (ESR) with the anodes in the solution but before any significant attack has started;
- confirm that the initial total capacitance is half that of the individual anodes;
- measure the series resistance and capacitance at intervals;
- deduct the above ESR from the measured series resistance;
- convert the remaining resistance and the capacitance to the parallel equivalents using the following formulae.

$$C(\text{true}) = \frac{C(\text{measured})}{1 + [240 \cdot \pi \cdot C(\text{measured}) \cdot R(\text{difference})]^2}$$

$$R(\text{hole}) = R(\text{difference}) + 1/A$$

where $A = 570000 \cdot C(\text{measured})^2 \cdot R(\text{difference})$
and the capacitance values are in Farads.

If the attack is to the same degree on the two anodes this parallel capacitance can be a true indication of the thickness change. The resistance will be a function of the area of the localised attack, a low value implying extensive corrosion.

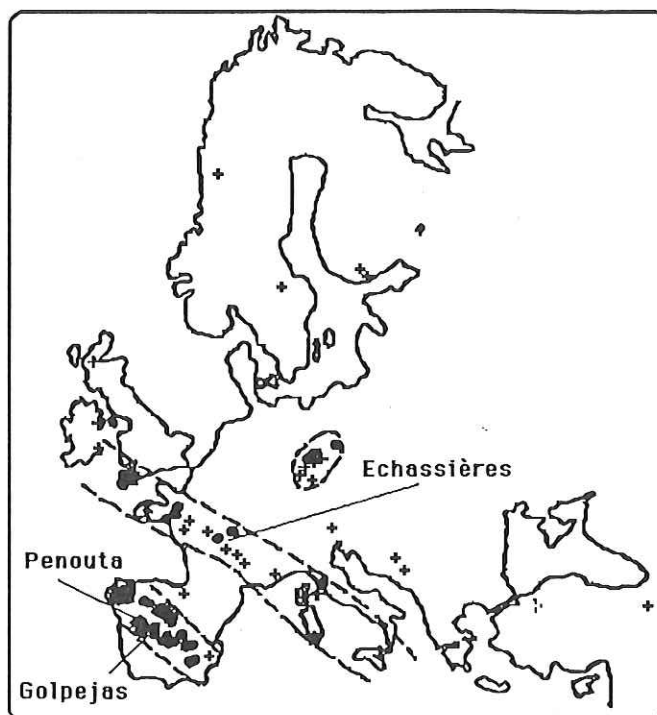
The final consideration is the fundamental question why one powder grade reacts differently from another. It appears that a very pure anode shows no sudden changes in the reciprocal capacitance plots. Therefore it is likely that such changes are related to the presence of impurity centres which either penetrate the whole thickness of the oxide layer or result in it being cracked or otherwise disrupted or to anodisation conditions which produce some breakdown effects. Either way they are also likely to have an undesirable effect on the DCL of the capacitor. The big advantage of this test would therefore be in its ability to highlight conditions of powder quality, sintering conditions or anodisation processing which would be expected to lead to DCL problems. It is hoped that this review of the method will allow it to be more fully utilised.

Tantalum- and niobium-bearing ores in Europe

(A précis of a paper presented at the October 1989 General Assembly of the T.I.C. by Dr. I. Gaballah of the Centre de Recherche sur la Valorisation des Minerais (CRVM), Vandoeuvre, France)

Tantalum- and niobium-bearing ores are to be found in Europe, often in conjunction with tin, but they usually contain less than 0.1 % of the oxides. The total known European reserves of Ta_2O_5 for example are estimated at 20 000 tons but the deposits are rarely of economic size.

The three mines considered in the paper are all in the "tin belts" described by Schuiling to the 1967 London conference on tin (Figure 1).



- Tin deposits (economic or marginal)
- + Uneconomic occurrence
- Approximate limit of tin belts

Figure 1
Tin belts in Europe.

In the case of the two Iberian deposits of Penouta and Golpejas the tantalum and niobium occur with tin, wolframite and rare earth minerals (such as monazite and xenotime) in the form of tantalocolumbite. This mineral also appears at the Echassières mine in France, but the greater proportion of the tantalum and niobium there (especially the finer fractions) is present as microlite. Typical analyses of the minerals from the three mines are shown in Figure 2.

It will be noted that the microlite contains uranium in significant quantities. This introduces a commercial complication in that concentrates of tin or of TaNb which contain uranium could prove difficult to transport and sell to processors in countries with strict controls on the import of radioactive materials.

Tantalum and niobium bearing minerals
of the Echassières concentrates

	Ta ₂ O ₅	Nb ₂ O ₅	UO ₂	WO ₃	CaO	Na ₂ O	PbO	BaO	Ta ₂ O ₅ /Nb ₂ O ₅
Tantalo-columbite	23.47	53.32	N.D.	1.54	N.D.	N.D.	N.D.	N.D.	0.52
Microlite	59.62	16.00	6.55	3.06	1.40	0.75	1.28	2.24	4.96
Cassiterite	1.70	1.09	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	1.56

Average chemical composition of
concentrates of tantalo-columbite

Origin	Ta ₂ O ₅	Nb ₂ O ₅	FeO	MnO	Ta ₂ O ₅ /Nb ₂ O ₅	FeO/MnO	Ta+Nb/Fe+Mn
Echassières	23.47	53.32	4.13	14.47	0.52	0.38	4.14
Penouta	37.38	42.70	4.33	12.39	1.50	0.41	4.86
Golpejas	35.20	42.50	10.16	6.45	0.89	1.80	4.70

Figure 2

Conventional mineral dressing can produce saleable concentrates of tin and tantalo-columbite, but, at present prices, the projects are barely viable, and the research done at CRVM has focussed on improving recovery and separation of the valuable constituents particularly from the stockpiled tailings. These already contain for example 15 times the tantalum concentration of the raw ore from which they derived.

The work has taken two routes, chlorination and high temperature vaporisation.

Chlorination of tantalo-columbite with a mixture of Cl₂-CO-N₂ at 1 000 degrees Celsius produces preferential volatilisation of niobium, so that the ratio of Ta₂O₅ to Nb₂O₅ increases from 0.4 to 5.6, and this can be further improved if the mineral is better separated from silico-aluminates (say by very high intensity magnetism). When microlite is chlorinated, the uranium stays with the tantalum in the residue, but there is an indication that the two elements may be separated as a result of the formation of binary chloride compounds. Tin is totally eliminated by the process.

High temperature treatment of tantalo-columbite either in a solar furnace (Figure 3) or a rotating plasma furnace (Figure 4) with oxygen at 2 700 degrees Celsius volatilised most elements, leaving a tantalum residue containing up to 80 % Ta₂O₅, with a recovery of approximately 96 %. The order of volatilisation was shown to be Sn; Si; U; Fe + Mn; Nb + Ti; Al; Ta. As would be expected from this, the same treatment applied to microlite permits the elimination of uranium.

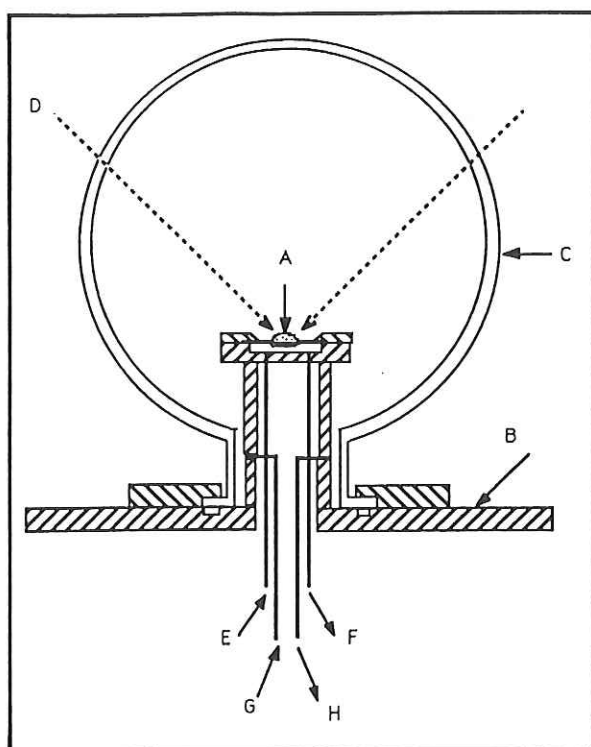


Figure 3

Solar experiment equipment : A. Sample; B. Holder; C. Pyrex spherical vessel; D. Concentrated solar radiation; E-F. Water cooling system; G-H. Gas inlet and outlet.

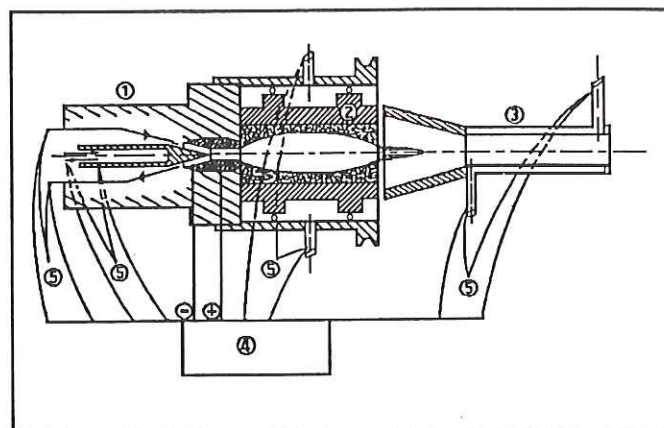


Figure 4

Rotating plasma furnace : 1. Plasma torch; 2. Rotating furnace; 3. Heat exchanger; 4. Data collector; 5. Differential thermocouple.

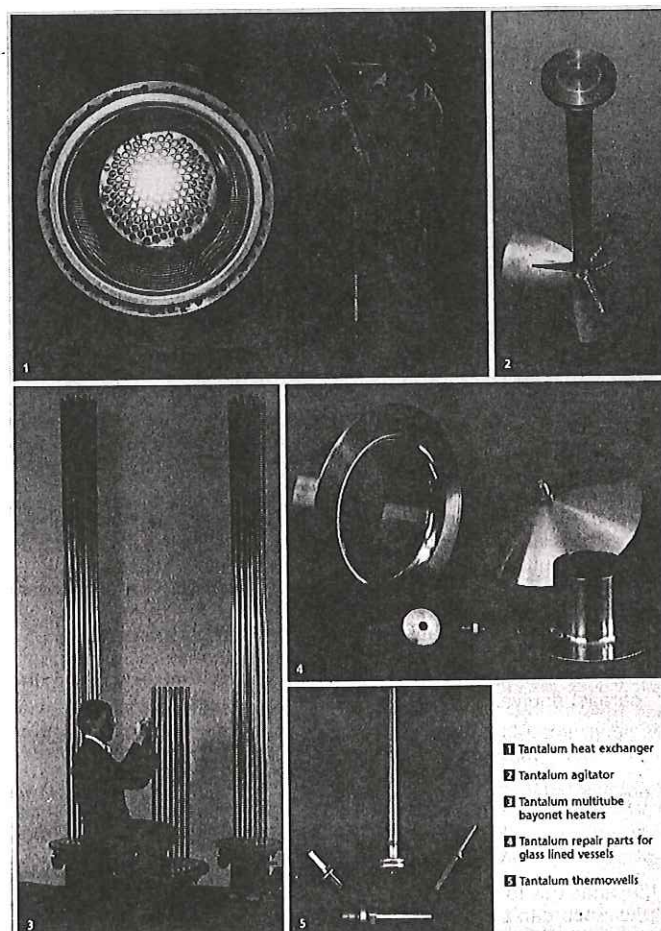
In reply to a question, Dr. Gaballah said that in the present market the proposed processes are not economic, but they clearly have considerable potential.

New members

Four of the new members, who joined at the time of the Frankfurt General Assembly in October last year, have given us details of their activities. Between them, they represent well the broad diversity of the T.I.C.'s membership which currently numbers sixty-eight.

1. Alex Stewart (Assayers) Ltd., Knowsley, England.

The company, which is privately owned, offers a service based on its Head Office on Merseyside, for the sampling and assaying of base metal ores and concentrates, metal scrap, precious metals, industrial minerals and general commodities. The main laboratories and administration are at Knowsley, but other offices and laboratories are situated in London (England), Santiago (Chile), and Lima (Peru). Technical sampling staff are located worldwide, and they



Some uses of tantalum by Climax Special Metals Fabrication.

cover not only the sampling of shipments, but also supervisory services for the loading and discharge of bulk shipments, vessel draft surveys, and certified weighing, sampling and moisture determination.

2. *Climax Special Metals Fabrication Ltd., Brentwood, Essex, England.*

Special Metals was 21 years old in 1989 and in its lifetime the staff has grown from two people to 65: its main products have, however, remained centred on molybdenum, tungsten and tantalum. Since 1988 it has been part of Climax Metals, Amax Corporation, which is one of the world's leading molybdenum companies among many other activities, so it is now even more involved in molybdenum and tungsten wrought products and fabrications.

However, its tantalum interests remain and it regards itself as one of the leading European fabricators of equipment in this metal.

Its range of supply goes from rolled sheet produced in its U.K. rolling mills at West Horndon to equipment of all sizes from nuts and bolts and glass vessel repair kits through crucibles, agitators, furnaces, etc. up to large bayonet, shell and tube heat exchangers. It offers a full technical and mechanical design service with its products and over the years has exported equipment worldwide. Some examples of its work in tantalum are shown in the accompanying photographs.

3. *Ethiopian Mineral Resources Development Corporation, Addis Ababa, Ethiopia.*

EMRDC was established in December 1982 as an autonomous government-owned body, with the objects of:

- (i) conducting detailed exploration of known mineral deposits (other than oil-based),
- (ii) developing economic mineral deposits,
- (iii) producing and processing minerals, and
- (iv) participating in joint ventures for the development, production and sales of minerals.

Since 1982 it has tried to diversify its activities away from the age-old alluvial gold mining for which Ethiopia is well known: in recent times it has concerned itself for example with primary gold, tantalum, soda ash, gemstones, ceramic raw materials and platinum.

One area of the country, Adola in the south east, has been closely examined under a development project which has resulted in the discovery of the Lega Dembi primary gold deposit (of which stockpiling is now underway and commissioning of the treatment plant imminent), the Kenticha rare metals deposit of tantalum- and niobium-bearing pegmatites (now the site of a 20 t.p.a. tantalite pilot plant) and some further gold and industrial mineral deposits. In the Rift Valley lakes, a pilot plant is now producing 20 000 t.p.a. of soda ash, with a projected tenfold scale up.

EMRDC currently employs 2450 people throughout Ethiopia (Addis Ababa plus nine branch enterprises and projects).

4. *Institut National de Recherche Chimique Appliquée, Vert-le-Petit, France.*

IRCHA is a state-controlled institute established in its present form in 1958 and specialising in research and predevelopment in the fields of chemistry and the environment. About 40 % of its resources are derived from the Ministries of Industry and Finance, the balance from French, foreign or international (especially EEC) public or private agencies, and also from the sale of fine chemical products for which the Institute is not competing with French industrialists.

Of particular interest to the T.I.C. is the work of the Institute on hydrometallurgy, including the study of new extraction media, and the development of supported liquid membrane technology. It is currently developing a new hydrometallurgical process for the separation and recovery of tantalum and niobium in ores and tin slag.

SYMPOSIUM PROCEEDINGS

Some copies of the Proceedings of the International Symposium on Tantalum and Niobium held in Orlando, Florida, in 1988 are still available, \$ US 80 including post and packing. Apply to the T.I.C. with your order.