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TIC

TANTALUM-NIOBIUM INTERNATIONAL STUDY CENTER

INFORMAL MEETING

On the morning of Tuesday April 27th 1993 delegates are invited to join members of the Executive Committee for informal discussions at 40 rue Washington, 1050 Brussels, followed by lunch. The Committee will report on its meeting to be held on April 26th, and in particular on the progress of plans for the General Assembly in October.

GENERAL ASSEMBLY IN VIENNA

The Thirty-fourth General Assembly will take place in Vienna on October 5th 1993. The conference will open with the traditional reception on Monday October 4th, and following the Assembly on Tuesday there will be a full programme of technical presentations, with a gala dinner in the evening.

On October 6th participants will be taken to Treibach by bus for a plant tour of Treibacher Chemische Werke, returning to Vienna in the evening at the close of the meeting.

Invitations will be sent to member company delegates some two months before the meeting. Others who might be interested in attending should contact

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SUMMARY

PRESIDENT'S LETTER

This newsletter should arrive at your desk near the arrival of Springtime, a good time to consider attending the T.I.C. meeting in Brussels. This informal meeting provides a useful opportunity to review the current situation of our industry with other T.I.C. members and delegates and, most importantly, to contribute your insights.

The months since the conclusion of our General Assembly have included a number of important holidays throughout the world and it is rather difficult to draw a clear picture of the prospects for our industry. However, change continues to be the most predictable feature of our environment. The short time since we met in Phuket has already brought a new administration in the United States, clear improvement in the U.S. economy, a mellowing of expectations for "Europe 93", major questions regarding the future directions of world trade and other micro and macro changes which will undoubtedly influence our industry.

The tantalum/niobium industry continues to see changes in the form of further consolidations, vertical integration, and the departure of familiar participants. In common with most commodity-based industries our business will continue to be driven by the imperative of doing more with less, that is, providing greater value to its customers and users. Success in this environment means focusing on higher-grade, higher-quality products and searching out new applications where our materials can be particularly valuable to a product or process. It is in this latter area that the T.I.C. must do more if it is to be of real worth to its membership.

Best wishes,

Peter Maden
PRESIDENT

TANTALUM POWDER : PAST, PRESENT AND FUTURE

A resumé of a talk given by Mr David Maguire (Chairman and C.E.O. of Kemet Corporation) to the T.I.C.'s Phuket meeting in November 1992.

I have recently been looking through the T.I.C. tantalum statistics with our Technical Adviser and using them to prepare some material balances for the metal, and then looking more closely at tantalum powder production and usage. I will show them in graphical form and give my observations on the figures, and finally I will review trends in capacitor consumption.

My first chart (1) shows the material balances for the five years 1988 to 1992 (final year is first half times two).
The hard numbers from the T.I.C. are given in large bold type,

T.I.C. STATISTICS

TANTALUM

PRIMARY PRODUCTION

(quoted in lb Ta_2O_5 contained)	*4th quarter 1992*
Tin slag (2 % Ta_2O_5 and over)	52 863
Tantalite (all grades), other	143 441
Total	196 304

Note : 14 companies were asked to report, 14 replied.
The companies which reported included the following, whose reports are essential before the data may be released :
Datuk Keramat Smelting, Gwalia/Greenbushes, Malaysia Smelting, Mamoré Mineraçao e Metalurgia, Metallurg group, Pan West Tantalum (Wodgina Mine production), Tantalum Mining Corporation of Canada, Thailand Smelting and Refining

QUARTERLY PRODUCTION ESTIMATES

(quoted in lb Ta_2O_5 contained)

LMB quotation :	*US $ 30*	*US $ 40*	*US $ 50*
1st quarter 1993	314 000	341 000	353 000
2nd quarter 1993	314 000	391 000	403 000
3rd quarter 1993	314 000	391 000	453 000
4th quarter 1993	314 000	391 000	453 000
1st quarter 1994	314 000	391 000	453 000

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

PROCESSORS' RECEIPTS

(quoted in lb Ta contained)	*4th quarter 1992*
Primary raw materials (e.g. tantalite, columbite, struverite, tin slag, synthetic concentrates)	291 043
Secondary materials (e.g. Ta_2O_5, K_2TaF_7, scrap)	201 958
Total	493 001

Note : 18 companies were asked to report, 17 replied.

PROCESSORS' SHIPMENTS

(quoted in lb Ta contained)

Product category	*4th quarter 1992*
Ta_2O_5, K_2TaF_7, carbides	106 121
Alloy additive	29 322
Powder/anodes	243 046
Mill products	104 665
Ingot, unworked metal, other, scrap	19 129
Total	502 283

equivalent to 678 081 lb Ta_2O_5.

Notes :
In accordance with the rules of confidentiality, categories have been combined as shown.

Response : October 15/16, November 16/16, December 17/18.
For both receipts and shipments by processors, reports by the following companies are essential before the data may be released :
Cabot Performance Materials, W.C. Heraeus, Kennametal, Metallurg group, Mitsui Mining and Smelting, H.C. Starck Inc. (NRC), Showa Cabot Supermetals, H.C. Starck, Thai Tantalum, Treibacher Chemische Werke, Vacuum Metallurgical Company, H.C. Starck - V Tech

NIOBIUM

PRIMARY PRODUCTION

(quoted in lb Nb_2O_5 contained)	*4th quarter 1992*
Concentrates : columbite, pyrochlore	9 933 445
Occurring with tantalum : tin slag (over 2 % Ta_2O_5), tantalite, other	87 056
Total	10 020 501

Note :
15 companies were asked to report, 15 replied. The companies which reported included the following, whose reports are essential before the data may be released :
Cambior, Mineraçao Catalao de Goiás, Niobium Products Co. (CBMM)

PROCESSORS' SHIPMENTS

(quoted in lb Nb contained)	*4th quarter 1992*
Compounds and alloy additive : chemical and unwrought forms (e.g. $NbCl_5$, Nb_2O_5, NiNb, FeNb [excluding HSLA grades])	440 837
Wrought niobium and its alloys in the form of mill products, powder, ingot and scrap	
(i) Pure niobium	21 038
(ii) Niobium alloys (such as NbZr, NbTi and NbCu)	55 761
HSLA grade FeNb	5 791 732
Total	6 309 368

Note :
19 companies were asked to report, 18 replied. Reports by the following companies are essential before the data may be released :
Cabot Performance Materials, W.C. Heraeus, Kennametal, Metallurg group, Mitsui Mining and Smelting, Niobium Products Co. (CBMM), H.C. Starck Inc. (NRC), H.C. Starck, Teledyne Wah Chang Albany, Thai Tantalum, Treibacher Chemische Werke, Vacuum Metallurgical Company

CAPACITOR STATISTICS

CONSUMPTION BY AREA

(figures in millions of units)

	Average per quarter			
	1988	*1989*	*1990*	*1991*
North America	340	302	337	356
Europe	220	206	232	230
Japan	635	681	808	965
Rest of world	207	304	361	492
World	**1402**	**1493**	**1738**	**2043**

	1992			
Quarter :	*1st*	*2nd*	*3rd*	*4th*
North America	392	403	448	
Europe	245	259	216	
Japan	847	769	735	
Rest of World	541	637	592	
World	**2025**	**2068**	**1991**	

Source : Members' estimates

assumptions (mostly related to stocks) are given in bold italics, and derived numbers are in small bold type.

	1988	1989	1990	1991	1992 first 1/2 times 2
PRIMARY PRODUCERS					
Production (lbs of Ta oxide)	**1694**	**1638**	**1628**	**1450**	**1432**
Shipments (lbs of Ta contained)	1254	1212	1205	1073	1060
PROCESSORS (Ta contained)					
Beginning inventory	*5000*	4389	4185	4404	3881
Plus receipts	*1850*	*1850*	**2310**	**1481**	**1594**
Less shipments	**2461**	**2054**	**2091**	**2004**	**2012**
Ending inventory	4389	4185	4404	3881	3463
USERS (Ta contained)					
Beginning inventory	*1000*	1301	1195	1126	970
Plus receipts	2461	2054	2091	2004	2012
Less end consumption	*1800*	*1800*	*1800*	*1800*	*1800*
Less scrap recycle @ 20%	360	360	360	360	360
Ending inventory	1301	1195	1126	970	822

TIC DATA
ESTIMATED DATA
CALCULATED DATA

Chart 1 :
Tantalum metal summary balance (thousands of pounds)

If we start with the assumption that processors had 5 million pounds of contained tantalum in their inventories at the beginning of 1988, and in each of the first two years they received 1.85 million pounds for treatment (from January 1990 actual receipts have been reported), then their current inventory amounts to 3.5 million pounds, or 18 months' deliveries.

At the user level, if we begin with 1 million pounds of stock, and assume 1.8 million pounds net consumption each year and scrap recycle at 20 %, then we are showing an inventory at the end of 1992 of only five months' net consumption. I consider this to be consistent with the worldwide trend towards faster cycle times and lower inventories. [Readers can make their own assumptions on opening inventories, and may well have data on powder consumption that differs from mine, but I think the conclusion will be similar.]

My second chart (2) shows graphically the T.I.C. statistics for primary production of tantalum, split between tin slags and mineral sources (mostly tantalite). The shift away from tin slags is clearly shown. This has resulted from the low production of tin and the increased availability of relatively low-cost tantalite from Australia.

Chart 3 shows processors' shipments of tantalum products over the last five years. In 1988 shipments totalled 2.5 million pounds of contained tantalum, but price rises in January 1989 coincided with a 20 % fall in offtake to 2 million pounds annually, where it has since stayed. You will note a significant fall in the use of tantalum carbide, from 25 % of total shipments to 15 %.

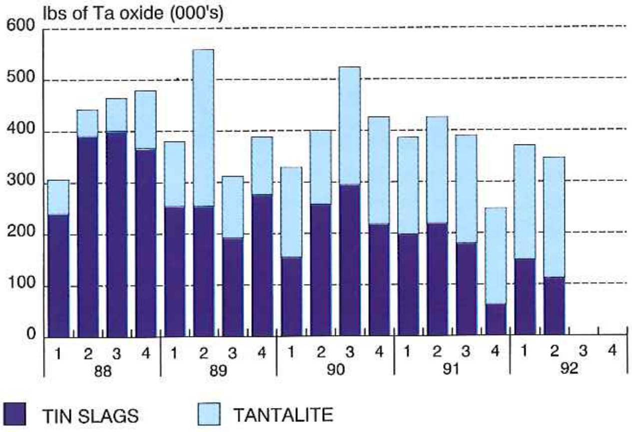

Chart 2 :
Tantalum raw material : primary production (T.I.C. statistics)

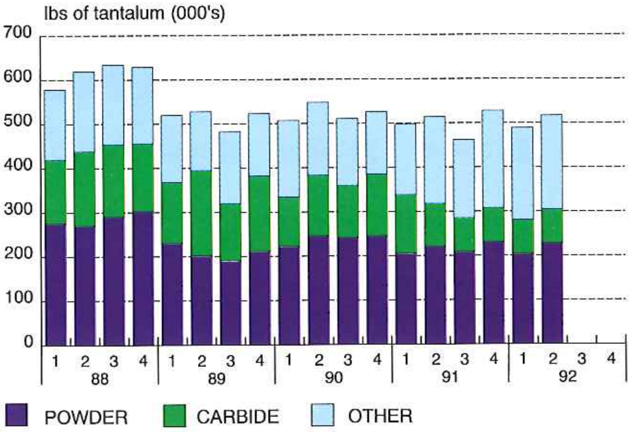

Chart 3 :
Tantalum production : processors' shipments (T.I.C. statistics)

Just under half of the total represents tantalum powder, shipments of this are shown in more detail separately by month on Chart 4. Anticipation of the price rise mentioned above resulted in very heavy purchases by consumers in the third and fourth quarters of 1988. Intake naturally dropped in 1989 while user inventories were worked off — fortunately it coincided with a period in which capacitor makers were at full production. Powder offtake now has stabilised at about 75 000 pounds per month.

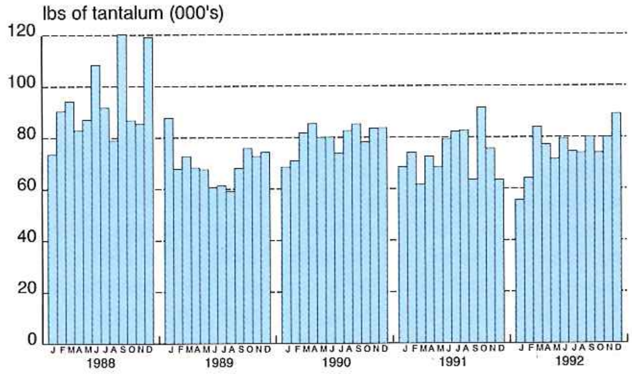

Chart 4 :
Tantalum powder : monthly shipments

Chart 5 shows tantalum capacitor consumption by region, from which it can be seen that U.S. consumption has grown since 1989 from 300 million pieces per quarter to the present 400 million. Europe is flat at an average of 225 million per quarter, but Japan showed a dramatic rise between 1988 and 1991 from just under 600 million to over 1 billion per quarter. Demand has fallen by 30 % in the past year as consumer demand has softened, and more manufacturing has moved offshore. This is in the "rest of the world" category, much of it in East Asia, and these markets (many being subsidiary companies of Japanese, European or U.S. parents) have shown a trebling of consumption in the five years being reviewed. Total world production was just under 6 billion units in 1988, and is over 8 billion units per year today. It is clear that recovery of Japanese demand would soon push this total beyond 9 billion.

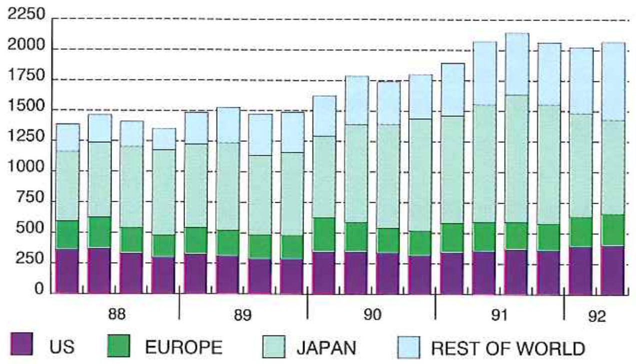

Chart 5 :
Tantalum capacitor market : quarterly consumption, by region (millions of units)

Chart 6 is produced from figures of powder shipment divided into the consumption of capacitors for each quarter. This gives the "learning curve" shown (inventory movements of powder account for most of the quarterly variations from the general line). You will see that the world is currently making 1 000 capacitors from 0.11 pounds of tantalum : in 1963 it took 4.0 pounds of powder to make the same number !

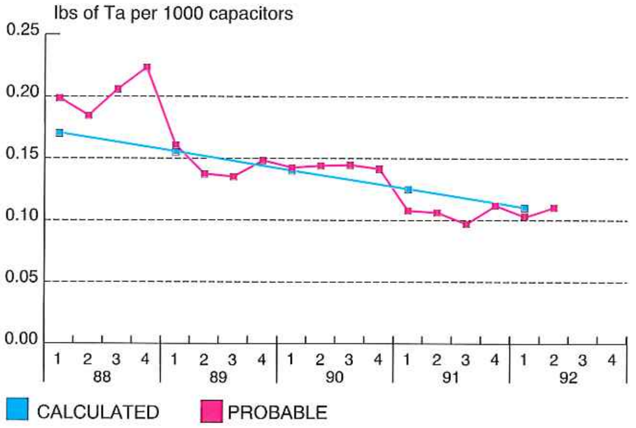

Chart 6 :
Tantalum powder usage : learning curve data

At the 1985 T.I.C. meeting in Boston, the diagram of Chart 7 was displayed and it shows the "learning curve" in a different way (against cumulative production in the United States). For many years there was a 30 % decline in powder used per unit each time the cumulative volume produced doubled. The 1980 price runaway in the tantalum industry so shocked the system that extraordinary efforts accelerated usage reduction (and incidentally depressed the market growth). As the cost pressures were relieved in 1984 it was then projected that usage reduction would return to the old slope. This has in fact happened. As U.S. cumulative production of capacitors passed 25 billion units in 1992, the usage rate was just over 0.125 pounds per thousand pieces.

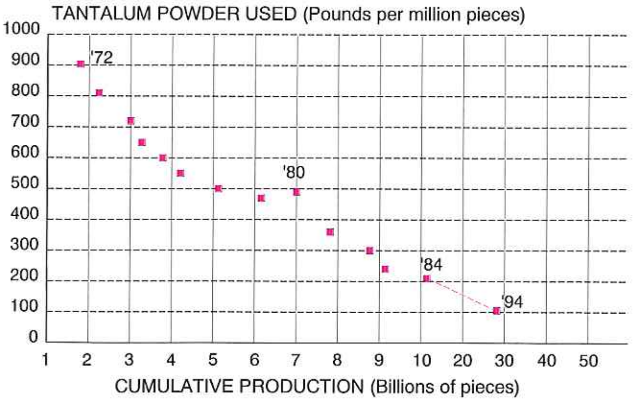

Chart 7 :
Tantalum powder usage

	1988			1992			Growth Rate	
	Quantity Billion	unit cost $/1000	Value $ Millions	Quantity Billions	unit cost $/1000	Value $ Millions	Quantity	Value
Ceramic (Single layer)	51	25	1296	52	21	1100	1	- 4
Ceramic (Multilayer)	66	25	1650	115	19	2200	15	7
Tantalum	6	186	1043	9	130	1200	13	4
Aluminium	46	74	3395	50	70	3550	2	1
Film	18	79	1449	20	76	1540	2	2
Other	1	286	200	1	275	210	2	1
Total	188	48	9033	248	40	9800	7	2

Chart 8 :
Capacitor market : worldwide total

Chart 8 compares the markets for tantalum capacitors and their competitors. Tantalum has shown a 13 % annual quantity growth rate since 1988 (second only to a multilayer ceramic), but the learning curve works on prices as well as powder consumption, so annual value growth has been only 4 %.
It is important to note that if we could drive the cost of tantalum capacitors closer to that of aluminium capacitors, there could be a very large growth in sales volume (industry currently uses more than five times as many aluminium capacitors as tantalum).

To summarise the economic factors in tantalum capacitor manufacture over the past five years :

1. The amount of powder used annually is flat.
2. The price has increased by 14 % per year.
3. The number of capacitors produced has grown at the rate of 13 % per year.
4. The average unit price of capacitors has declined at the rate of 8 % per year.

As a result, the tantalum capacitor industry value has increased by only 4 % per year. The cost of the powder, as a proportion of total direct cost of capacitors, has increased from 21 % to 31 % in the five-year period. This indicates very clearly how the future health and potential growth of all three elements of the tantalum industry — producers, processors and capacitor-makers — are today even more closely linked.

ENERGY CONSUMPTION IN THE EXTRACTIVE METALLURGY OF NIOBIUM AND TANTALUM

(Notes on a talk given by Dr Peter Paschen, Montanuniversitat, Leoben, Austria, to the T.I.C. meeting in Phuket, Thailand on November 17th 1992.)

Every stage in the preparation of niobium (or ferroniobium) and tantalum from the appropriate mineral deposit (usually pyrochlore for niobium, columbite or tantalite for tantalum) involves an expenditure of energy, and it is instructive to determine what the total expenditure is for different source materials and process routes and alternative technologies.
The typical flowsheets for niobium and tantalum are shown in figures 1 and 2 respectively.

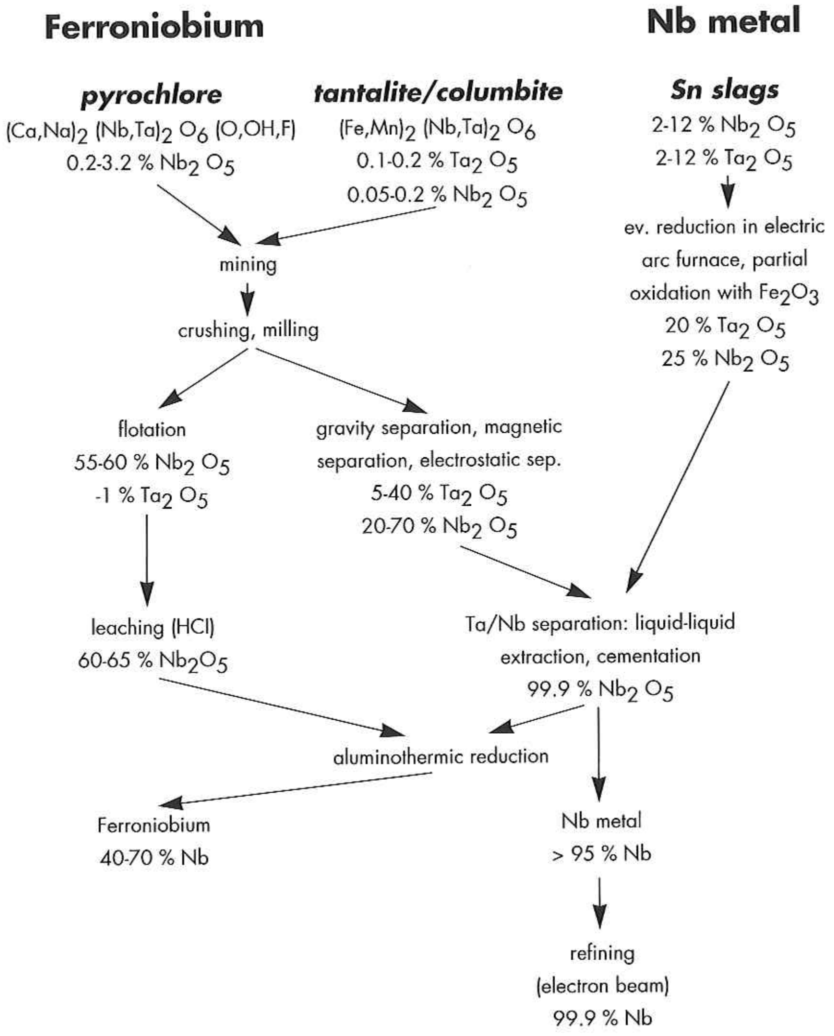

Figure 1 :
Metallurgical flowsheet for niobium

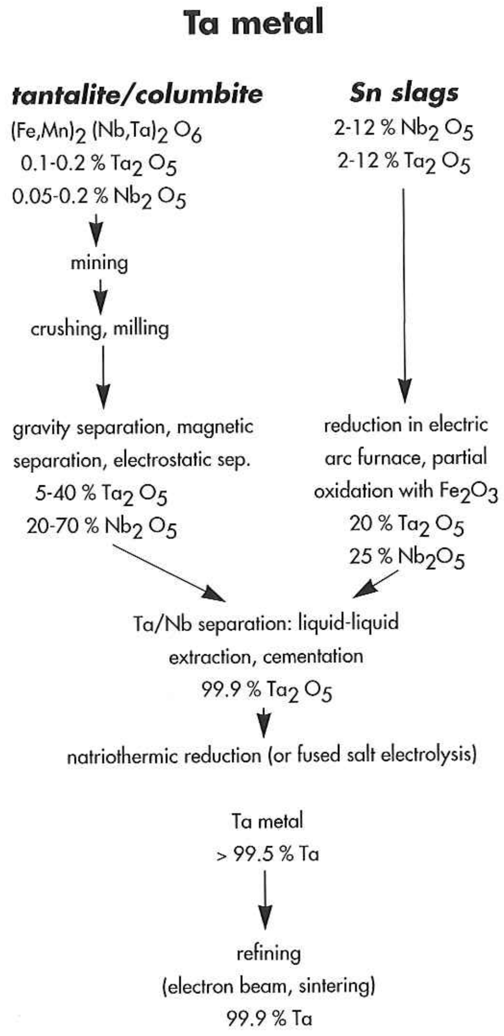

Figure 2 :
Metallurgical flowsheet for tantalum

We can put values on the energy consumed at each stage for the preparation of the three metal products (ferroniobium, pure niobium and pure tantalum) with which we are concerned, but first we must specify values for the sources of that energy. Electricity is the most common source and the theoretical conversion is 1 kWh = 3.6 Megajoules (MJ). However, after allowing for generation efficiency and losses in distribution, this efficiency is only 36 %, so we have used 1 kWh = 10 MJ in our calculations. Other sources of energy considered are fuel oil (1 kg = 41 MJ), natural gas (1 m^3 = 32 MJ), coal (1 kg = 29.6 MJ), and electrode graphite (1 kg = 144 MJ).

FERRONIOBIUM

The literature indicates the energy cost for the mining of one ton of niobium ore (at 3 % Nb_2O_5,or 2.1 % Nb) is 78 MJ. This however must be adjusted for the niobium recovery in mining and ore dressing (taken as 65 %), and the recovery in reduction metallurgy (taken as 86.5 %). After applying these corrections, mining energy cost *per ton of FeNb* at 60 % Nb is 3.55 Gigajoules (GJ).

Mineral dressing is quite energy intensive, not just from the use of electricity in grinding, flotation and calcining, but also from the consumption of such materials as flotation agents and steel balls for comminution. Leaching with HCl is, by comparison, cheap in energy cost.

Reduction is, as would be expected, the principal consumer of energy, almost all in the form of aluminium powder (which was itself produced by an electrical process).

Mining	78 MJ/t crude ore	
	= 3.55 GJ/t FeNb	
Dressing	6.89 GJ/t FeNb	comminution
	7.90 GJ/t FeNb	flotation
	3.03 GJ/t FeNb	calcining
	0.24 GJ/t FeNb	leaching (HCl)
	3.03 GJ/t FeNb	calcining
Reduction	147.02 GJ/t FeNb	reagents
		135.27 GJ/t for aluminium
Total	171.66 GJ/t FeNb	
	~ **172 GJ/t FeNb**	

Figure 3 :
Energy consumption for production of ferroniobium

The grand total of energy consumed in the production of ferroniobium is 172 GT/ton; the details are given in figure 3.

NIOBIUM METAL FROM ORE

Much of pure niobium has been traditionally recovered from columbite ores which are found in much lower concentrations than those of pyrochlore (0.1 % Nb_2O_5 against 3.0 % Nb_2O_5).

If we take mining energy cost per ton of ore as the same in both cases then the cost is much greater per ton of niobium recovered. * It would be even greater than that shown in the schedule if not for the credit given for the co-production of tantalum. Ore dressing, including some comminution, tabling and magnetic and electrostatic separation is expensive in energy because of the relatively low grade of feed.

The separation of the niobium from tantalum and the purification of the resulting oxide involves several energy intensive steps. Leaching with hydrofluoric acid (which has an energy content of 17 GJ per ton) requires 1.8 tons of acid for each ton of niobium, and the ensuing liquid-liquid extraction incurs energy expense in consumption of the organic phase and for electrical power. Precipitation and filtration, with final calcining to produce a 99.9 % pure niobium oxide, result in a grand total for the separation of 87 GJ per ton.

The oxide is reduced with aluminium, in a similar way to that used for producing ferroniobium, but an additional step is required for refining which is effected by electron beam melting. In the latter, energy is not only consumed in the melting as such, but also in vacuum pumping and water cooling. The energy consumption is estimated at 76 GJ per ton of niobium, and this brings the grand total of energy required to produce a ton of pure niobium metal to 369 GJ (see figure 4).

Mining	78 MJ/t crude ore = 37.49 GJ/t Nb	
Dressing	9.88 GJ/t Nb	comminution
	5.77 GJ/t Nb	gravity separation magnetic separation electrostatic separation
Nb/Ta separation	0.25 GJ/t Nb	grinding
	35.32 GJ/t Nb	leaching
	29.69 GJ/t Nb	liquid-liquid extraction
	18.24 GJ/t Nb	precipitation, filtration
	3.71 GJ/t Nb	calcining
Reduction	151.80 GJ/t Nb	reagents 133.14 GJ/t for aluminium
Refining	76.50 GJ/t Nb	EBM
Total	368.65 GJ/t Nb **~ 369 GJ/t Nb**	

Figure 4 :
Energy consumption for production of niobium metal (from ores)

NIOBIUM METAL FROM TIN SLAGS

In this case, there is no mining step (but it should be pointed out that the tin metallurgists have already paid the energy bill !). In place of mineral dressing, we have, in the case of lower-grade tin slags (say, those with less than 5 % each of Nb_2O_5 or Ta_2O_5), a pyrometallurgical concentration in an arc furnace to produce "synthetic concentrate" (see figures 1 and 2).

This is estimated to cost 25 GJ per ton of niobium, and the effect on the overall energy cost of producing the niobium metal is to bring the total down to 341 GJ (high-grade tin slags can go straight into the Nb/Ta separation for a further saving of 25 GJ).

TANTALUM FROM ORES

Much the same sequence is followed for tantalum, but the following differences are important in energy terms :

(1) The cost per ton of resulting metal is significantly less for tantalum where reduction is involved because of its greater atomic weight (181 against 93).

(2) Precipitation of the tantalum in its separation from niobium is by potassium fluoride as the double fluoride, a cheaper route than that of niobium by ammonia as niobic acid.

(3) Sodium is used to reduce the fluoride of tantalum, as opposed to aluminium for the oxide of niobium. The cost of reductant (whose amount is influenced by consideration (1) above) plus that of other minor consumptions come to 108 GJ per ton in the case of tantalum against 152 GJ for niobium.

(4) In some cases, it is sufficient to refine tantalum metal by sintering by direct current traverse, or by melting in an arc furnace, thus avoiding expensive electron-beam melting. The arc remelting is estimated to cost 25 GJ/ton against 96 GJ/ton for EBM.

The total energy cost is shown in detail in figure 5.

Mining	78 MJ/t crude ore = 37.49 GJ/t Ta	
Dressing	9.88 GJ/t Ta	comminution
	5.77 GJ/t Ta	gravity separation magnetic separation electrostatic separation
Nb/Ta separation	0.25 GJ/t Ta	grinding
	35.32 GJ/t Ta	leaching
	29.69 GJ/t Ta	liquid-liquid extraction
	11.11 GJ/t Ta	precipitation, filtration
	3.71 GJ/t Ta	calcining
Reduction	108.20 GJ/t Ta	reagents + heating energy 98.36 GJ/t for sodium
Refining	25.00 GJ/t Ta sintering	96 GJ/t Ta EBM
Total	266.42 GJ/t Ta **~ 266 GJ/t Ta**	337.42 GJ/t Ta **~ 337 GJ/Ta**

Figure 5 :
Energy consumption for production of tantalum metal (from ores)

TANTALUM FROM TIN SLAGS

As in the case of niobium, energy costs in treating slags are less than those of ores by the omission of the mining and dressing stages, but addition of arc furnace smelting in the case of lower-grade slags.

CONCLUSIONS

A summary of all the above calculations is shown in graphical form in figure 6. Not surprisingly, the preparation of ferroniobium (for use as an additive in steel-making) is far less energy intensive than that of high purity niobium and tantalum metal. The reduction stage, mostly by consumption of aluminium, is the most expensive (which justifies the recent surge of interest shown in the technical literature in the development of carbothermic processes for niobium and FeNb production : Ed.).

The diagram indicates just how much energy is required for the Nb/Ta separation, and for reduction (by metals which themselves have consumed a very high amount of secondary energy — electricity — in their production). These are clearly fruitful areas for research. In the case of reduction, interest is strong in fused salt electrolysis, and in Leoben tantalum has been produced at energy consumption figures between 15 and 30 GJ/ton. There are, however, still many problems to be resolved.

A final observation : if the reduction step could be made to yield a higher purity metal, then much of the high energy cost for refining could be saved.

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* This may go some way towards explaining the development work at this time on the recovery of niobium direct from pyrochlore or ferroniobium. Ed.

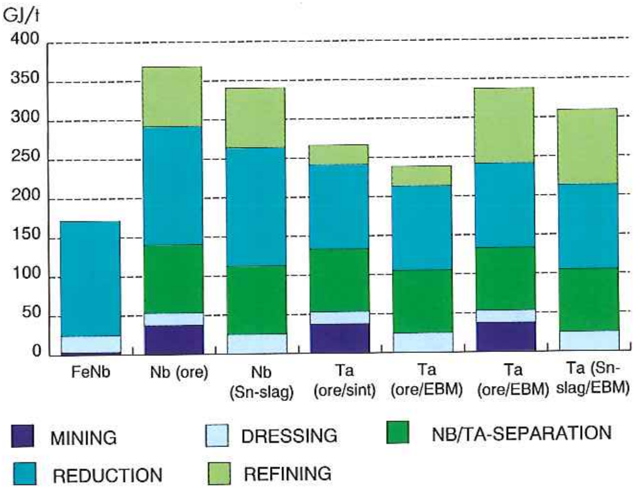

Figure 6 :
Energy consumption in the extractive metallurgy of tantalum and niobium

TANTALUM WIRE AND ROD AT H.C. STARCK INC.

by Mr Gerard J. Villani, Product Manager for the wire group at H.C. Starck Inc., Newton, Massachusetts

Tantalum wire production at H.C. Starck Inc. at Newton in the United States is a unique marriage of chemistry and metallurgy, high vacuum, high temperature and metalworking technology and personnel with over 50 years of experience in the industry. Its NRC(tm) brand of high quality products derives its name from National Research Corporation, which was founded in 1940 as a company specializing in research and development, including the extraction and refining of refractory and reactive metals such as titanium, zirconium, hafnium, tantalum and niobium.

In 1976, NRC Inc. became a member of the Hermann C. Starck Group. By the end of 1992, the name "NRC Inc." was changed to H.C. Starck Inc. when HCST's New York sales office, which sells molybdenum, tungsten, tantalum, niobium, rhenium, their compounds and a host of other space age materials from its European facilities, was merged with the Newton facility. Similar mergers took place at the same time between H.C. Starck Japan Ltd. and V Tech Corporation in Japan. The name "NRC" was retained as a trade mark to distinguish the products made in HCST's Newton facility from those made elsewhere.

Today, HCST's Newton facility manufactures tantalum and niobium products for the electronic, chemical, aerospace and nuclear industries. Among these products are high capacitance tantalum powders and stabilized tantalum wire for the electrolytic capacitor industry. In the manufacture of electrolytic capacitors, tantalum powder is pressed and sintered at high temperatures with a tantalum lead wire as the anode conductor. Electrolytic capacitors may be found throughout high tech consumer and industrial equipment, including computers and communication equipment. The consumption of tantalum wire is expected to grow faster than that of tantalum powder as capacitors become smaller but more numerous.

The Newton facility is one of the world's largest tantalum and niobium production facilities of its kind. It is completely integrated with research, development and testing laboratories along with a full range of manufacturing systems, including powder production, arc melt, plasma melt and electron beam melt, forging, rolling, swaging, drawing, heat treating and fabricating.

As an addition to the Newton facility, HCST acquired Fansteel's tantalum mill products and wire assets and transferred them to the Newton complex where they became fully operational by 1991. One of the unique aspects of the Fansteel acquisition was the powder metallurgy route for making capacitor grade tantalum wire. The two brands, TPX and GPX, are highly desired by the capacitor industry because of their grain size stability, electrical characteristics and other physical properties.

View of the wire plant

Powder metallurgy wire begins with a special mixture of tantalum powders produced in Newton. The powder blend is compressed under very high pressures and sintered at high temperatures in vacuum furnaces with powerful electrical equipment. The sintered bars are then rolled into coarse rods using heavy equipment, and subsequently formed into finer rods with moderately sized machines. Throughout the rod rolling process, the metal work-hardens and must be annealed periodically in large, high temperature, vacuum furnaces designed for this purpose. The rods are progressively drawn into fine wire using staged wire drawing machines and space age lubricants.

The final wire product, which is available in four basic tempers : annealed, half-hard, hard and extra hard is straightened and spooled for delivery to customers world wide under the NRC(tm) brand of TPX and GPX wire. Sales and service are also made through sister divisions of HCST Newton in Tokyo, Japan (H.C.Starck/V Tech Ltd) and Goslar, Germany (H.C.Starck GmbH & Co. KG).

Throughout the wire manufacturing process, HCST's extensive analytical and metallurgical testing facilities in Newton provide the necessary testing and statistical process control to ensure high quality wire with respect to chemical, electrical and metallurgical properties. These laboratories are also available to provide technical support to customers and to assist in the development of new materials.

As can be seen, the manufacture of tantalum wire at H.C. Starck Inc. is a highly capital and labor intensive process requiring a variety of technologies and skills, equipment and processes that are uniquely suitable to the HCST Newton facility. In addition, the capacity at Newton is sufficient to supply high quality wire for all of HCST's customers for the foreseeable future.

Tantalum wire produced at HCST Newton

INDUSTRY SURVEY OF T.I.C. MEMBERS

Products offered for sale by T.I.C. members (those which replied to our survey)

	Raw materials							Compounds								
	Tantalite	Columbite	Struverite	Tin slag	Pyrochlore	Synthetic concentrate	Other	Tantalum oxide, standard-grade	Tantalum oxide, optical-grade	Tantalum oxide, ceramic-grade	Potassium fluotantalate	Niobium oxide, standard-grade	Niobium oxide, optical-grade	Niobium oxide, ceramic-grade	Potassium fluoniobate	Other
AVX																
Cabot Performance Materials								●	●	●	●	●	●	●		
Cambior					●											
Catalao de Goias																
Cerex																
Ethiopian Mineral Resources	●															
Goldrim Mining	●															
Gwalia/Greenbushes	●			●												
Heraeus																
Intermet Resources																
Kennametal																
Alfred H. Knight																
Malaysia Mining			●													
Malaysia Smelting				●												
Metallurg group	●	●	●	●		●		●	●	●	●	●	●	●	●	
Mamore Mineracao e Metalurgia								●				●				
Mitsui Mining & Smelting								●	●	●		●	●	●		
National Resources Trading	●															
Niobium Products (CBMM)					●							●	●	●		
H.C. Starck Inc. (NRC)																
Pan West Tantalum	●															
Seco Tools																
Showa Cabot Supermetals																
Sogem-Afrimet	●	●	●	●	●											
Solikamsk Magnesium Works								●	●			●	●			●
Sominki	●															
Vishay Sprague																
H.C. Starck GmbH & Co KG	●	●				●	●	●	●	●	●	●	●	●	●	●
Alex Stewart (Assayers)																
Straits Trading				●												
Tantalum Mining Corp Canada	●															
Technologies International								●			●	●				
Teledyne Wah Chang Albany												●				
Thai Pioneer				●												
Thailand Smelting & Refining				●												
Treibacher Chemische Werke								●	●			●	●			
Vacuum Metallurgical Co	●	●	●	●				●	●	●	●	●	●	●		
H.C. Starck-V Tech																

	Carbides						Alloy additives						
	Tantalum carbide	Niobium carbide	Binary carbides	Mixed carbides	Tools	Other	Nickel-tantalum	Tantalum (unalloyed)	Nickel-niobium	Ferro-niobium	Ferro-niobium (steel-grade)	Niobium (unalloyed)	Other
AVX													
Cabot Performance Materials							●	●	●	●		●	
Cambior													
Catalao de Goias											●		
Cerex	●	●											
Ethiopian Mineral Resources													
Goldrim Mining													
Gwalia/Greenbushes													
Heraeus													
Intermet Resources	●	●	●	●				●					
Kennametal	●	●	●	●									
Alfred H. Knight													
Malaysia Mining													
Malaysia Smelting													
Metallurg group	●	●	●	●			●	●	●	●	●	●	
Mamore Mineracao e Metalurgia													
Mitsui Mining & Smelting	●	●	●	●									
National Resources Trading													
Niobium Products (CBMM)									●	●	●	●	
H.C. Starck Inc. (NRC)								●				●	
Pan West Tantalum													
Seco Tools				●									
Showa Cabot Supermetals													
Sogem-Afrimet													
Solikamsk Magnesium Works													
Sominki													
Vishay Sprague													
H.C. Starck GmbH & Co KG	●	●	●	●		●	●	●	●	●		●	
Alex Stewart (Assayers)													
Straits Trading													
Tantalum Mining Corp Canada													
Technologies International								●				●	
Teledyne Wah Chang Albany										●		●	●
Thai Pioneer													
Thailand Smelting & Refining													
Treibacher Chemische Werke	●	●	●	●					●	●	●		
Vacuum Metallurgical Co	●	●	●	●			●	●	●			●	
H.C. Starck-V Tech							●	●	●			●	

	Metallurgical-grade products										
	Tantalum melting stock	Tantalum ingot, unalloyed	Tantalum ingot, alloyed	Tantalum mill products, unalloyed	Tantalum mill products, alloyed	Niobium melting stock	Niobium ingot, unalloyed	Niobium ingot, alloyed	Niobium mill products, unalloyed	Niobium mill products, alloyed	Other
AVX											
Cabot Performance Materials	●	●	●	●	●	●	●	●	●	●	
Cambior											
Catalao de Goias											
Cerex											
Ethiopian Mineral Resources											
Goldrim Mining											
Gwalia/Greenbushes											
Heraeus	●	●	●	●	●	●	●	●	●	●	
Intermet Resources		●	●	●	●	●					
Kennametal											
Alfred H. Knight											
Malaysia Mining											
Malaysia Smelting											
Metallurg group	●	●					●	●			
Mamore Mineracao e Metalurgia											
Mitsui Mining & Smelting											
National Resources Trading											
Niobium Products (CBMM)						●	●	●			
H.C. Starck Inc. (NRC)	●	●	●	●	●	●	●	●	●	●	
Pan West Tantalum											
Seco Tools											
Showa Cabot Supermetals	●	●		●							
Sogem-Afrimet											
Solikamsk Magnesium Works											
Sominki											
Vishay Sprague											
H.C. Starck GmbH & Co KG	●	●				●	●				
Alex Stewart (Assayers)											
Straits Trading											
Tantalum Mining Corp Canada											
Technologies International	●	●		●		●	●		●		
Teledyne Wah Chang Albany						●	●	●	●	●	
Thai Pioneer											
Thailand Smelting & Refining											
Treibacher Chemische Werke											
Vacuum Metallurgical Co	●	●	●	●	●	●	●	●	●	●	
H.C. Starck-V Tech	●	●	●	●	●	●	●	●	●	●	

	Capacitors								Serv.	
	Powder, sodium-reduced	Powder, EB-melted	Foil	Wire	Cases	Anodes	Capacitors	Other	Assaying, analysis	Other services
AVX							●			
Cabot Performance Materials	●	●	●	●						
Cambior										
Catalao de Goias										
Cerex										
Ethiopian Mineral Resources										
Goldrim Mining										
Gwalia/Greenbushes										
Heraeus					●					
Intermet Resources										●
Kennametal										
Alfred H. Knight									●	●
Malaysia Mining									●	
Malaysia Smelting										
Metallurg group										
Mamore Mineracao e Metalurgia									●	
Mitsui Mining & Smelting										
National Resources Trading										
Niobium Products (CBMM)										
H.C. Starck Inc. (NRC)	●	●	●	●	●					
Pan West Tantalum										
Seco Tools										
Showa Cabot Supermetals	●	●								
Sogem-Afrimet										
Solikamsk Magnesium Works										
Sominki										
Vishay Sprague						●	●			
H.C. Starck GmbH & Co KG	●	●				●			●	
Alex Stewart (Assayers)									●	●
Straits Trading										
Tantalum Mining Corp Canada										
Technologies International										●
Teledyne Wah Chang Albany									●	●
Thai Pioneer										
Thailand Smelting & Refining										
Treibacher Chemische Werke										
Vacuum Metallurgical Co	●	●	●	●	●	●	●		●	
H.C. Starck-V Tech	●		●	●	●	●				