Thirtieth General Assembly and associated meeting

The Thirtieth General Assembly will be held on Thursday October 19th 1989 at the Frankfurt Kempski Hotel, Neu-Isenburg, Federal Republic of Germany.

On Wednesday October 18th delegates will be able to register at the T.I.C. desk at the hotel, and in the evening there will be a cocktail party to open the meeting.

On October 19th the General Assembly (with attendance restricted to delegates of member companies) will be followed by a programme of technical presentations for the rest of the morning and afternoon sessions, with a break for lunch. The technical programme will close with a panel discussion. In the evening there will be a banquet dinner, also in the hotel.

The participants will go to nearby Hanau on Friday October 20th for a tour of the metallurgical plant of W.C. Heraeus GmbH, where they will also be the guests of Heraeus for lunch. The meeting will close at about 15.30.

The formal sessions of the meeting, and the social events, on October 18th and 19th, will be held at the Frankfurt Kempski Hotel, where delegates will also stay — a large number of rooms has been reserved for the group. The hotel is at Neu-Isenburg, about fifteen minutes' drive from Frankfurt International Airport and some thirty minutes from Hanau. It has the atmosphere of a country house, and is set in a park of 37 acres (15 hectares) with woodland and a lake, but it also has the facilities of a modern luxury hotel, with several restaurants in various styles, indoor and outdoor swimming pools, fitness room, tennis courts and beauty farm. There is a golf course nearby.

Tours of some of the interesting and historic places in the surrounding area will be arranged during the meeting for ladies accompanying delegates, and the ladies will be most welcome at the cocktail party and the banquet dinner.

A varied technical programme with presentations of interest to all sections of the industries involving both niobium and tantalum is being arranged by the Executive Committee.

Heraeus is well-known as a company in the forefront of metallurgical technology concerned with both tantalum and niobium, and it also works with gold, silver, platinum, titanium, zirconium and beryllium. Participants are assured of a most interesting and informative plant tour when they visit the Hanau works of this company which has been a member of the T.I.C. since 1976.

Invitations will be sent to the nominated delegates of member companies by August 15th 1989. Others interested in attending the meeting should contact the Secretary General of the T.I.C.

President's letter

All the participants in the International Symposium on Tantalum and Niobium, held in November 1988, have by now sent their copies of the book of the Proceedings. This is a publication which will be most useful to many interested in tantalum and niobium, copies are selling well and we are sure that other readers of the Bulletin will wish to order them.

Now the Executive Committee, with the help of W.C. Heraeus GmbH, is arranging the programme for the autumn meeting of the T.I.C. I believe this will be another successful event for the association and I hope to see you there.

Harry Stuart
President

Pancontinental Mining to produce tantalite in the Pilbara

This article is based on company information.

Pancontinental Mining Ltd. is an Australian company involved in the production and marketing of coal and gold, as well as mine operator, joint-venture partner or holder of interests. Its sales during the year 1987-88 were $194.2 million (US$110 million, approximately). The company has also been active in the exploration for a number of other minerals, including tantalum, as part of a policy of becoming a diversified mining house.

In 1983, Pancontinental set itself the objective of discovering high-grade tantalum reserves which could be mined by open-pit methods. Exploration has continued since 1983 despite the low tantalum prices immediately after that time, and last year the discovery and proving were announced of tantalum mineralisations at four locations in Australia.

In a joint venture with Goldrim Mining Australia Ltd., Pancontinental has earned a 50% interest in tenements at Wodgina, Wodgina West and Tabba Tabba in the Pilbara region of Western Australia. A further resource has been identified at Mount Farmer in the Murchison region of Western Australia.

At Wodgina, exploration drilling has demonstrated that the main lode deposit has a geological resource of 310 000 tonnes at 0.2% Ta₂O₅. A preliminary feasibility study suggested a production estimate of 340 000 tonnes at 0.16% Ta₂O₅. In the same region, drilling indicated resources at Wodgina West and Tabba Tabba. These are not of sufficient size to sustain a 'stand-alone' operation, but could, if proven by further drilling, be used as supplementary feed to the Wodgina main lode operation.

A production estimate of 15 000 tonnes at 0.23% Ta₂O₅, has been determined for Mount Farmer. Additional evaluation by bulk sampling, process testing and a preliminary economic study indicated that, while the grade is high, the economics would be significantly improved by a further recovery of tantalum reserves. To achieve this, further exploration is planned in the area.

The pegmatite bodies at Wodgina and their resultant alluvial and eluvial deposits have been mined for tin, tantalum and beryl since their discovery in 1902 until 1965. From 1903 to 1965, a total of 231 tonnes of tantalite concentrate was produced from the alluvial and eluvial deposits. The lode deposit was also worked by small-scale, open-cut and underground methods to produce a total of 112 tonnes of concentrate.

The main pegmatite lies in the heart of the Wodgina greenstone belt approximately 110 km south of Port Hedland or 1600 km north of Perth. The pegmatite body is up to 150 000 lb Ta₂O₅. A new wholly-owned subsidiary, Pan West Tantalum Pty Ltd., will hold all of Pancontinental's tantalum mineral and exploration assets.
Pancontinental's tantalum resources and reserves in the Pilbara and Murchison regions

<table>
<thead>
<tr>
<th>Geological in-situ resources</th>
<th>Grade (% Ta2O5)</th>
<th>Content (lb Ta2O5)</th>
<th>% Interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wodgina main lode (proved/probable)</td>
<td>0.20</td>
<td>1360000</td>
<td>50</td>
</tr>
<tr>
<td>Wodgina-West (probable)</td>
<td>0.10</td>
<td>97000</td>
<td>50</td>
</tr>
<tr>
<td>Tabba Tabba (probable)</td>
<td>0.28</td>
<td>328000</td>
<td>50</td>
</tr>
<tr>
<td>Wodgina-Pancon (probable)</td>
<td>0.07</td>
<td>386000</td>
<td>100</td>
</tr>
<tr>
<td>Mount Farmer (proved)</td>
<td>0.29</td>
<td>91000</td>
<td>100</td>
</tr>
<tr>
<td>Mining reserves</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wodgina main lode (proved/probable)</td>
<td>0.21</td>
<td>1250000</td>
<td>50</td>
</tr>
</tbody>
</table>

Tantalite production in China

An update of "The Chinese tantalum and niobium industry", Bulletin no. 54, April 1989

The two known Chinese sources of tantalite concentrates are the Limu mine, Guangxi province, and Yichun mine, Jiangxi province. A test programme has been performed to upgrade the ore from a tantalum deposit at Guangning, Guangdong province. Limu has been in production for at least ten years. There are three separate mines, of which only one, known as "Tiger Head", is currently operating. Grades established are 0.15-0.20 % Sn, 0.16-0.17 % Ta2O5, and 0.020-0.04 % W; reserves amount to 12 million tonnes. Tiger Head is worked by open-cut methods, whereas the other two mines at Limu ("Water Stream Temple" and "Golden Bamboo Garden") are underground. In 1980, production was equivalent to about 50 tonnes Ta2O5 a year.

The deposit at Yichun has been identified as an apogranite. These mineralizations are typified by their large ore tonnages and fine-grained minerals. Apogranites occur close to the surface and so can be exploited by open-cut mining at a low cost. A number of these deposits have been brought into production elsewhere in the world, an example being the Pilguba tin-niobium-tantalum deposit in Amazonas state, Brazil.

Yichun was discovered as a result of a five-year exploration programme to find such a deposit. Due to the steep terrain and fine grain size of the minerals, no surrounding placers have been formed. The average grain size of the columbite-tantalite and microcline is less than 0.1 mm.

Reserves in one of the ore bodies exceed 100 million tonnes; the grades are 0.017 % Ta2O5, 0.009 % Nb2O5, and 0.012 % Sn. Close to this ore body are located two others which are of an equivalent size. It was reported in 1987 that 1500 tonnes of ore a day were being treated at Yichun, suggesting a production of about 50 tonnes Ta2O5 a year. The mine also produces mica and feldspar.

In 1966, a prospecting and exploration programme was concluded by the Ministry for Geology and Raw Materials, Guangdong province, and the Federal Institute of Geosciences and Natural Resources, West Germany. The venture was successful in identifying tantalum occurrences in pegmatites near Guangning, Guangdong province. Concentrations of 0.023 % Ta2O5 and 0.008 % Nb2O5 in the ore were reported, as well as significant zircon and cassiterite values. An ore processing flowsheet was developed, consisting of two milling, four sieving and nine sorting stages followed by magnetic separation. The basic process was grinding, high-intensity magnetic separation, table grading and flotation of middlings. Tests demonstrated a recovery of 70-75 % and an attainable concentrate grade of 30 % Ta2O5. In 1987, a local dressing plant was using the developed route to process 32 tonnes of ore daily.

Besides the processing plants at Juijiang, Limu, Ningxia and Zhuhou which were identified in the Bulletin article of April 1988, another tantalum plant exists in Guangdong province, south-east China. The Conghua Tantalum and Niobium Smelting produces potassium fluorotantalate, tantalum and niobium oxides, tantalum powder and ferro-niobium, using tantalum-niobium ore concentrates as feedstock. The plant's annual capacity is five tonnes of tantalum powder and 50 tonnes of ferro-niobium. Conghua was originally built as a concentrating mill in 1980, but was converted into a tantalum/niobium smelter in 1970. It is located north-east of Guangzhou city, Guangdong province.

Almost no Chinese exports of tantalite are expected this year. Mine production is probably declining due to internal difficulties, and China is even having to import some material to meet its own demand for tantalum. Rising prices for tantalite led to a high level of exports in 1988, but these were probably supplied by stockpiled material, accumulated during the poor tantalite market of the mid-1980s. Until China can develop further tantalum sources, exports are likely to remain at a low level.

LITERATURE


Some newer uses for niobium

This article is based on "Outlook", a Teolyne Worh Chang Albany publication, and other company literature.

Past issues of the Bulletin have discussed many developing applications for niobium. The metal has a number of useful properties, and its range of uses is expanding constantly. This article presents an update rather than a complete survey of niobium's newer applications. The reader is invited to refer back to past Bulletin articles such as that in issue no. 50, April 1987, for a full discussion of applications for niobium.

WATER PURIFICATION SYSTEMS

A new type of water purification system uses anodes made from niobium. The system, developed by a company in California, USA, could revolutionize water purification for the consumer market.

The electrochemical-based system effectively and automatically combines seven different, proven water treatment processes in a self-contained unit. Most water treatment devices combine only two or three processes; the new system, with seven process steps, bears a close resemblance to a large-scale, municipal water treatment plant. Niobium was selected for use in the anodes because it provided superior operating performance with less maintenance than was possible with previously used materials.

A major benefit of the system (known as the Watergizer) is that it does not use chemicals for cleaning or regeneration. These chemicals add contamination to the sewage environment and consequently their use is often prohibited. The system offers a viable alternative that does not leave salt deposits in waste water.

The initial household model is approximately 50 inches high, 17 inches wide and 16 inches deep, and weighs about 250 lb. (continued on page 4)
T.I.C. statistics

TANTALUM

PRODUCTION AND SHIPMENTS 1988
(quoted in lb Ta_2O_5 contained)

<table>
<thead>
<tr>
<th>Material</th>
<th>1st quarter</th>
<th>2nd quarter</th>
<th>3rd quarter</th>
<th>4th quarter</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tin slag (2 % and over)</td>
<td>240 063</td>
<td>390 765</td>
<td>401 102</td>
<td>366 598</td>
<td>1 396 528</td>
</tr>
<tr>
<td>Tantalite (all grades), other materials</td>
<td>82 495</td>
<td>52 357</td>
<td>63 760</td>
<td>112 112</td>
<td>294 724</td>
</tr>
<tr>
<td>Total</td>
<td>306 558</td>
<td>443 122</td>
<td>464 862</td>
<td>478 710</td>
<td>1 693 252</td>
</tr>
<tr>
<td>Response</td>
<td>16/16</td>
<td>16/16</td>
<td>16/16</td>
<td>16/17</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Material</th>
<th>1st quarter</th>
<th>2nd quarter</th>
<th>3rd quarter</th>
<th>4th quarter</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tin slag (2 % and over)</td>
<td>220 096</td>
<td>408 847</td>
<td>154 689</td>
<td>274 049</td>
<td>1 057 681</td>
</tr>
<tr>
<td>Tantalite (all grades), other materials</td>
<td>24 392</td>
<td>90 657</td>
<td>40 574</td>
<td>103 894</td>
<td>269 517</td>
</tr>
<tr>
<td>Total</td>
<td>244 488</td>
<td>499 504</td>
<td>195 263</td>
<td>377 943</td>
<td>1 317 198</td>
</tr>
<tr>
<td>Response</td>
<td>16/16</td>
<td>16/16</td>
<td>16/16</td>
<td>16/17</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
1. The response from companies asked to report included these producers, whose reports are essential before the data may be released:
   - Datuk Keramat Smelting
   - Greenbushes
   - Malaysia Smelting
   - Mamore Mineração e Metalurgia
   - Metallurg Group
   - Tantalum Mining Corporation of Canada
   - Thailand Smelting and Refining

2. The figures are subject to review and final confirmation. An adjustment has already been made to the figures previously circulated for the first two quarters, in the light of information subsequently received.

PROCESSORS' SHIPMENTS 1988
(quoted in lb Ta 2 contained)

<table>
<thead>
<tr>
<th>Material</th>
<th>1st quarter</th>
<th>2nd quarter</th>
<th>3rd quarter</th>
<th>4th quarter</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ta_2O_5, K_2TaF_7</td>
<td>19 959</td>
<td>27 442</td>
<td>23 574</td>
<td>10 588</td>
<td>81 563</td>
</tr>
<tr>
<td>Alloy additive</td>
<td>41 863</td>
<td>37 811</td>
<td>31 388</td>
<td>33 313</td>
<td>144 375</td>
</tr>
<tr>
<td>Carbides</td>
<td>144 286</td>
<td>167 768</td>
<td>163 592</td>
<td>152 565</td>
<td>628 191</td>
</tr>
<tr>
<td>Powder/iodides</td>
<td>275 253</td>
<td>269 567</td>
<td>288 853</td>
<td>302 458</td>
<td>1 119 131</td>
</tr>
<tr>
<td>Mill products</td>
<td>98 823</td>
<td>102 001</td>
<td>103 188</td>
<td>107 010</td>
<td>410 992</td>
</tr>
<tr>
<td>Scrap, ingot, unworked metal, other</td>
<td>16 310</td>
<td>14 125</td>
<td>22 906</td>
<td>23 480</td>
<td>76 821</td>
</tr>
<tr>
<td>Total</td>
<td>578 474</td>
<td>618 714</td>
<td>634 471</td>
<td>629 414</td>
<td>2 461 073</td>
</tr>
<tr>
<td>Ta_2O_5 equivalent</td>
<td>780 941</td>
<td>835 264</td>
<td>656 536</td>
<td>849 709</td>
<td>3 322 450</td>
</tr>
<tr>
<td>Response</td>
<td>17/18</td>
<td>17/18</td>
<td>16/16</td>
<td>14/16</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
1. The response from companies asked to report included these processors, whose reports 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
   - Showa Cabot Supermetals
   - Hermann C. Starck Berlin
   - Treibacher Chemische Werke
   - Vacuum Metallurgical Company
   - V-Toch

2. Reports were made in lb tantalum contained.

QUARTERLY PRODUCTION ESTIMATES
(quoted in lb Ta_2O_5 contained)

In the fourth quarter of 1988, the following estimates of production were made:

<table>
<thead>
<tr>
<th>Quarter</th>
<th>LMB quotation</th>
<th>$30</th>
<th>$40</th>
<th>$50</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st quarter 1989</td>
<td>232 000</td>
<td>358 500</td>
<td>416 500</td>
<td></td>
</tr>
<tr>
<td>2nd quarter 1989</td>
<td>277 000</td>
<td>361 500</td>
<td>416 500</td>
<td></td>
</tr>
<tr>
<td>3rd quarter 1989</td>
<td>220 000</td>
<td>353 500</td>
<td>421 500</td>
<td></td>
</tr>
<tr>
<td>4th quarter 1989</td>
<td>220 000</td>
<td>343 500</td>
<td>451 500</td>
<td></td>
</tr>
<tr>
<td>1st quarter 1990</td>
<td>215 000</td>
<td>333 500</td>
<td>415 500</td>
<td></td>
</tr>
</tbody>
</table>

Capacitor statistics: see page 4.
Capacitor statistics

EUROPEAN TANTALUM CAPACITOR SHIPMENTS
(Thousands of units)
4th quarter 1988 151 933
Total for 1988 676 436
(Data from ECTSP)

JAPANESE TANTALUM CAPACITOR PRODUCTION
AND EXPORTS
(Thousands of units)
Production Of this, exports
4th quarter 1988 944 647 253 105
Total for 1988 3 515 879 991 164
(Data from JEIDA)

U.S. TANTALUM CAPACITOR SALES
(Thousands of units)
4th quarter 1988 U.S. shipments Exports Total
Foil 256 256
Metal-cased 25 792 7 412 33 204
Moulded 66 829 11 298 78 126
Dipped 87 817 15 854 103 671
Chips 42 532 6 669 49 221
Wet slug 2 037 188 2 225
Total 226 262 41 421 266 683
(Data from EI(A)

Production of the system began in 1988 and was the culmination of nearly 10 years of design and research efforts. There are also plans to manufacture other types of unit in the future for different applications, such as the desalination of seawater.

SHAPE MEMORY ALLOYS

A "shape memory" material can be transformed from a heat-unstable condition (the martensite phase) to its original, stable condition (the austenite phase) by the application of a small amount of heat. Articles made from these materials in effect "remember" their original shape.

The main shape memory alloy being used commercially is nickel-titanium. To expand the temperature range over which the alloy remains austenitic so that it includes room temperature, niobium is being added in contents of up to 30 at. %. However, the most usual contents are 5-20 at. % niobium. The new alloy is also easier to machine.

Applications for shape memory alloys have included pipe couplings, electrical connectors and switches, but the improved properties of the niobium-containing alloy are leading to many more uses being actively developed.

AEROSPACE FASTENERS

Materials for the aerospace industry need both lightness and strength. An alloy of niobium and titanium has both these characteristics and so has been used to manufacture aerospace fasteners since 1972.

The bimetallic, one-piece fastener combines a 95 ksi shear strength shank with a tail made from titanium-niobium alloy (55 Ti-45 Nb). A major advantage of these fasteners is the 10-40 % weight saving over comparable two-piece ones.

The upper shear part of the fastener is made from a titanium-based alloy, while the lower part is titanium-niobium alloy, which is ideal because of its ductility, lightness and heat resistance. The shear part and the tail are joined by inertial welding.

These fasteners are installed in airframe structures by an automated process and provide excellent blind side clearance. Over 30 million have been produced by a company in California, USA, in the last 15 years.

LIGHTING COMPONENTS

Niobium's hot strength and superior formability has led to its use in small tubular parts in sodium gas discharge lamps. The niobium component holds the sodium, which is vaporized and channelled through the quartz tube to create light. Road lighting is the most common application of these systems.

Niobium can be reduced from 0.75 inch diameter by 0.065 inch wall tubing to dimensions of only 0.12 inch diameter by 0.01 inch wall. These tubes can be fabricated into components by a variety of processes. They can be bent and coiled, slotted, dimpled, punched, lanced, notched, shaped and cut precisely to size.

CATALYSIS

Niobic acid, a solid niobium-based compound, has been found to be an effective catalyst for a number of reactions, including: pollution abatement; selective oxidation; hydrocarbon conversion; hydrogenation and dehydrogenation; hydroisomerization; hydrogenation; peroxymonosulfate; dehydrogenation; and photochemistry and electrochemistry.

The niobic component in these catalytic applications is present as a compound of niobium oxides, mixed with oxide, oxide support or surface niobium oxide phase. Current research is focusing on the development of new niobium-based catalytic materials that will expand the available applications.

(Readers are referred to an article in issue 56 of the "Bulletin" published in December 1988, "Niobic acid in a new catalytic material", K. Tanabe.)

Niobium industry statistics

Statistical data on niobium production and shipments for the years 1980-86 have been compiled and published by the T.I.C. These data, which are summarised here, will be updated quarterly and published in the Bulletin when available.

RAW MATERIAL PRODUCTION

Between 85 % and 90 % of niobium is added to micro-alloyed, stainless and heat-resisting steels. Since niobium supply and demand have approximately been in balance over the past few years, raw material production more or less reflects the movements of the niobium market: a downturn from 1980 to 1983, followed by a recovery in the years since then.

Photomicrograph of the bimetallic fastener installed in an aluminium frame (the lower part is TiNb alloy).
The portion of total niobium demand supplied as a tantalum by-product has remained below 5% during the years in question. The bulk of niobium production is centered at just three mines.

**COMPOUNDS AND ALLOY ADDITIVE**

Most of the material reported in this category consists of vacuum-grade superalloy additive, namely nickel-niobium and ferro-niobium. The remainder is in the form of carbide, for cutting tools, and extra-purity oxide, for the optical and ceramic markets. T.I.C. data only cover the years 1980-88 so far, but from other available data it can be estimated that approximately 2.5 million lb Nb were shipped in 1987 and 2.7 million lb Nb in 1988.

**Niobium requirements for the Superconducting Super Collider**

This article is based on a presentation made by Dr Rae Stiening, SSC Central Design Group, at the International Symposium on Tantalum and Niobium, Orlando, November 7th-9th 1988.

The Superconducting Super Collider (SSC) is a proposed, but not yet approved, project for elementary particle physics research that would use about a million pounds of niobium-titanium alloy in the many thousand bending, focusing and trim magnets needed for its one trillion electron-volt (1 TeV = 10^{12} electron-volt) injector and its two 82 km circumference main rings.

Superalloys are nickel-, cobalt- and iron-nickel-based alloys applied extensively in manufacturing components for turbines, mostly jet engines, because of their high-temperature properties. Over 90% of the category "compounds/alloy additive" consists of vacuum-grade additives so the increase in shipments during the 1980s has been driven by the superalloy market.

High prices for cobalt during the late 1970s resulted in its substitution out of superalloy components favouring IN718, an iron-nickel-based composition containing 5.3% Nb. Today, this alloy accounts for 35% of all wrought superalloy production. Because of its ease of fabrication and welding and its adequate strength up to 650°C, IN718 has been adopted for all kinds of jet engine components. Its growth in popularity accounts for much of the increase in demand for niobium alloy additive in the 1980s. The downturn in 1986 is explained by the release of a large quantity of stockpiled 718 scrap by a jet engine manufacturer.

**NIOBUM-BASED ALLOYS**

Applications for niobium alloys lie in aerospace, corrosion protection and superconductivity. From other available data, it can be estimated that about 470 000 lb Nb in metal and alloys were shipped in 1987 and about 500 000 lb Nb in 1988.

![Schematic concept of the SSC's proposed layout](image-url)
PARTICLE PHYSICS

In the SSC’s main rings, contra-rotating beams of protons, about 1 mm in diameter, will be accelerated to 20 TeV each before being guided into collisions at interaction regions where the beams will be further reduced in diameter to about 5 microns.

This collision energy will be distributed between the various quarks and gluons making up the proton constituents. At 20 TeV, the effective mass of the proton is increased 20,000 times and in the collisions this energy is converted to mass in the form of other particles. These are to be studied in detectors surrounding the interaction region and containing a large degree of suitable analytical instrumentation. It is hoped that the information generated will enhance our understanding of the underlying physical laws governing the interaction of matter, energy and gravitation in our universe, and of their nature.

THE SUPERCONDUCTING SUPER COLLIDER

Detectors for the SSC might weigh 50,000 tonnes or more. Many collider detectors will contain large magnets for analysing the charge and momentum of the emitted particles and not all of these magnets will be superconducting. The recently commissioned 4500 tonne, $35 million detector for the Tevatron at the Fermi National Accelerator Laboratory in Batavia, Illinois, USA, contains a superconducting magnet. This machine is the highest energy collider in operation and the first very high energy machine to use superconducting magnets in its main ring.

![Schematic drawing of cable for SSC dipole](image)

Each strand contains 7250 six-micron diameter filaments. Such fine filaments are essential to minimize magnetization effects which, at low injection fields, could produce unacceptable distortion in the dipole guide field. In magnets of this type, thermal transients, which occur as the conductors move when the coil is energized, are an important cause of instability. These are minimized by the use of kapton round the cable to reduce friction when slippage occurs and by the thermal diffusivity of the stabilizing copper.

MATERIAL REQUIREMENTS

Specified copper to superconductor ratios for the inner- and outer-layer magnet conductors are 1.3 : 1 and 1.3 : 1, respectively. Consideration is being given to increasing the inner-layer ratio to 1.5 : 1. These ratios, filament numbers and diameters may be changed as magnet development continues.

The current conductor specification calls for a superconductor current density of 2750 A/mm² at 5 T measured at an effective conductor resistivity of 10⁻¹⁴ ohm-m with a strain tolerance of 0.5%. The peak operating field at the conductor is around 7 T. The improvement in current-carrying capacity of conductors since 1984 is one reason why the SSC is considered economically feasible, since much less of the expensive conductor and alloy is now needed.

Copper-stabilized, NbTi multifilamentary wire manufacture is now a well-established process. The alloy is produced in ingot form by vacuum-arc melting niobium and titanium. The resulting material is reduced to rods, typically 3-6 mm diameter, and these rods are inserted into rods of copper with circular bore and hexagonal outer periphery or directly into holes in a copper billet. In the former case, the hexagonal elements are packed in a cylindrical container to obtain the highest possible density. In these ways, billets containing several thousand NbTi tubes in a matrix of copper, chosen to give the desired copper to superconductor ratio and filament size, are formed. The billets are then drawn down until multifilamentary wire of the necessary dimensions is obtained.

CURRENT STATUS OF THE SSC

Funding for the machine has not yet received the approval of the US Congress, but about $180 million has already been spent on conceptual design and prototype magnet construction. A decision as to when construction could proceed is expected in 1988. The complex would be built with massive industrial participation, including magnet fabrication, and an active programme of technology transfer to industry has begun. International participation may also be encouraged. The machine, if approved, could be in operation by the mid-1990s and be expected to be operating for as long as 20 years.

In late January 1988, the Department of Energy nominated a director and a management organization for the project. Based on a decision to start construction in fiscal year 1990 (which begins in October 1989), a feasible construction funding plan has been developed by the SSC Central Design Group. From the order schedule for magnet cable, the consequent niobium metal and alloy demand has been estimated.
Recycling of tantalum

This paper was presented by Dr Meinhard Alts, Gesellschaft für Elektrotekallurgie mbH, at the International Symposium on Tantalum and Niobium, Orlando, November 7th-9th 1988.

A remarkable amount of the world’s total consumption of tantalum is covered by scrap recycling. The most important sources for this tantalum-containing scrap are the hard-metal, glass and ceramic industries, and tantalum equipment and capacitor manufacturing.

The composition of scrap materials varies widely, some examples being: nearly pure metal, such as turnings and grey anodes; complex systems where tantalum occurs as carbide or oxide; and heterogeneous systems of metal partially oxidised together with plastic, other oxides and metals in electronics scrap. To recover the tantalum from these different sources, individually adapted techniques had to be established, not only to extract the tantalum content but to do it in the most economical way with adequate recoveries.

The amount of tantalum being recycled in the industry is estimated to cover between 10% and 20% of total raw material requirements. These recycling activities reflect a general trend in the industry towards improving the usage of limited natural resources and with a acceleration of more than 10% by increasing raw material costs. Due to tantalum’s high value, the industry has reached a high standard of integration, comparable to that of the precious metals industry.

RECYCLING DURING TANTALUM PROCESSING

In each step of tantalum processing, from the chemical digestion of ore concentrates to the manufacture of the final products, tailings, off-grade materials and scrap arise.

Wastes from the production of oxides, carbides and metals are recycled in the system itself as far as technically possible. If not — and the tantalum content is high enough — these materials can be fed into the chemical line again. Tailings, leaching residues, grinding sludges and wastes with low tantalum content can be processed via the block-metal process together with tail slags.

Technically it is possible to treat materials with contents as low as one percent Ta with some exceptions, e.g. materials with high levels of radio-active components. The economic limits depend on the tantalum raw material price. Obviously, the value which can be placed on such materials is very low, but in times of tight raw material supply, substantial quantities of tantalum could be recovered via the chemical and metallurgical process.

All efforts should be made to recover tantalum from every possible source, to recycle this valuable material in the most economic way, and to avoid additional recovery losses. That means keeping the stage of refinement as high as possible.

The following possibilities for recycling tantalum should be considered as examples, as it is impossible to mention every possible alternative in this short review.

TANTALUM IN GLASSES AND CERAMICS

Up to now, no special technical method is known for treating glass and ceramic scrap. If the material is separated in a pure form during the production process, it is normally recycled directly into the glass melt. But if tantalum is present as oxide, the glass or ceramic scrap are fed back into the chemical tantalum line if the Ta₂O₅ content is high enough, or they can be processed like tin slags. The laboratory-scale recovery of high-purity tantalum oxide from lithium tantalate single crystals using an ion exchanger has already been described in the literature.

During the last decade, a number of glasses and ceramics with exotic compositions was developed using other valuable materials, such as lanthanum and yttrium. Special techniques have to be developed to recover these rare elements too. During these operations, a sludge containing tantalum will normally arise, suitable for standard chemical treatment.

RECOVERY OF TANTALUM FROM HARD METALS

Recycling operations on hard-metal scrap are mainly used to recover the combined carbides as powder, or the tungsten as ammonium paratungstate and the remaining elements as oxides.

TREATMENT WITH MOLTEN ZINC

Tantalum recovery from hard metals

For this purpose, the zinc process is commonly used as the first step to disintegrate the sintered parts. Liquid zinc at temperatures of about 800°C breaks the linkage between the carbide particles and the cobalt metal. The zinc is recycled via vacuum distillation, and grinding the residue produces a powder with the original composition of carbides and cobalt. This powder can be used in the as-produced condition or blended with virgin powders.

In the zinc process, no purification of the material takes place. Therefore, contaminated or not well defined compositions must be treated in a way that allows the recovery of nearly all components in a chemically pure condition.

For this reason, the zinc-treated hard-metal powder, grinding sludges, etc. are oxidised under alkaline conditions to form sodium tungstate. During the following leaching operation the soluble tungstate is filtered off with the mother liquor, then purified by precipitation and transformed into ammonium paratungstate, better known as APT. The remaining residue contains cobalt, tantalum, niobium and titanium as insoluble hydroxides from which the cobalt and the titanium are extracted by leaching with sulfuric acid. These elements can be separated easily from each other by the selective precipitation of titanium hydroxide and cobalt oxalate. The final residue containing the tantalum and niobium is used as feedstock for chemical processing.

RECYCLING OF CAPACITOR SCRAP

Different types of capacitor scrap need specially adapted techniques for the recovery of the tantalum content as pure metal if possible.

During capacitor manufacturing, scrap arises as powder, grey and coloured anodes, foil, manganin or silvered items, as well as pins from the connecting wires. All the materials from these sources can be fed into the various steps of the recovery process.

Recovery of tantalum from plastic-encapsulated capacitors

The removal of the cover is done by treatment with hot sulfuric acid, which cracks the material, chemically yielding undetermined organic compounds and carbon. The waste acid is normally neutralised with lime and discarded. This technique may lead to environmental problems because of the uncontrolled formation of secondary organic compounds.

In most instances, the chemical destruction of the case can be avoided by using mechanical techniques. The scrap is ground to a size of about 1 mm to produce isolated particles of plastic, wire and metal from the original capacitor. The lead wires can normally be separated magnetically leaving a mixture of light plastics and heavy metal. This mixture is separated in a second step using the differences in the density, either by classical ore dressing methods or by using a high-density liquid.

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Tantalum recovery from plastic-encapsulated capacitors

As the core of the capacitor also contains tin, silver and manganese dioxide, additional chemical leaching steps have to be applied. Tin is soluble in sodium hydroxide solution, silver in nitric acid, and manganese dioxide in hydrochloric acid, so at least three leaching steps have to be carried out, combined with careful intermediate washing with de-ionised water. The remaining solutions can be treated individually in order to recover tin and silver. Manganese compounds are not normally recovered due to their relatively low price. The coloured anodes are deoxidised using base metals like sodium potassium or sodium at temperatures up to 900°C. The formed oxide of the base metal is leached out with acid, yielding grey anodes, a granulate or coarse powder: these materials can be refined either by electron-beam melting, compacting into sintered bars or conversion into tantalum carbide.

Recovery of tantalum from metal-cased wet capacitors

If the case is made from nickel or copper, an electrolysis using the capacitor as anode and a stainless steel cathode is a suitable method to remove and recover the metal. The problem using electrolysis is the complete removal of the metal, therefore additional acid leaching is normally required.

Tantalum recovery from metal-cased wet capacitors

Aluminium cases can be dissolved in sodium hydroxide solution, copper cases in nitric acid, stainless steel cases in nitric acid. But the chemical removal of the outer cases always requires a relatively large amount of chemicals and leads to a waste water problem, because all the dissolved metals have to be neutralised and precipitated to avoid environmental pollution.

In certain cases, especially if larger amounts of a single size of capacitor scrap are available, mechanical removal of the case is possible and more economical. That means using mechanical equipment which is able to separate the metal from the core.

In any case, the liquid electrolyte has to be leached out afterwards and neutralised. Aluminium or other metals can be dissolved by additional leaching. To separate the metal content from plastic or glass insulations, the material can be ground to a size below 1 mm and separated by gravity as described before. The final step is a deoxidation to reduce the oxygen content and prepare the material for EB refining or other uses.

It is shown that a ready-for-use recycle cannot be given as the structure of the capacitor scrap varies widely and a lot of adaptation work has to be done to find a technically suitable and economical method of treatment.

If the capacitor scrap contains another refractory metal besides tantalum in sizeable amounts, e.g. molybdenum from doped tantalum wire, the resulting metal may be out of specification. In this case, the material has to be chemically processed, with the corresponding economic disadvantage.

TANTALUM IN SUPERALLOYS AND COATINGS

Direct recycling of superalloy scrap requires careful attention and is mostly done by the superalloy producers themselves. Collected scrap, such as turnings, etc., is very seldom available to the tantalum industry and only of interest at a high tantalum price level. In this case, the scrap materials are normally recycled via the block-metal process as the tantalum content is usually bw.

Coatings normally contain only small amounts of tantalum metal, therefore this recycling is not economical. More frequently, off-grade powders, used targets, etc. are collected and recycled as described before. If coatings have to be recycled, they can be dissolved in hydrofluoric acid and chemically recovered.

SUMMARY

The recycling of tantalum has become an important factor in the total market, but is up to now only used for materials with a relatively high tantalum content. Whether or not certain materials can be recycled depends directly on the price level for raw materials.

In this sense, the design and production of devices containing a costly material like tantalum should involve a number of considerations:

- the production process should be optimised to keep losses to a minimum;
- if the occurrence of scrap or other tantalum-containing wastes cannot be avoided, it should be collected where it arises in order not to devalue it by dilution with other wastes;
- pure materials are preferable to complex compounds as recycling is easier and thus more economic;
- during the design of new products, experts in recycling should be contacted as early as possible to avoid losses in the scrap's value, thus keeping the tantalum-containing product more competitive.

Although tantalum recycling has already reached high standards compared to other industries, more development work is still needed to use the limited sources in the most economic way. It is a question of availability, the total amounts and the economics whether tantalum will be recovered from other sources, but recycling has become an important factor in judging a process or a product's overall economy and environmental compatibility.