

Twenty-second General Assembly

The Tantalum International Study Center held its Twenty-second General Assembly on October 30th 1984 at the International Association Centre, 40 rue Washington, 1050 Brussels. The Assembly enacted the formal business of the association, including approval of the minutes of the previous Assembly, held in Stockholm in June, and of the audited accounts for the year ended June 30th 1984.

The President and Executive Committee were constantly maintaining their efforts to extend the services offered by the T.I.C. They were seeking candidates for the post of Technical Officer and conducting interviews. The library had been established, and the first librarian, Mrs Bradnock, had prepared an index to the first thirty-nine issues of the quarterly Bulletin. This index is being printed and will be circulated shortly to all whose names are currently on the usual Bulletin mailing list. Mrs Jillian Wilkinson had subsequently taken over as librarian and was engaged in cataloguing the material in the T.I.C. library.

Collection of statistics was continuing, and the Committee were pleased with the prompt presentation of the T.I.C.'s production and processing figures for the quarter ended September 30th, circulated at the meeting: these are reprinted in this Bulletin. Statistics for tantalum capacitors in the U.S.A. and Japan were being obtained on a regular basis and also appear in this issue. The General Assembly agreed to attempt forecasts of production and processing and to set up a system for carrying out these projections on a regular basis.

Seven companies applied for membership and were elected, and two companies resigned, bringing total membership to 74. Names and addresses of the new member companies are given on the last page of this Bulletin.

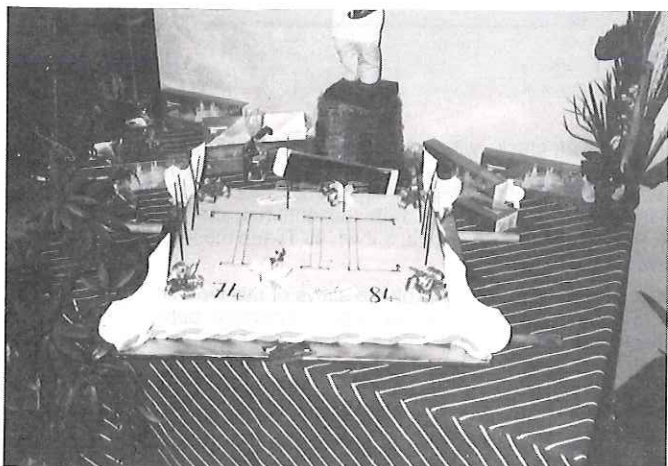
Mr Carroll G. Killen, of Sprague Electric Company, was elected President for the coming year, succeeding Mr Robert Franklin, of STC, at the end of his term of office, which had seen considerable progress in the work of the association. Mr Ake Janson, of Sandvik, had resigned from the Executive Committee; the other current members were re-elected to serve a further term in office. In addition Dr C. Hayashi, of Vacuum Metallurgical Company, was elected to join the Committee.

After the General Assembly, two presentations were made:

Tantalum: metallurgy and applications, by Professor Jean Vereecken, Department of Metallurgy and Electrochemistry, Brussels University (Vrije Universiteit Brussel)

The nature of the niobium industry, by Dr Harry Stuart, Niobium Products Company, Pittsburgh, Pennsylvania, U.S.A.

On the evening of October 29th 1984 the T.I.C. celebrated the tenth anniversary of the foundation of the association with a party in the elegant salon of the Maison des Brasseurs in the Grand'Place of Brussels, one of the elaborately decorated and gilded houses dating from the end of the seventeenth century. A special birthday cake was shared by the guests.



Twenty-third General Assembly

This meeting will be held on June 12th, 13th and 14th 1985 in Boston, Massachusetts, U.S.A., hosted by NRC and Sprague Electric Company. Invitations will be sent to delegates of member companies when the detailed programme is complete. Non-members interested in this meeting may apply for information to the Secretary of the T.I.C., 40 rue Washington, 1050 Brussels, Belgium.

President's Letter

As I start my term in office, the tantalum industry — to a large extent — has recovered from the difficult period which began in the early 1980's and lasted for a period of three years. The decline in the industry shipments of tantalum products during this period was the result of economic forces which affected the world demand for tantalum by the manufacturers of all types of equipment in which tantalum was used. There was also the drive to eliminate or reduce the amount of tantalum used because tantalum products for most applications were no longer cost effective.

The decline of tantalum usage was abruptly halted by the spectacular recovery of the worldwide electronic market which began in late 1982 with the result that the tantalum capacitor industry achieved record shipments during both 1983 and 1984. This tremendous recovery in the market for tantalum capacitors demonstrated that this product survived the material cost crisis of 1979 which saw the average price for the capacitors fall from a peak of 0.47 cents in 1979 to 0.30 cents by late 1984. This reduction in average selling price was made possible by lower ore costs, higher CV powder from the material suppliers and cost reduction on the part of capacitor manufacturers. Although the capacitor prices have come down, they must be reduced even further if tantalum capacitors are to fulfill their destiny. Certainly, the use of still higher CV powder, plus a further cost reduction in the manufacture of the product, gives promise of further decreases in price. Such an eventuality will allow this product to become more cost effective when compared with multi-layer ceramic and/or miniature aluminium electrolytic capacitors. The result will be a larger demand for tantalum capacitors which, in turn, will trigger a greater demand for powder and, eventually, ore.

The electronic component industry recovery of 1983 and 1984 was part of a broad worldwide economic recovery of the electronic end equipment markets and involved not only an increase in demand for parts which were required to build the equipment but also parts to rebuild the equipment manufacturers' component inventories. This recovery process has run its course with the result that the industry, in 1985, will experience only a modest growth above that achieved during 1984. Coping with the slower rate of growth during this period after such a long and difficult adjustment period will be a major challenge to our industry — but there is a bright side: all forecasts indicate that the adjustment period will not last very long, perhaps no longer than four or five quarters before continued solid growth is resumed.

Carroll G. Killen
President

T.I.C. - Ten years old

In the spring of 1973 during a business discussion in Brussels, Mr. Paul Leynen of Cie. Geomines of Brussels and Mr. Herman Becker-Fluegel of National Resources Trading Co. of New York found that they shared concerns about the lack of useful information about tantalum source materials within the tantalum community. During their discussion, the concept of an association of tantalum source material producers was born.

Inviting some other producers to join their conversations, a series of meetings was held in Brussels during the latter part of 1973 and early 1974 out of which evolved a formal organization, the Tantalum

Producers International Study Center. Application was made to the Belgian government for legal recognition of the T.I.C., ultimately granted on October 24, 1974 as a non-profit association of tantalum source material producers with the main objective "to promote and further cooperation between members on matters of research in and studies of all aspects of tantalum source materials industry and of collecting, disseminating and maintaining statistics and information on any matters affecting that industry".

By the time of the Third General Assembly in Brussels on March 20, 1975, there were twelve members representing both mining and smelting operations on five continents. Not long thereafter, the General Assembly in September 1975 amended the By-laws of the T.I.C. to include in the membership "companies or manufacturers engaged in treating tantalum or columbium-tantalite raw materials, industrial consumers of the products supplied by the former (producers and processors) and commercial intermediaries who provide technical or financial assistance to mining operators of these primary materials, who are not members of the Association".

As a result, the membership grew rapidly, reaching thirty-three companies by the end of the fifth year and reaching seventy companies in the tenth year. These member companies represent all facets of the tantalum industry including major source material producers, free-world processors, a major portion of the end-product producers and the principal international companies engaged in the trading of tantalite. The membership is world-wide from seventeen countries on six continents.

The T.I.C. has collected and published statistics relating to tantalum, having started at the very beginning with product data from the United States and Japan. Source material production and shipment data was added in 1977 followed by world-wide product shipments in 1983. In 1984, the T.I.C. began to publish capacitor production data for the United States and Japan.

Since 1976, the T.I.C. has sponsored three studies of the world-wide tantalum situation. These studies have, for the first time ever, made available a comprehensive understanding of the tantalum industry and market to all segments of the tantalum community and to the public.

The T.I.C. "Bulletin" has been published quarterly since the beginning of 1975 starting as a simple four-page issue which has gradually expanded into a regular eight-page publication. In addition to providing in print the presentations made at the T.I.C. meetings and reporting on the activities of the T.I.C., articles have been published covering every facet of the tantalum business from mining and smelting to the use in end-products as well as periodic analyses of the supply and demand conditions of the market. Also, sketches of the businesses of twenty members have been included.

There have been twenty-two General Assemblies, one each spring and each fall. Although the first six meetings were held exclusively in Brussels, the practice of holding the spring meetings at a member site began in 1977 at the Tantalum Mining Corporation of Canada in Winnipeg, Canada. Since then, the spring meetings have been held all over the world from Perth and Penang to Tulsa, Torquay, Bad Harzburg and Stockholm. In 1978 the spring meeting was held in Rothenburg, West Germany, in conjunction with the T.I.C. sponsored First International Symposium on Tantalum. Attendance at these meetings has exploded from a mere forty-six at Tanco in 1977 to over two hundred at Stockholm in 1984, demonstrating the rapid development of the T.I.C.

The business of the T.I.C. has been carried on by the Secretariat located in Brussels, first in a small office sub-let from a larger organisation and, since early 1983, in its own office in the International Association Centre. The first Secretary of the T.I.C., Mrs. J.E. Goodyear, left in 1977 and the affairs of the T.I.C. have since been managed by Mrs. J.A. Wickens.

The T.I.C. has obviously become a truly mature international association which encompasses the entire industry. Continued growth and expansion of its activities assures that the T.I.C. will, in the future, be an even stronger authoritative organization which will serve its members well and will generate a better understanding outside the tantalum community of tantalum as an important commercial commodity.

The role of tantalum in tools for metal cutting (continued)

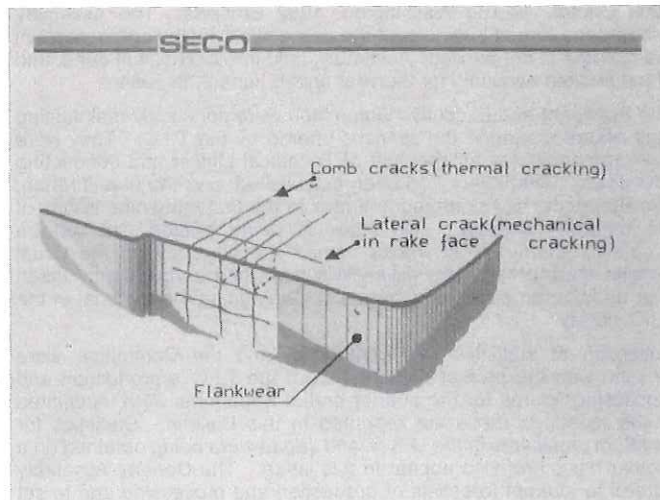
The first half of this paper was published in issue no. 40 of the T.I.C. "Bulletin". The entire paper, written by Mr. P.O. Snell and Mr. K. Nordlund of Seco Tools, Fagersta, was presented at the Twenty-first General Assembly of the T.I.C. in Stockholm on June 5, 1984.

REVIEW

The first part of the paper covered the history of development of tantalum-containing hard metal cutting tools and the turning of steel and cast iron. This part, covering the milling of steel and cast iron and the development of the demand for the cutting tool business, completes the paper as presented.

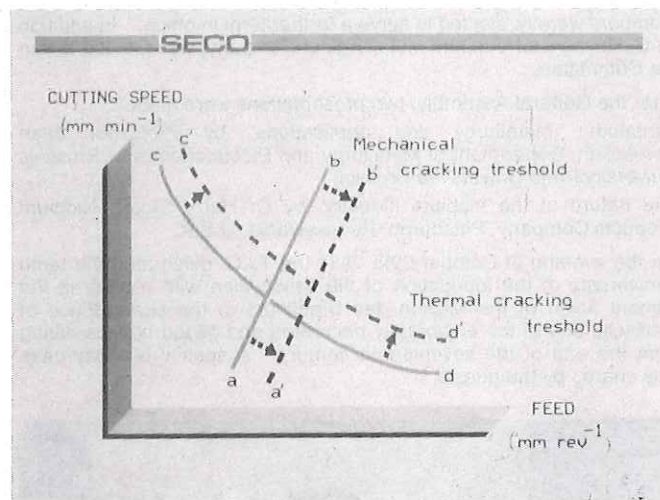
MILLING OF STEEL

During the milling of steel the tool material is subjected to very special strains which in general are greater than those during turning. Conventional wear processes such as crater wear and flank wear are superimposed with fatigue phenomena in the form of thermal cracks and mechanical cracks caused by the intermittent nature of milling. The milling insert is worn partly through large fragments of the cutting edge being dislodged.



Development has therefore been concentrated on increasing the resistance of the milling grades to the growth of mechanical and thermal cracks by means of an optimization of analysis and microstructure (23, 24).

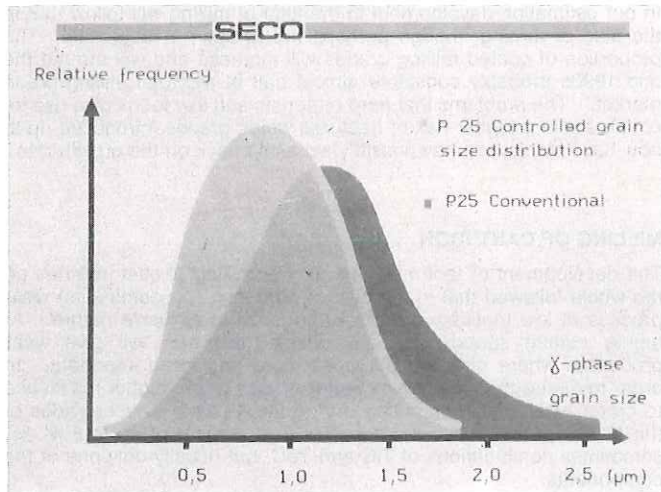
In order to describe the area of application for a milling grade a so-called safety operating chart can be used (25), the principles of which are shown in this chart:



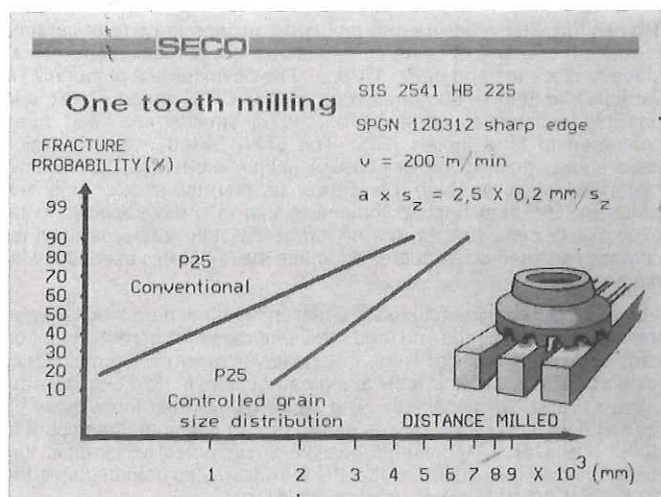
On the chart, cracks will occur in the area to the right of a-b and above c-d. Also, information can be obtained about the feed and cutting speed combinations that permit cutting without insert fracture. To illustrate this a P 25 alloy with the nominal analysis 9.5 wt. % Co, 12.0 wt. % Ta, 1.1 wt. % Nb, 5.2 wt. % Ti and the remainder W and C has been studied.

Mechanical cracks in three phase alloys of this type propagate mainly in the binder phase and in the grain boundaries between the binder phase and the γ -phase. An increasing grain size in the γ -phase increases, however, the risk of transgranular fractures. Two alloys with different grain size distribution in the γ -phase but identical in all other respects have been studied during single tooth milling.

The size distribution of the γ -phase for a conventional alloy and for an optimized P 25 alloy can be seen in the chart.

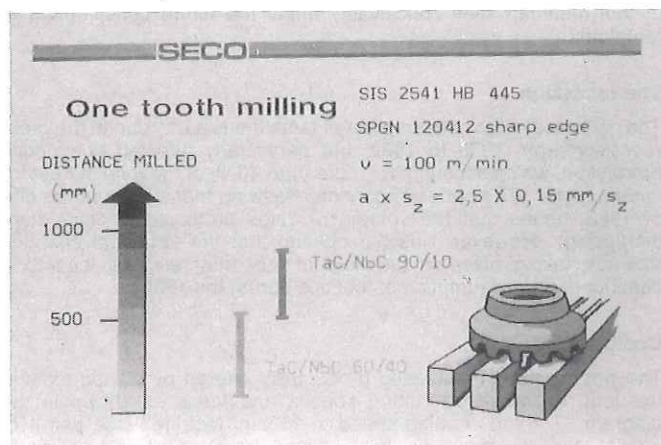


In the conventional variant the largest grains will act as defects when they are in that part of the edge that is loaded critically during the cutting. These edges will cause a greater spreading in the cutting performance. The variants that have been studied differ only marginally as regards transverse rupture strength, fracture toughness and hardness. When it comes to milling over slotted steel bars, which is a more complicated loading example, the two variants differ considerably.



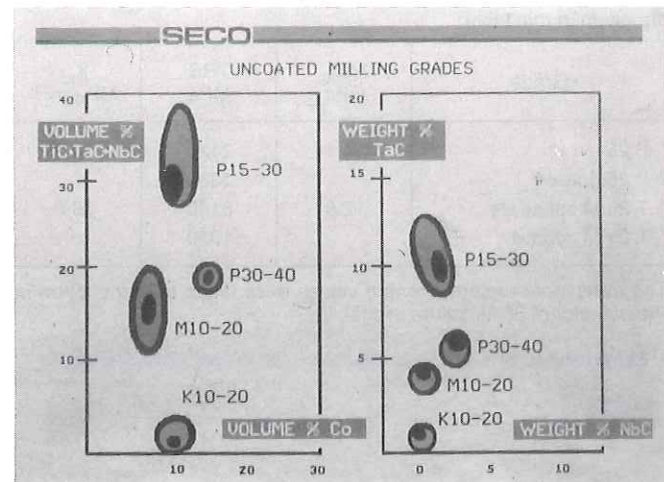
By restricting the grain distribution of the γ -phase, the threshold for mechanical fractures can be moved up to higher values, as illustrated on the previous safety operating chart by the line a-b being moved to a'-b'.

The tantalum content in the γ -phase has a positive effect on the wettability against cobalt and consequently on the grain boundary strength. A variant with a high content of tantalum in the γ -phase can therefore be expected to have a better thermal shock resistance. To illustrate this two variants with the same volume proportions of α -, β - and γ -phase have been produced, where in the first case the γ -phase has been based on TaC/NbC 90/10 and in the second case on TaC/NbC 60/40. The following chart shows that the variant with a high proportion of tantalum in the γ -phase displays a much higher performance in spite of the fact that the volume proportions of α -, β and γ as well as structure and binder phase composition can be considered of equal value.



The criterion for fractures in this cutting example has been comb cracks. By means of an increasing tantalum content in the γ -phase, it has been possible to move the comb crack threshold upwards from c-d to c'-d' in the safety operating chart previously shown.

Milling grades from about twenty producers have been analysed chemically and metallographically. In a β/γ diagram, the composition areas into which these grades fall are marked. In addition, the TaC/NbC content in these alloys is also shown.



As far as insert consumption is concerned, the completely predominant group in steel milling is ISO P 15-30. Analysis deviations between grades of this type from different producers are small. The centre of gravity, ISO P 25, lies at 13.5 vol. % β -phase and 30 vol. % γ -phase, where the TaC content is about 10 wt. %. For P 30-40 grades, which are used to a predominant extent for heavy duty applications, the weighted average lies at 16 vol. % β -phase and 18 vol. % γ -phase, where the TaC content is about 6 wt. %.

Development in the central P 25 group has been aimed at producing a material with high thermal shock resistance and high resistance to chipping. Higher TaC contents than the 10-14 wt. % already used do not result in any improvements of performance and a too large substitution of Ti with Ta impairs the high temperature resistance of the alloys.

As a result of the structure and analysis optimizations that have been carried out during the seventies and eighties uncoated milling grades have probably reached a state of maturity.

Coated grades for steel milling still only have a small proportion of insert consumption. In special applications such as crank shaft milling coated grades have however gained a certain significance. Conventional milling grades have usually been coated with thin nitride layers, using CVD or PVD technique, and the deterioration of mechanical shock resistance has been balanced with edge reinforcements.

Conventional milling grades furnished with a CVD coating do not however function satisfactorily in normal milling operations. They are therefore often accompanied by a recommendation for increased cutting speeds and reduced feeds. The reason for this is that the surface coating constitutes a "precrack", which means that the coated tool fractures at a considerably lower load than the uncoated substrate. In order to be able to raise productivity with conventional coated milling grades they must therefore be used at higher cutting speeds to compensate the lower feed which must be resorted to for reasons of brittleness. This has restricted their use. The advantages of coated milling tools have however been apparent for a long time. The coating gives a decreased crater wear and an increased resistance to the growth of comb cracks. In order to avoid the decarburization that is usually considered the reason for part of the toughness reducing effect of the CVD layer, PVD coating has been tried. The low coating temperature for PVD (400-500 °C) often means however that the adhesion is not as good as for CVD methods. PVD coating of conventional milling grades has not solved the problems of brittleness.

In the same way as in turning, a better understanding of the interaction of layer and substrate has made possible the development of improved coated milling grades. With the aim of fulfilling the toughness demands that milling makes on coated tools development is now focused on the substrate properties of the tools and the geometric form of the cutting edge. By using substrates with a high fracture toughness and high resistance to plastic deformation the good high temperature properties of the coating material can be utilized. For small feeds, which involve a high specific cutting force in the outermost parts of the cutting edge, the requirements as to deformation resistance and adhesion will however be difficult to maintain. Furthermore, it is necessary that the geometry of the tool is formed in such a way that the engagement/disengagement conditions are as favourable as possible (26, 27).

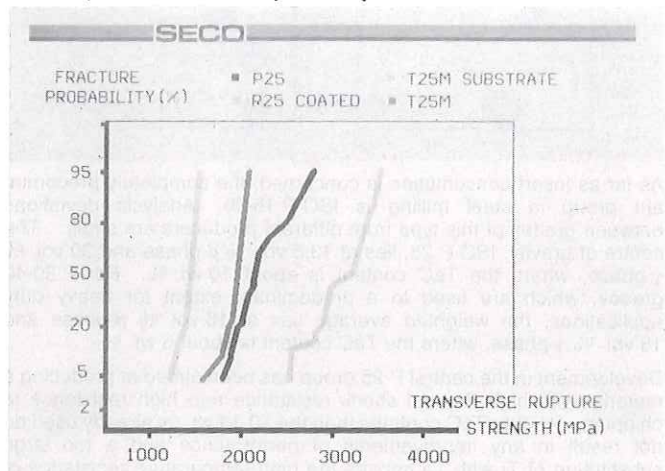
Thanks to the optimization of substrate, coating and insert geometry Seco Tools has succeeded in developing an almost TaC-free coated milling grade with excellent cutting properties in the central P 25 group (28).

The coated product displays a toughness behaviour that is equivalent to that of existing grades in the P 25 group.

The strength data for one P 25 grade in a coated and uncoated version and the new coated milling grade T 25 M in coated versions are given in this table.

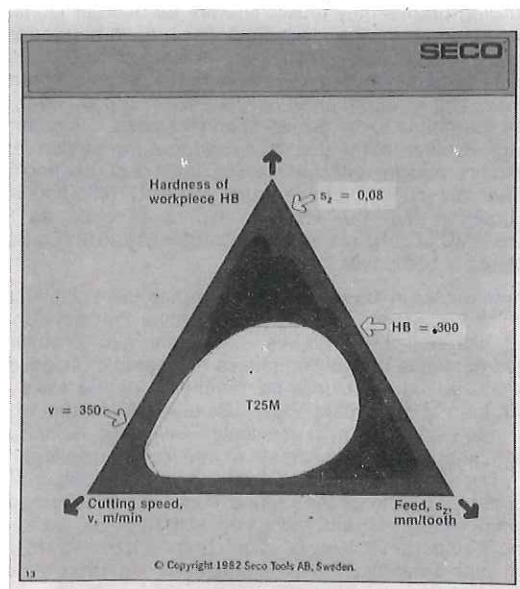
Grade	HV ₃₀ GPa	TRS MPa	K _{IC} MPa m ^{3/2}
P 25	14.1	2170	10.2
P 25 coated		1360	
T 25 M substrate	12.5	3140	15.0
T 25 M coated		1950	

The transverse rupture strength values were taken from the following Weibull plot at 50 % failure probability.



This plot clearly demonstrates that the transverse rupture strength of the coated grade is reduced by almost 40 %. The transverse rupture test bars were coated with a TiN/TiC/TiN layer with a thickness of approximately 4.6 μ m. A slight decarburization during the coating resulted in an eta-phase layer with a thickness of approximately 0.7 μ m. These data show that the coated T 25 M grade, from a fracture mechanical point of view, can be compared to the uncoated P 25 grade.

An attempt to present T 25 M in an unconventional way has been made by Jonsson (28). By using a HFS (hardness, feed, speed)-diagram information can be obtained about where chipping, fracture or detrimental deformation can be avoided in an acceptable sense. The most important information is that T 25 M is recommended for "normal" cutting conditions and that it is a favourable alternative to uncoated grades in most cutting operations. Its application is however limited to materials with hardnesses lower than 300 HB and feeds greater than 0.08 mm/tooth. Otherwise T 25 M replaces conventional P 15-30 grades and double lengths of life can be expected.



In our estimation development in the field of milling will follow that in the field of turning, though perhaps not at such a rapid rate. The proportion of coated milling grades will increase and will around the mid 1990s probably constitute almost half of the total milling grade market. The problems that hard materials and low feeds give rise to, coupled with a higher risk of fractures which grades introduced up to now have displayed, may possibly act as a check on the growth rate.

MILLING OF CAST IRON

The development of tool materials for the milling of cast iron has on the whole followed that in the field of turning. The dominating wear process at low tool/chip temperatures is of an abrasive nature. At higher cutting speeds specially ductile cast iron will give wear processes where diffusion becomes more and more important. In order to deal with these strains better grades with a higher resistance to crater wear were introduced during the 1970s. These grades of the M 10-type contain cubic carbides to a content of up to 8 wt. %, sometimes combinations of TiC and TaC, but usually only one of the components.

At the end of the 1970s carbide- and oxide-coated tools for cast iron milling were introduced. For reasons of brittleness the coated tools were furnished with greater tumbling radii than the uncoated variants, which limited their use to cutting where frittering does not constitute the criterion for the change of the tool. The tools were accompanied by a general recommendation about increase in cutting speed as uncoated K 10-20 grades held their own in the competition as long as the abrasive wear dominated at low cutting speeds, but they fell short when diffusion wear became predominant.

Thanks to better machine and tool constructions the use of ceramic tools for the milling of cast iron has increased, particularly in the car industry since the end of the 1970s. The development of tough ZTA variants and thermal shock resistant Al₂O₃/TiC/TiN variants has made possible substantial increases of cutting speeds and feed rates compared to hard metals (29). The Si₃N₄ based materials which have shown themselves to possess unique properties, for ceramic materials, such as high resistance to thermal shock, high hot hardness and high fracture toughness can in a developed form be expected to manage cast iron milling at the cutting speeds used for ceramics and should be able to approach the feed rates used today for hard metals.

Although cost considerations still speak in favour of hard metals, when the high cutting speeds and feed rates that ceramics permit cannot be used in existing transfer lines, it is however even now economically justifiable to use ceramic tools to a greater extent in rigid and powerful universal and NC-machines. The share of the total throw-away tip market held by ceramic tool materials is today estimated to amount to about 5 % (16). A continued positive development of ceramic tool materials may give the result that the throw-away tip market during the 1990s is to 10-15 % made up of ceramic tools.

DEVELOPMENT IN DEMAND FOR TANTALUM IN THE HARD METAL INDUSTRY

The consumption of tantalum in the hard metal industry followed on the whole the fluctuations of the market right up to 1979. During the 1970s consumption increased up to 1974, when the hard metal industry accounted for about 30 % of the world consumption which at that time amounted to about 1000 tons of Ta-contained. The consumption in the hard metal industry then decreased but increased again annually during the period 1976-1979 with 5 %, from 280 tons of Ta-contained in 1976 to 325 tons of Ta-contained in 1979. Since then consumption has continuously decreased and in 1982 amounted to about 180 tons of Ta-contained (30). We shall discuss in the following paragraphs the factors that can have contributed to this dramatic decrease and how trends outlined above in the development of tool materials may conceivably affect the future consumption of tantalum.

The recession

The decrease in the consumption of tantalum is partly due to the great recession from 1978 to 1982 that particularly affected automotive production, which accounts for more than 40 % of the total market for cutting tools. The general economic upswing that started at the end of 1983 means that the volume of chips produced is once more increasing. However, it is our opinion that the structural changes that are taking place in the field of tool materials will lead to a continued low consumption of tool tips during the 1980s.

Coated tools

The possibilities of increased productivity offered by coated tools in the form of increased cutting speeds and feeds as shown in the diagram "Turning : cutting speed to 15 min. tool life" (see part 1 of article) cannot always be fully utilized because of restrictions in

existing machinery. This means that improvements are taken out in increased tool life. Even though the proportion of coated tools — which in Europe and USA is estimated to amount to slightly more than 50 % whereas in Japan it has still only reached about 30 % — has started to reach a state of saturation, particularly in the field of turning, this does not mean that the development has come to a stop. A gradual change-over is now taking place from carbide- and nitride-coated tools of the second generation to aluminium oxide-coated tools for turning, at the same time as coated tools are gaining more and more ground in the field of milling. This may probably mean that the consumption of hard metal based throw away-tips will stabilize at around 300 million tips per year during the remainder of the 1980s. At the same time as a change-over to new coated grades is being made, a continuous decrease in the tantalum content of the alloys is also taking place.

Scrap processing

Since 1979 the recovery of tantalum carbide by the zinc method has increased rapidly. According to Kieffer (31) 11-12 companies used the zinc process in 1982 with an installed capacity of about 3400 tons per year. This quantity corresponded to approximately 20-25 % of the primary production of hard metals. Even if the zinc process has contributed considerably to the increase of scrap recovery, not all the tantalum carbide recovered now was previously lost. Conventional chemical methods and the Coldstream method, which dominated before, have however been pushed into the background by the zinc method. The recovery of tantalum from hard metal scrap was estimated (30) to be about 20 % in 1982. The recovery in 1990 is estimated to be about 30 %. The degree of recovery is limited, partly by the concentration of impurities that occurs when oxide-coated tools are processed, partly by problems connected with being able to re-utilize analytically and as regards grain size high contents of reclaimed powder without additions of virgin powder. If effective methods for grade separation and decoating are developed, the degree of recovery can increase very considerably.

Weights of tool tips

The average weight of brazed tips has lain stable at around 20 grams while a slight trend downwards in the weight of throw-away tips can be discerned. The average weight in 1970 was 10 grams but in 1983 this had sunk to less than 9 grams. The reason for this is chiefly an increased proportion of pin locked inserts. The proportion of brazed tips has decreased substantially since 1970 when it accounted for more than 50 % of tool production. We estimate that the world production of brazed tips today amounts to about 60 million tips. Even though this has led to a substantial decrease in the volume of hard metals the effect on the consumption of tantalum has not been so drastic, as the average tantalum carbide content of the brazed tips only amounts to about 2.5 wt. %.

Yields

New production methods introduced during the 1970s, combined with increased efforts to reduce costs because of material price increases, have led to improved yields in production. By means of spray-drying it has been possible to raise the primary yields in powder manufacture. New sintering techniques in combination with a better temperature and carbon balance control has resulted in increased yields during sintering. The introduction of direct-pressed tools has led to reduced grinding losses. We estimate that the average weight yields have gone up from approximately 80 % in 1970 to 85 % today and a continued increase up to 90 % is predicted for 1990.

Mixed carbide substitution

European, and to a lesser extent Japanese, hard metal producers have for a long time used tantalum niobium mixed carbides instead of pure tantalum carbide. The niobium contents have been gradually raised and in a recent TIC study (30) the Ta/Nb relations given in the following table were reported for a low demand estimate.

Market Area	1979	1985
Western Europe	81 : 19	75 : 25
Japan	90 : 10	88 : 12
USA	97 : 3	93 : 7

A follow-up of tools from the leading hard metal producers shows that the mixed carbide substitution which increased at the end of the 1970s and beginning of the 1980s has now come to a stop. Pure tantalum carbide and mixed carbide of the 90/10 type still dominate in uncoated grades for milling. If the price of tantalum is maintained it is not likely that substitution will increase above what has been estimated will apply to the low consumption alternative in 1985.

Alternative tool materials

The titanium carbide based tool materials, the so-called cermets, have for a long time been considered the tool materials of the future. These expectations have however not been fulfilled. In Western Europe and the USA their share of the market is only slightly more than 1 % whereas in Japan they account for rather more than 15 %. The coated hard metals are in many cases a better alternative and cermets outside Japan will probably only be of limited use in finishing.

The share of the market held by ceramic tool materials now amounts to about 5 % which is equivalent to approximately 15 million inserts. It has been estimated that they can achieve a market share of 10 % during the 1980s (32). The impact these materials will have on tantalum consumption is understated by their market share since they generally have longer life times than conventional tool materials. The rate at which the ceramic tool materials can achieve a larger share of the market is probably determined by the rate at which more stable and powerful machine tools are installed, so that the capability of these materials can be better utilized.

CONCLUSION

An appraisal of the requirements of tantalum carbide in the hard metal industry has been made, based on the potential estimate of the consumption of throw-away tips in different segments of the market and estimates made of tantalum carbide contents, tool numbers, weights of tool tips, yields and the degree of scrap recovery.

We have presumed that the hard metals used for other cutting operations and materials than the turning and milling of steel and cast iron have an average tantalum carbide content that corresponds to those mentioned previously. The values estimated for the years 1970, 1983 and 1990 are given below :

Variables	1970	1983	1990
Brazed tips (millions produced)	250	60	40
Inserts (millions produced)	230	280	300
Yield (wt. %)	80	85	90
Steel turning grades (wt. % TaC)	9.3	6	5
Steel milling grades (wt. % TaC)	6.5	8.5	7
Cast iron turning grades (wt. % TaC)	3	1	1
Cast iron milling grades (wt. % TaC)	3.6	2	2
TaC requirements (tons)	360	190	155

The consumption figures for 1970 have been based on the average analyses and weights of Seco Tools' hard metal production of throw-away tips and brazed tips for this period. The consumption in 1983 and 1990 is based on the fact that the consumption in the segments of turning and milling of steel and cast iron is static. This is a rough approximation as it can be expected that the ceramic tool materials will above all increase their share of cast iron cutting. Bearing in mind that the tantalum consumption in this segment is small, the total consumption is only affected slightly. The table indicates that if a scrap recovery of 30 % is considered only 100 tons of tantalum carbide would need to be produced from virgin raw materials in 1990. A strong, broad and prolonged economic upswing is a condition that this gloomy prophecy will not be fulfilled.

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32. American Metal Market, February 3, 1983.

The fabrication of a tantalum mesh construction for use in a chemical plant

The following paper, written by Mr. C.E.D. Rowe who is the Technical Manager of the Refractory Metals Department at Murex, Ltd. in Rainham, Essex, England, was first published in the February 1984 issue of "Metal Construction". It is reproduced here with permission for the benefit of the readers of the T.I.C. "Bulletin", modified only to the extent necessary to conform to the format of the "Bulletin".

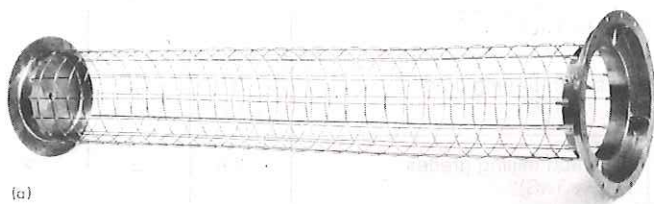
ABSTRACT

The construction of a concentric mesh structure from .105" and .192" pure tantalum wire is described. The heavier mesh was to be load bearing and was fitted with 1/4" thick tantalum flanges. Although spot welding was adequate for this application, a combination of spot and fusion welding in argon was employed to give the structure added rigidity. The light meshes were spot welded in an argon shield using a suitable jig to achieve the necessary mesh configuration. Prior to construction, weld methods were evaluated for strength, analysis, microstructure and corrosion resistance and details of the results obtained are given. All welds of the sheet material were carried out in an argon chamber using pure tantalum filler wire and conventional arc-welding techniques.

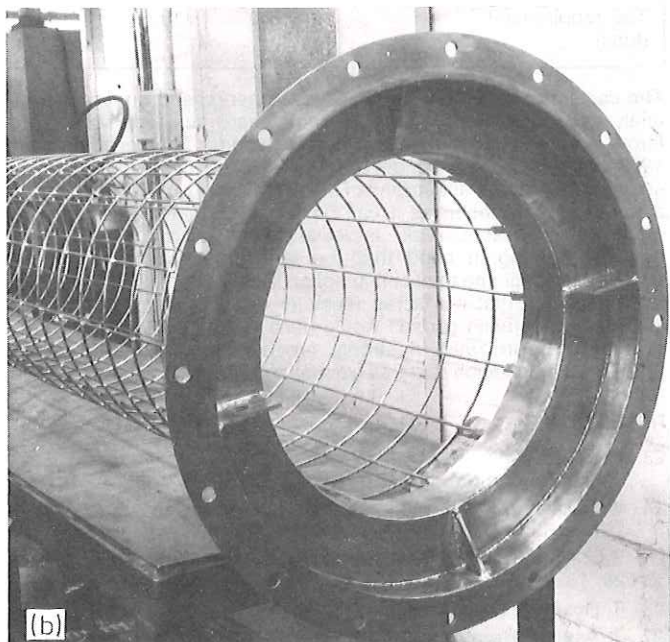
INTRODUCTION

Two tantalum mesh constructions were required for an application in a chemical plant treating hydrochloric acid. Tantalum was chosen for its excellent corrosion resistance in the environment concerned. The construction consisted of a main supporting frame with flanges manufactured from 0.192" tantalum wire with concentric, non-load bearing meshes of 0.105" tantalum wire. Because of the reactive nature of tantalum at welding temperatures (tantalum melting point = 2996 °C), it is necessary to weld in an atmosphere of pure argon in order to achieve a perfect weld.

The general arrangement of the main structure is evident from the following photographs :



(a)

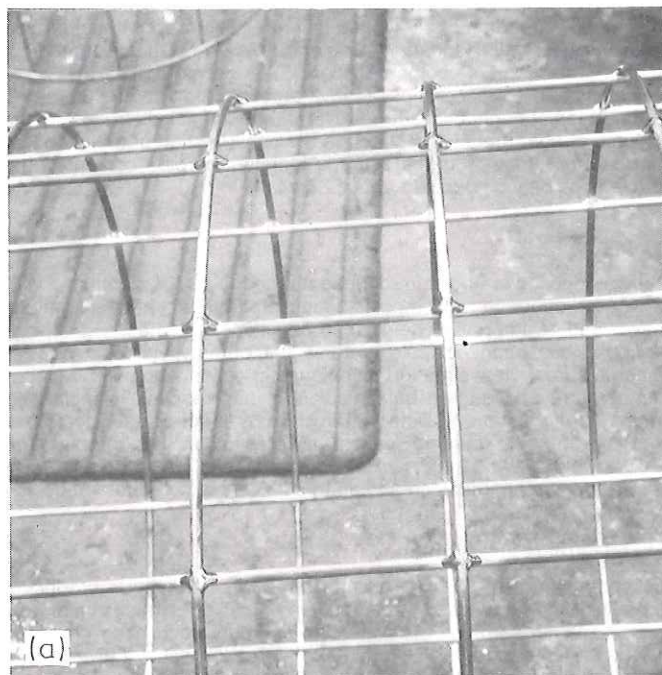


(b)

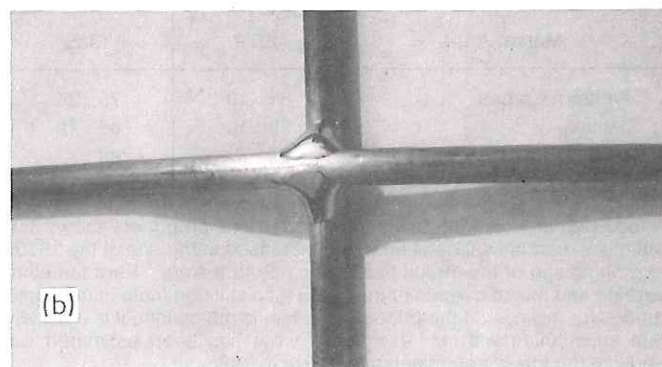


(c)

The structure consisted of a grid made from 0.192" thick wire welded to the flanges made from 1/4" thick tantalum plate. Although, as will be shown below, spot welding was adequate to achieve the necessary load-bearing strength, it was decided to use fusion welds to achieve added rigidity. All welds were carried out in the argon chamber, supporting the wires in a specially constructed jig to achieve the necessary configuration. Some welds were also spot welded in pure argon prior to fusion welding to assist assembly as shown here :



(a)



(b)

Pure tantalum wire was used as the filler material and the rod and sheet used for the construction was to ASTM B364-77 and B365-77, respectively. The concentric, non-load bearing meshes were constructed from 0.105" tantalum wire spot welded together to form the required grid, again using a suitable jig to support the wire during assembly. Spot welding was carried out in a protective shield of argon gas. Details of the method of construction will now be considered.

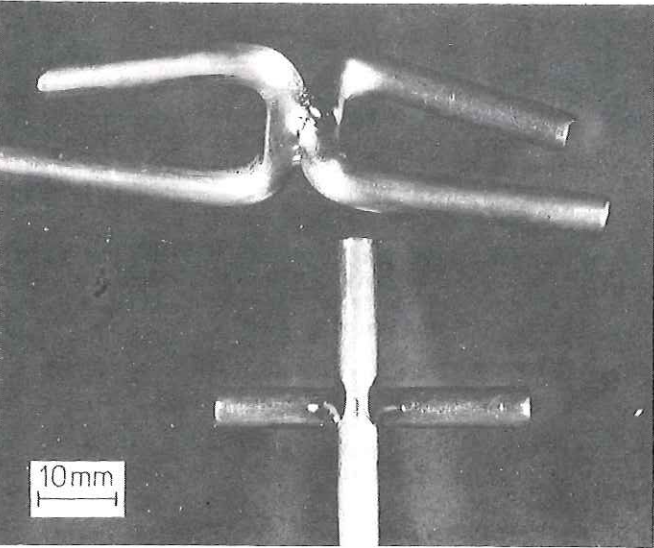
All welds on the plate material were carried out using conventional argon arc equipment and tantalum filler wire in a chamber filled with pure argon. The argon was gettered by arcing on a scrap piece of zirconium before welding the main structure to remove any remaining oxygen. Because of the high melting point of tantalum and the thickness of the material, the structure was allowed to cool after each weld to minimise distortion.

WELD STRENGTH

It was required that the main frame of the structure should be able to support an evenly distributed load of 275 kg. suspended from the bottom when held in a vertical position without distortion of the mesh. Several methods of welding were possible but the combinations evaluated were :

- (i) conventional spot welding in air
- (ii) conventional spot welding in argon
- (iii) fusion welding in an argon chamber
- (iv) spot welding in argon followed by fusion welding in the argon chamber.

Spot welding was carried out using a conventional spot welding machine with water-cooled copper electrodes. Pressure and current were adjusted so as to achieve a satisfactory weld without excessive heating of the wire and flattening of the wire in the weld region. The wire was lightly abraded prior to welding to remove surface oxide. Ten welds of each type were prepared, welding lengths of wire at right angles to form a cross. These samples were for the various tests described below and for submitting to the customer for evaluation at a later date if required. For weld strengths evaluation, 3" long pieces were used but at right angles into U-shape after welding so that they could be gripped in jaws of an Instron Tensile machine.



For microscopic examination, corrosion testing and chemical analysis of the weld regions, 1" wires were used as shown at the bottom of this photograph. The breaking strength of each weld is given in the following table. (In many cases with the thin wire, the weld itself was stronger than the parent wire. So the wire broke before the weld. These welds are marked * in the table.)

Weld Strengths. Test speed 2 mm/min. in an Instron 1195 Machine

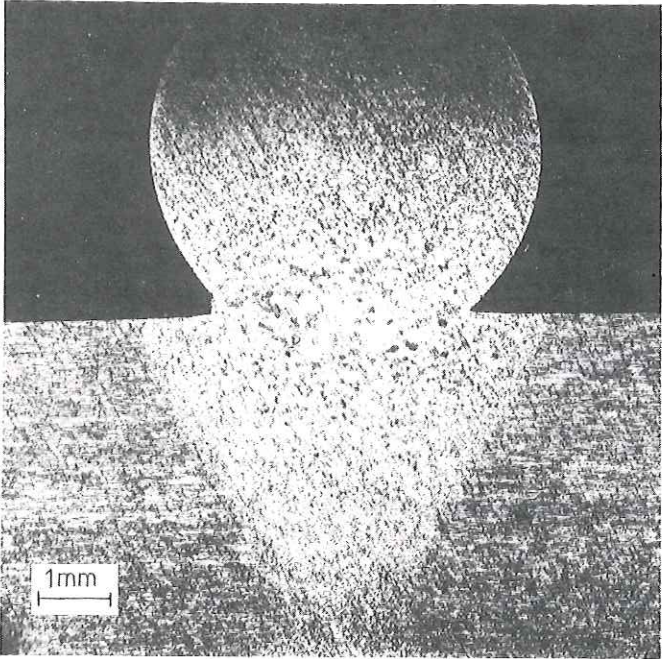
Weld Type	Weld Strength kg. 0.192" wire			Weld Strength kg. 0.105" wire		
(i) Conventional Spot	32.6	34.0		23.3	23.8	19.4
(ii) Spot in Air	32.4	41.4		23.5	26.0	22.6
(iii) Fusion in Argon	90.3	87.3	80.4	27.2*	27.8*	34.0*
(iv) Spot in Air + Fusion in Air	93.2	82.9	94.9	25.4*	33.2*	33.6*

It was concluded that the conventional spot welding alone would be sufficient to support the 275 kg. distributed load (14 wires at

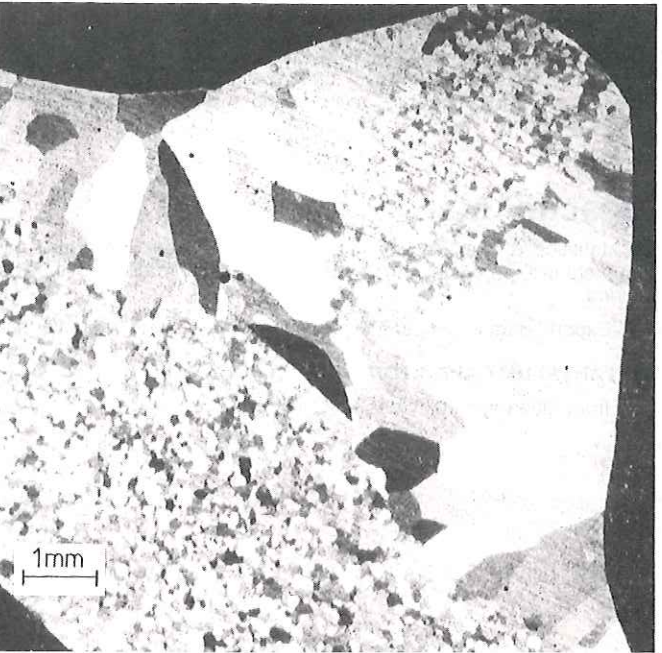
32.6 kg. = 465 kg.). It will be noted from the first photographs that the 14 wires are double fusion welded to the flanges. 25 mm long welds down both sides of the wire at the flange junction. So, as far as load bearing is concerned, the strength of the welds of the mesh was irrelevant. The only advantage of fusion welds was the added rigidity of the structure.

WELD STRUCTURE

Samples of all welds were examined metallographically and on the scanning electronmicroscope (SEM). Only welds of the type used in the final construction are shown in these photographs along with the fracture structures. (The black deposit on the wires in the Scanning Electron Micrographs is graphite used in specimen preparation and not contamination of the wire during welding.)

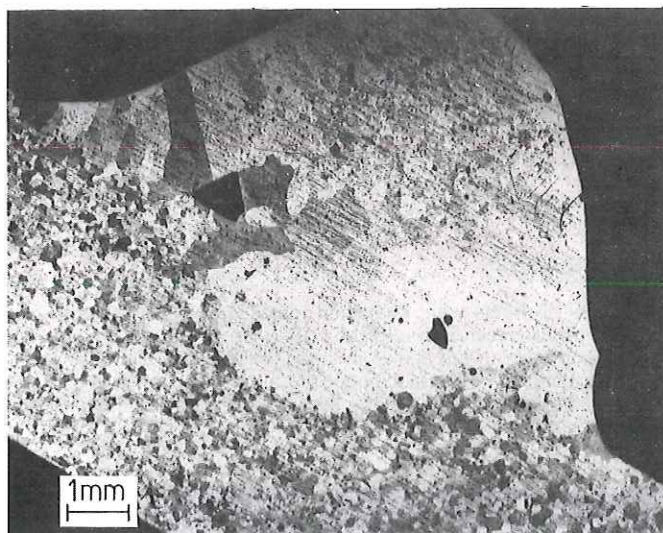


Structure of Spot Weld in 0.105" Wire



Fusion Weld in 0.192" Wire

Fracture samples were examined at high magnification on the SEM for evidence of lack of fusion, porosity of oxide inclusion but none was found. Etching was carried out using a mixture of lactic acid and hydrofluoric acid at 60 °C for 10 minutes.



Spot and Fusion Weld in 0.192" Wire

(This article will be completed in issue n° 42.)

Statistics

T.I.C. member companies report their production and processing during the third quarter of 1984 as follows :

TANTALUM PRODUCTION AND SHIPMENTS

Quoted in lb. Ta_2O_5 contained

1984 - 3rd quarter	Production	Shipments
Tin slag	169 956	55 312
Tantalite	54 773	98 744
Other materials	28 190	—
Total	252 919	154 056

Note : 19 companies out of 25 replied.

In accordance with the rules to protect the confidentiality of members, categories "Tantalite under 25%" and "over 25% Ta_2O_5 " have been combined, because one return accounted for more than 65% of one of the categories.

Capacitor statistics

The statistics of capacitor sales in the U.S.A. and Japan are given below. For the U.S.A. data "Manufacturers" covers U.S. capacitor manufacturers' products sold in the U.S.A. "Distributors" covers products imported by those manufacturers for resale. Other imports are not included.

The "Export" data in the Japanese manufacturers' statistics cover sales to eight main overseas countries only.

U.S. TANTALUM CAPACITOR SALES (THOUSANDS OF UNITS)

(Data from Electronic Industries Association)

Type	Manufacturers	Distributors	Export	Total
Foil	220	93	9	322
Metal cased solid	45 079	14 884	16 455	76 418
Non-metal cased solid	148 938	24 013	26 083	199 034
Chips	8 777	109	2 892	11 778
Wet slug	1 952	851	289	3 092
Total	204 966	39 950	45 728	290 644

JAPANESE TANTALUM CAPACITOR SALES (THOUSANDS OF UNITS) (Data from Japanese Electronic Industry Development Association)

3rd quarter 1984

Production :
531 206

Of this, export :
114 645

MEMBERSHIP

The following companies were elected to membership by the Twenty-second General Assembly :

Bayer AG

D-5090 Leverkusen, West Germany.

Bomar Resources Inc.

445 Park Avenue,
New York, N.Y. 10022, U.S.A.

Metamin Sdn. Bhd.

Lot 5234, Batu 28, Jalan Teluk Intan,
Mambang Diawan, Kampar,
Perak, Malaysia.

Nava Bharat Enterprises Ltd

(Electronics Division)
Navabharat House, 6-3-654, Somajiguda,
Hyderabad - 500 004, India.

Niobec Inc.

1000 ouest, rue Sherbrooke, Suite 1710,
Montreal, Canada H3A 3G8.

Niobium Products Co. Ltd.

440 Bld. Two, Parkwest Office Ctr.,
Cliff Mine Road, Pittsburgh,
PA 15275, U.S.A.

Willan Wogen Alloys Limited

Devonshire House, 1 Devonshire Street,
London W1, England.

Resignations were accepted from :

ITT Bauelemente GmbH

Ekman and Co. AB

TANTALUM PROCESSORS' SHIPMENTS

Quoted in lb. tantalum contained

1984 - 3rd quarter

Shipments

Tantalum oxide	27 732
Carbides	166 320
Powder/anodes	255 064
Mill products	90 463
Alloy additive, scrap, ingot, unworked metal, other	100 509
Total	640 088

Note : 17 companies out of 19 replied.

In accordance with the rules to protect the confidentiality of members, the categories of "alloy additive", "scrap" and "ingot, unworked metal and other" have been combined, as three individual returns exceeded the 65% limit in these categories.