TANTALUM PRODUCERS INTERNATIONAL STUDY CENTER

QUARTERLY BULLETIN ISSUE N° 37 MARCH 1984 FIRST QUARTER

June Meeting

The Twenty-first General Assembly of the T.I.C. will be held on June 5th 1984 as part of a meeting in Stockholm from June 4th to 6th. Presentations of papers will be given on June 5th, and this part of the meeting will be held in the Grand Hotel, where delegates will stay. On June 6th plant tours will be made to the facilities of Sandvik and Seco Tools. Joint hosts for the meeting will be the Swedish companies which are members of the T.I.C. : AB Sandvik Hard Materials, Seco Tools AB, Ekman and Co. AB and Axel Johnson Ore and Metals AB.

Monday June 4th 1984 : Grand Hotel, Stockholm

— Arrival of delegates and guests
— Registration with the T.I.C.
— Executive Committee meeting
— Cocktail Party in the Spegelsalen
— Evening free.

Tuesday June 5th 1984 : Grand Hotel

— 9 a.m. : Twenty-first General Assembly of the T.I.C., attendance limited to delegates of member companies
— 10 a.m. : Coffee break, during which other delegates and invited guests join the meeting
— 10.30 a.m. : Presidential Address by Mr R.W. Franklin
— Followed by a programme of presentations on the theme of the use of tantalum in cemented carbides and hard materials (see below)
— 12.30-2 p.m. : Luncheon : delegates and guests are invited to luncheon in the Vapensalen as guests of the T.I.C.
— 2-5 p.m. : The programme of presented papers will continue
— 6.45 p.m. : The party will embark on the S/S Gustafsberg for the evening, as guests of the four host companies. During a boat tour of the archipelago of Stockholm dinner will be served; a folk-dance performance will be given, and the guests will be invited to join in the dancing.

Wednesday June 6th 1984 : Västberga and Fagersta

There will be a choice of two factory visits : participants may tour either the Sandvik Coromant Factory at Västberga or the Seco Tools Factory at Fagersta. The number of visitors for each tour is limited.

— 10 a.m.-1.30 p.m. : Tour of Sandvik Coromant Factory : Research and Development, sintering and the chemical factory. Swedish Smörgasbord luncheon at the Västberga Restaurant.
— 7 a.m.-6 p.m. : Tour of Seco Tools Factory at Fagersta, about two and a half hours' journey from Stockholm. The factory tour will include the entire manufacturing process. After lunch the group will visit the Engelsbergs Ironwerk before returning to Stockholm.

Tours for the ladies will be arranged for both June 5th and June 6th, including visits to Waldemarsudde and Skansen (glass workshops and the open air museum), the Royal Palace, the Old Town of Stockholm, picturesque Mariefred and Gripsholms Castle.

Invitations to the meeting are being sent to the representatives of member companies. Further information may be requested from the Secretary of the T.I.C.

T.I.C.
TWENTY-FIRST
GENERAL ASSEMBLY

The Twenty-first General Assembly of the T.I.C. will be convened at 9 a.m. on Tuesday June 5th 1984 in the Grand Hotel, Stockholm.

AGENDA

1. **Voting proxies.**
2. **Minutes of the Twentieth General Assembly (held in Brussels on November 2nd 1983).**
3. **Membership applications.**
4. **Report of the Executive Committee.**
5. **Motion :**
   (a) **to change "Tantalum Producers International Study Center" to "Tantalum International Study Center".**
   (b) **to amend the Charter of the T.I.C.**
6. **Report on the quarterly Bulletin.**
7. **Statistics.**
8. **Twenty-second General Assembly.**
9. **Other business.**

The Presidential Address by Mr R.W. Franklin will open a programme of presented papers. These presentations will focus on the theme of cemented carbides and hard materials.

Further information concerning the association and the meeting may be obtained from the Secretary of the T.I.C., rue Washington 40, 1050 Brussels, Belgium. Telephone (02) 649.51.58, telex 65080 INAC B.

Presentations

The presented papers on June 5th 1984 will include :

B. ARONSSON, SANDVIK HARD MATERIALS :

"The influence of tantalum on the microstructure and properties of cemented carbide".

Abstract :

Available information on the composition of the phases in cemented carbides as a function of total contents of tantalum as well as on phase equilibria in parts of the Ta-Ti-W-Nb-Co-C system will be reviewed. There will be emphasis on the mixed cubic (Ta, Ti, W, Nb)C carbide for which some recent atom probe investigations will be particularly discussed. The microstructure (grain size distribution, contiguity, etc.) of cemented carbides with different tantalum contents and its relation to more fundamental mechanical properties (hardness, transverse rupture strength, etc) will be described.

P. BORCHERS, HERMANN C. STARCK BERLIN :

"Production and properties of tantalum carbide and mixed carbides".

Abstract :

Production of tantalum carbide and TaC containing mixed crystals is directed towards the requirement on physical and chemical properties for their use in cemented carbides and must be adjusted in case of new developments. Preferably in response to raw material availability and economic considerations.

Addition of TaC in form of mixed crystals and optimum carbide combinations as well as partial substitution by NbC will be discussed.

Coating of cutting grades and improvements in scrap reclamation generally allow better usage of all constituents of cemented carbides. Some important reclamation methods will be described with special consideration as to the quality and volume of the reclaimed product.

W. HANTEL, METALLURG INC :

"The future of virgin TaC in steel grade cutting tools".

Abstract :

A review of the amounts of material consumed at peak production levels in 1979-1980 compared to the material requirements at today's level and future upturns in business. Models will be developed to compare price and availability to changes in usage based upon increased usage of scrap recovery, coated cutting tools, Nb substitution in mixed crystals of Ta-NbC, and the development of smaller automobile engines requiring less steel and therefore less metal removal.

These effects will be the basis to determine demand in the next few years for virgin TaC.

P. O. SNELL, SECO TOOLS :

"The role of tantalum in carbides for metal cutting".

Abstract :

A review of modern carbide grades for different metal cutting applications in reference to their tantalum content will be made. The cutting performance in the turning and milling of steel with carbide grades based on a varying tantalum niobium ratio in the mixed cubic (Ta, Nb, Ti, W)C phase will be described, with special emphasis on the beneficial effect of tantalum on fracture and wear resistance. The influence of future trends and developments in grade composition, coating technology, insert shape and machining procedure on the future need of tantalum will be described.

DAG BJURSTRÖM, A. JOHNSON ORE AND METALS AB :

"Exploration for tantalum in Sweden".

Abstract :

Tantalum can be found in complex oxide minerals. The most interesting minerals from an economic point of view are columbite, tantalite and pyrochlore.

Tantalum in mostly associated with niobium and often also with rare earths and uranium.

From a geological point of view, the most interesting rocks are complex pegmatites and alkaline intrusions.

The fundamental exploration methods are radiometric measurement and heavy mineral geochemistry.

Letter from the President

It is in the long term interest of us all that the demand for tantalum should pick up to a level which will maintain operation of and investment in tantalum mining. Although the present low raw material prices may be of short term gain to parts of the industry they reflect an unhealthy situation in which the future stability could be at risk. The recovery in tantalum demand will be controlled by the rate at which the end-users, particularly carbide & capacitor industries expand out of the recession. Therefore, the next General Assembly with its associated presentations and plant visits will be of considerable interest in allowing members to assess how one of the major end-use industries is progressing. We are most grateful to the representatives of Sandvik, Seco Tools, A Johnson Ore & Metals and Ekman & Co for hosting this meeting.

By now members should have started to receive copies of a monthly bulletin, « Headline News ». This is a trial run on an interim service offered until the T.I.C. can provide a more comprehensive from its own office. At the same time a collection of information is being built up in the Brussels office and we would welcome contributions to this library system. Copies of papers written by members would be appreciated. As part of this improvement in information distribution we have had report "Untersuchungen über Angebot and Nachfrage mineralischer Rohstoffe : XVII Tantal" translated into English and copies are available to members on short term loan from the T.I.C. office. This is a very substantial report of over 200 pages in length.

I look forward to meeting you all again at the Stockholm meeting.

R.W. Franklin

Stockholm

The Twenty-first General Assembly of the T.I.C. will be held in Stockholm. The city, which is often called the « Venice of the North », spreads across fourteen islands in the navigable waterway from Lake Mälaren to the Baltic Sea, about 30 km. away. Stockholm was first founded in the thirteenth century on the island Stadholmen (City Island) which is now known as Gamla Stan, the « Old City ». Although the purpose for establishing Stockholm was to develop a commercial center for the towns that were beginning to flourish along the southern coast of the Baltic, Stockholm was built as a fortress to ward off the pirates prevalent at the time. Legend has it that barricades of logs were built first, hence the name « Log Island », Stockholm.

A castle was erected on the northeastern corner of Stadholmen and the city was surrounded by walls with fortification towers to the north and south. During the Middle Ages, the city developed rapidly and grew to command all foreign commerce of the Midlands and the North. It was not until the seventeenth century, however, that Stockholm became the capital of Sweden.

Modern Stockholm has a center-city area equal to about one-fourth that of New York City with a population of almost 800,000 people. Greater Stockholm encompasses nineteen suburban "Kommuns" with a total of 1.4 million inhabitants, one-sixth of all of the people in Sweden.

In the brighter season, Stockholm sparkles not only in water-reflected light but also in itself. Its centuries-old buildings look as trim as the latest skyscrapers with the landscape softened everywhere by greenery. Stockholm kommun alone, known as the « country-side city », has over 12,000 acres of parks.

The ancient origins of Stockholm are apparent in the narrow, winding streets of Gamla Stan although the individual houses are not so old because of the ravages of frequent fires. A few, however, preserve antique narrow fronts with gables in the style of some of the north German towns. But, even so, Gamla Stan is the liveliest part of Stockholm. It is favored by the young and artistic, by the visitors and tourists. Late at night, sounds of gaiety filter from the « källeri » — restaurants in medieval warehouse cellars — discotheques, night clubs and sidewalk cafes. During the day, the narrow streets are crowded with people coming to and from the many government offices and commercial establishments, and, particulary in the summer season, by the innumerable visitors experiencing the flavor of ancient Stockholm.

The redeveloped center portion of the city is to the north of Gamla Stan connected to it by the Norrbro (North Bridge). This area, known as Norrmalm, is the finest quarter of the city with broad straight streets, open spaces with paths and gardens, and handsome buildings. The Royal Opera is located on the river opposite the Royal Palace. To the north and east of it is the Kungsträgarden (Royal Garden), a favorite summer meeting place where open-air concerts and exhibitions of arts and crafts take place.

Stockholm is the seat of the government of Sweden and the usual residence of the king. There are schools of painting and architecture under the direction of the Royal Academy of Arts; a conservatory of music under the Royal Academy of Music; and experimental gardens and laboratories directed by the Royal Academy of Agriculture. The Natural History Museum, the observatory and meteorological office, the botanical gardens are under the supervision of the Royal Academy of Science. There are many collections, particularly those at the State Historical Museum, the Nautical History Museum and the Technical Museum. Among places of entertainment, the Royal Opera and the Royal Dramatic Theatre are known for excellent presentations.

In summary, Stockholm is one of the great cosmopolitan centers of the world, combining beautifully preserved reminders of the Middle Ages, monuments reflecting the wealth and pride of Sweden's imperial era, and the social and aesthetic experiments of the last hundred years.

In early June, at the time of the T.I.C. meeting, the weather is usually mild and bright. Temperatures will probably range from about 5 °C to 20 °C. The prospects of rain are slight, but some showers may be expected. The most surprising feature, particularly to those visitors from more southern climes, will be the length of the day, fifteen to sixteen hours of daylight.

The seat of the Twenty-first General Assembly will be the Grand Hotel, one of the most prestigious hotels in Europe. Located facing the Royal Palace on the opposite side of the Strömmen, it is in the center of Stockholm only a short walk across the Norrbro to Gamla Stan, to the Royal Opera, the Royal Gardens, the National Museum and many department stores, boutiques and theatres. Built in 1874 and renovated many times, the Grand Hotel is today truly modern but retaining the old-time atmosphere. Long famous for its elegance and graciousness, Grand Hotel has been used as the locale for drama and novels.

The New Sandvik : an international industrial group

The Sandvik Group was founded as a steel industry in 1862. Over the past century it has developed into an international industrial group of companies with manufacturing and sales within various business areas on five continents. Today, Sandvik's worldwide activity employs 25,000 people in more than 100 subsidiaries in over 40 countries. The Group turnover in 1983 amounted to appr. US$ 1.25 billion.

As of January 1st 1984, the Sandvik Group consists of the Parent Company, Sandvik AB, and a number of self-reliant product companies, each concentrating on its own specific business area : AB Sandvik Coromant, AB Sandvik Rock Tools, AB Sandvik Hard Materials, AB Sandvik Steel, AB Sandvik Electronics, AB Sandvik Saws and Tools and Sandvik Process Systems GmbH, the latter headquartered in West Germany.

A MAJOR CEMENTED-CARBIDE PRODUCER

Sandvik is the world's largest producer of cemented carbide. The cemented carbide is mainly used in three types of products : tools for chipforming machining, rockdrilling products and wear parts and forming tools.

Today, Sandvik's cemented carbide activity is channelled through three different product companies, each one specialises in its own particular area.

SANDVIK COROMANT

Sandvik Coromant is the largest of Sandvik's cemented carbide companies. It is the world's leading supplier of cutting tools for milling, turning and drilling within most types of industry. This area covers not only tools, but has, of late, made a wide commitment in metal cutting. A continual expansion of the product range, together with a growing co-operation with customers and machine tool makers worldwide, has, among other things, led to the company's activities increasingly being concentrated on the development of complete systems and tooling solutions for manual as well as automated machining.

SANDVIK ROCK TOOLS

In rock drilling techniques Sandvik has long been a world leader. Sandvik Rock Tools is the Group company concerned with this specific task, nursing the knowledge and know-how gathered in this field over the years.

AB Sandvik Hard Materials' main plant in Stockholm, Västberga is the centre for the Sandvik Group's production of cemented carbide powder and the development of new cemented carbide grades and coating technique. An increasing portion of the research is also devoted to other types of hard materials.

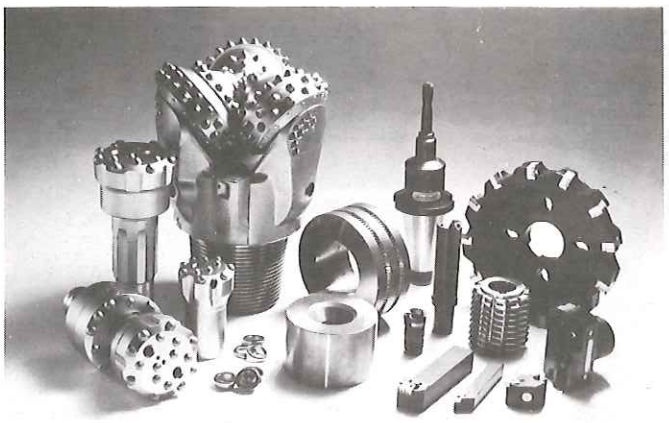
The product line includes, among other things, drill steels, drill bits and extension drill steel equipment for mining, tunnelling and civil engineering work. The products in this sector are sold through Atlas Copco, a company with which Sandvik has had a close co-operation agreement for almost 40 years.

Sandvik Rock Tools also manufactures products for oil drilling, on shore as well as offshore. For the mining of softer materials, such as coal, the company has developed special tools; this is also the case for various specific areas like asphalt breaking.

SANDVIK HARD MATERIALS

The Group's third cemented carbide operation, Sandvik Hard Materials, develops and markets cemented carbides for a great number of applications. It is also the Sandvik Group's development centre for cemented carbide, but research is also directed to other hard materials that will be used in the near and more distant future.

Manufacture and internal, as well as external, sales of cemented carbide powder form the basis for Sandvik Hard Materials' activity. A unique material technology has made the company a leading supplier of tools and products for applications that demand higher degrees of wear resistance and strength. Examples of such products are rolls for the hot-rolling of wire, tools for deep-drawing, extrusion or powder-compacting as well as pump seals and blades for road-graders.



Sandvik is the world's largest producer of cemented carbide, used mainly in three types of products : metal cutting tools, rock drilling tools and wear parts.

As the members of T.I.C. are most interested in that part of Sandvik's activity where cemented carbide powder is used, we will only briefly describe the other companies.

SANDVIK STEEL

Special steel accounts for approximately one third of the Sandvik Group's total output. The production is concentrated on special steel products — in the shape of tube, strips and wire — for advanced technical applications. Some 85 per cent of the production is in stainless grades.

SANDVIK ELECTRONICS

The Sandvik Group's advanced manufacturing processes, mainly in the cemented carbide and steel areas, require, to an increasing extent, electronic equipment for the monitoring and control of production processes, techniques and quality control. The electronics know-how, built up within the Group during a number of decades, is available to other firms besides the members of the Sandvik Group.

SANDVIK SAWS AND TOOLS

More than a century ago, and thanks to its steel know-how, Sandvik became a specialist in handsaws, a product which still today is a dominating feature in the Group's extensive assortment of tools. The range has successively been increased and now covers a wide range of tools for leisure, hobby and industrial purposes.

SANDVIK PROCESS SYSTEMS

Steel conveyor belts were already a part of Sandvik's manufacturing programme at the turn of the century. Since then, this sector has undergone a spectacular development and today embraces a wide range of industrial areas as well as production of complete process installations for the chemical, foodstuff, pulp and paper industries.

INTENSIVE R&D

Sandvik is a research intensive organisation. Every year some four per cent of the Group turnover is spent on research and development. More than 1,300 metallurgists, chemists, physicists, engineers and other researchers and assistants work in R&D units in many markets, such as the U.S., West Germany, Japan, India and Sweden.

ON THE WORLD MARKET

Sandvik is an international company with considerable resources. More than 90 per cent of the total output is to markets outside Sweden, channelled through its widespread subsidiary companies. Through domestic production, stock handling, distribution, technical service and efficient delivery systems, Sandvik is able to offer its customers the close and rapid service required.

Testing the properties and behaviour of different hard materials in practical use is an integral part of the development work at Sandvik Hard Materials. Modern machine tools are available for this comprehensive work.

Ekman & Co AB

Swedish merchants by the name of Ekman have engaged in trade continuously for more than 300 years. The Ekman Company in its present form was registered in 1802. At that time we had our own ships which carried herring to Pommerania and backhauled grain. As herring fishing in Sweden declined, Ekman was forced to adapt to new market conditions. During the Napoleonic blockade of England, Ekman succeeded in transporting vessels through the blockade with products from the colonies. Iron became the main product and dominated our business until the end of the 19th century when we made pulp and paper our chief product lines. Since then forest products have remained No. 1.

Today Ekman also markets steel products and, since 1980, Ekman is active in tantalite as a producer's agent for S.A.B., a Brazilian producer and collector of tantalite, ferberite and beryl.

One approach which has contributed to Ekman's succes through the years is the establishment of subsidiaries around the world. In 1913 we opened an office of our own in Japan and the following year in China, just to mention two.

In 1965 our company became a member of Säfvean, an investment company quoted on the stock exchange in Sweden. Säfvean operates internationally in four different areas — finance, property, trade and industry.

Axel Johnson Ore & Metals AB

The Johnson Group has been trading in ores and metals ever since the company was founded in 1873. Today, more than 100 years later, Axel Johnson Ore & Metals AB — AXORE — is the entity responsible for trading in these products.

The Johnson Group is the third largest industrial and commercial group in Sweden with a turnover of 3.5 billion dollars and offices in more than 30 countries. Among many different activities, it is one of the biggest stainless steel producers in Europe.

THE PRODUCTS WE TRADE

In Scandinavia AXORE is one of the main suppliers of metals and ferro-alloys to the metallurgical industry.

As agents for the Norwegian company Tinfos Jernverk and the Austrian company Treibacher Chemische Werke, AXORE supplies ferro-alloys like FeSi, SiMn, FeMn and micro ferro-alloys and carbides like FeMo, FeW, FeV and TaC/NbC. We are also one of the bigger suppliers of FeCr, SiCr and Ni to the Scandinavian steel industry.

Through branch offices in London and Cologne, AXORE is strengthening its position as a supplier of FeCr, SiCr, FeSi, FeTi and Ni to the European metallurgical industry.

In USA, the Johnson offices in New York and Lionville are well established suppliers of ferro-alloys and metals to the American metallurgy industry.

The activities in Lionville include an electronic beam furnace producing titanium metal and a conventional furnace producing FeTi and other micro ferro-alloys.

As a world-wide agent for the South African company EMCOR, producing manganese metal, AXORE is, through a network of its own offices and agents, supplier of this metal mainly to the aluminium and steel industry in the world.

AXORE has a long tradition as supplier of various grades of ores. We are partowners of an Australian wolfram ore mine, Queensland Wolfram Pty Ltd, and thus suppliers of tungsten ore.

As agent for the Swedish L.K.A.B. and C.O.M.I.L.O.G. in Gabon, we supply iron ore, copper concentrates and manganese ore in specific markets.

We trade in tantalite concentrates mainly supplied from Australia and the Far East.

Through our London office, close to the London Metal Exchange (L.M.E.), AXORE has broadened its activities in the non-ferrous field including trades in physical metal as well as hedging operations on the L.M.E.

HOW WE OPERATE

To ensure long-term reliable deliveries, AXORE has integrated into the production of ores and metals and is thus partowner of mines and metal works.

AXORE operates as exclusive and principal agents for producers world-wide and in specific markets.

AXORE converts ores and concentrates into ferro-alloys and metals.

The Johnson Group has a long experience in trading with the East Bloc countries and among AXORE's more important trading partners are the Soviet Union, The German Democratic Republic, Poland, Czechoslovakia, Yugoslavia, Roumania, Bulgaria, Hungary, Albania and The People's Republic of China. With some of these countries AXORE is the principal trade partner in this field.

Business with state-trading countries often includes compensation requirements. AXORE and the Johnson Group have wide experience in this type of business.

A basic concept in the business philosophy is to contribute added value in the market place and to be a long-term and reliable supplier. Accordingly, AXORE supports its suppliers and customers with financing, currency transactions and hedging operations. AXORE is also helping to set up reliable and efficient distribution systems, which includes stock handling and processing.

WHERE WE OPERATE

The AXORE head office is located in Stockholm. AXORE has branch offices in London and Cologne and is represented by specialists in the Johnson offices in New York, Lionville, Milan, Vienna, Düsseldorf, Madrid, Hongkong, Melbourne, Johannesburg, Moscow and Berlin-GDR. In all, the Group has offices in more than 30 countries.

A. Johnson & Co has a new company symbol and logotype. The well-known Johnson flag has served the company well as its symbol and trade mark for more than a century. The traditional star and "J" have been preserved in a new form. Today, A Johnson & Co is a modern, international enterprise. The new symbol reflects tradition and excellence while also representing a dynamic and outwardlooking philosophy.

Sprague Electric Company

Sprague Electric Company has begun production of solid-electrolyte tantalum capacitors at a new 75,000 sq. ft. facility in San Antonio, Texas. The new $ 10 million plant is expected to employ more than 500 by the end of 1984. The new Sprague Electric plant in San Antonio supplements the Company's other solid-electrolyte tantalum capacitor plants in Concord, New Hampshire and Sanford, Maine.

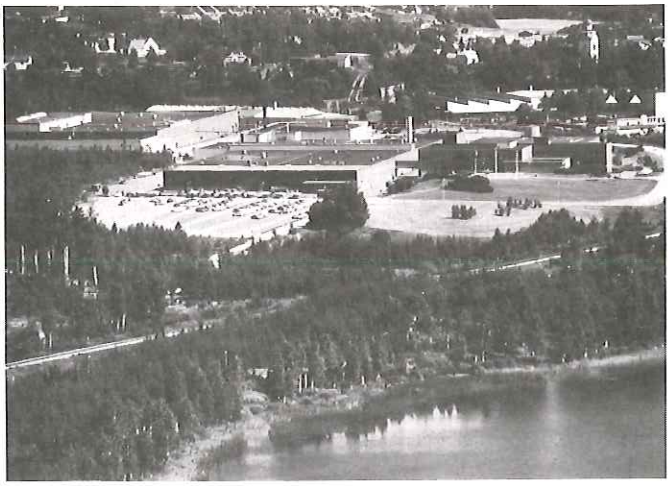
According to Dr John L. Sprague, President and Chief Executive Officer, the San Antonio location was selected over 15 other cities in the United States, based on criteria which include an adequate supply of labor, good local financing, low energy costs, low tax costs, a good transportation system, and for being a "good place to live".

Headquarters of Sprague Electric's tantalum capacitor operations is at the Sanford, Maine plant, where Mr Peter W. Maden, Vice President and General Manager of the Tantalum Division, maintains his offices.

Seco Tools AB

Fagersta is the name of a small town about 200 km northwest of Stockholm. It is also the name of the town's major industry — one of Sweden's oldest companies — Fagersta Steel Works.

Seco's history goes back to 1929 when Fagersta Steel Works decided to take up the manufacture of cemented carbides. The reason for Fagersta's interest in the new cutting tool material was the fact that the German Krupp-Widia "hard metal", launched a couple of years earlier, proved to be a serious competitor to Fagersta's high-speed steel.



Seco Tools factory and main office in Fagersta, Sweden.

The trade name Seco — Latin for "I cut" — was introduced in 1931 when the development work had resulted in the marketing of a sintered carbide grade for metal cutting.

Only ten years later Fagersta could sell know-how to Russia for a cemented carbide factory to be located in the Moscow region. The contract was signed in 1941, but the project was delayed by the war, and, after installation during 1945, the new factory was in production in 1946.

The next know-how sale happened in 1972 when Poland took a short-cut to modern metal cutting technology and built a modern cemented carbide factory based on Seco's processes and experience.

The know-how in these two cases, of course, had not much in common. The 30 years in between represented a tremendous build-up of knowledge. New laboratory equipment had made it possible to learn which effects the addition of alloying elements and the variation of process parameters had on the properties of cemented carbide grades. New production equipment had made it possible to control the processes and master a consistent high quality production.

The "throw-away insert" principle, which was introduced in the fifties, had created a demand for close tolerances in the production of carbide tips. The carbide manufactures had taken up large scale production of tool holders and milling cutter bodies with precision pockets and clamping systems for these indexable cutting inserts.

In 1967 Seco had managed to find a formula for a very successful milling grade, called S25M. The unique combination of wear

A sample of milling cutters developed and manufactured at Seco Tools.

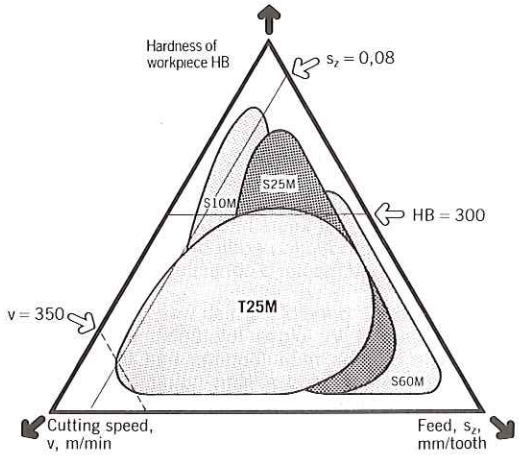
resistance, toughness and ability to withstand thermal shocks proved ideal for a broad range of milling operations. The toughness, combined with chemical resistance at high temperatures, necessary in steel milling, was achieved largely thanks to high content of tantalum carbide in the γ-phase. Despite more than 15 years of development work, which have seen many grades come and go, Seco S25M is still at the top of conventional carbide grades for milling. In later years Seco have introduced two complementary grades : S10M with better wear resistance and S60M offering greater toughness. But the majority of milling jobs is still handled by S25M.

In 1983 the R&D people at Seco took a new step of the same importance as the introduction of S25M. This time the grade is called T25M, and it is claimed to be the first coated milling grade that works in general milling applications. Its substrate is very tough to stand the endlessly repeated hammering blows when the individual teeth go in and out of engagement. In fact, the substrate is much tougher than any existing carbide grade for steel machining. The wear resistance is cared for by the coating — a gradual blend of titanium nitride with an increasing content of titanium carbide from the surface towards the central part of the coating layer. Both titanium compounds are well known for their chemical stability when subjected to heat in intimate contact with a steel swarf.

In 1974 Seco ceased to be a department of the Fagersta Steel Works and became a Company in its own right under the name Seco Tools AB.

Today Seco Tools AB is in fact a group of companies employing in all some 1900 people. Cemented carbide production is located not only in Fagersta but is also carried out by some of the subsidiaries, namely in Italy, Brazil and Australia. Other subsidiaries such as France, Germany and U.K. have factories for turning and milling tools, much of them specials to solve customers' machining problems.

And that is what it is all about really — to solve customers' machining problems, preferably with standard tools. Seco is one of the pioneers in the metal cutting business and is used being on top in development. Seco likes that, and intends to stay there. In that respect, only, Seco is a conservative company !



Cutting range of Seco's new coated grade T25M in comparison with uncoated grades.

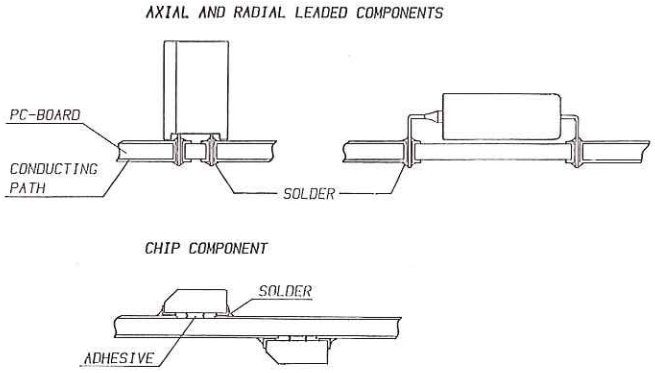
Chip Capacitors

The following article has been taken from a paper presented by Dr. Werner Schnabel, of Siemens AG in Heidenheim, West Germany, at the Twentieth General Assembly of the T.I.C. in November 1983.

Progress in electronics over the years has been mainly prompted by the demand for quality, compactness and low cost. With regard to these, axial and radial-lead components together with the printed circuit (PC) board and the corresponding assembly technology, have reached a relatively high standard. Now, with the introduction of leadless components directly mountable on PC boards, a further step toward higher density and lower cost is to be expected.

MOUNTING OF COMPONENTS

The following diagrams depict the basic difference between the mounting of components with leads and the leadless;



The axial or radial-lead components have to be inserted into through-holes in the PC board, which procedure is rather difficult compared to the placement of leadless components. The seemingly simple pick and place action for leadless components, however, requires extreme accuracy and the use of adhesive for temporary bonding to the PC board prior to soldering.

The main assembly features for surface-mounted capacitors are generally the same as for all kinds of leadless components which are directly placed onto PC boards.

— The package density gain is 30 % to 60 %.
— The relatively low mounting cost is only 20 % to 40 % of that for components with leads but these costs are only obtainable with high speed assembly machines which are still rather expensive as a result of the high speed and extreme placing accuracy demanded.
— Placement rates are high, 1,500 to 50,000 pieces per hour.
— High quality and reliability are obtained.

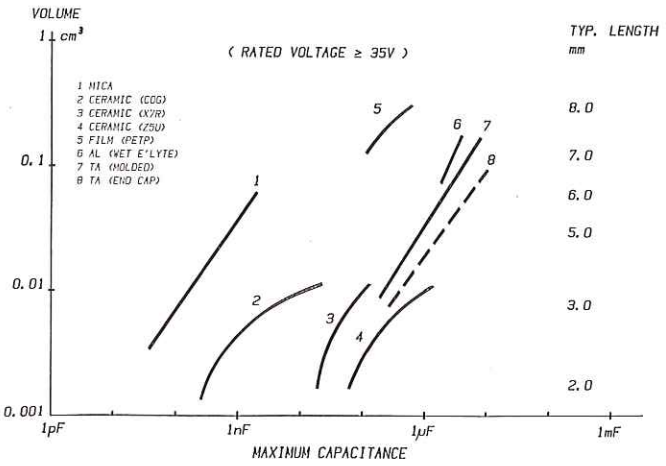
The overall cost evaluation as well as the quality and reliability criteria make this new technology very attractive.

SURFACE MOUNTED COMPONENTS

All elements of circuits are being surface mounted : resistors (metal film, carbon film, glaze), capacitors (multilayer ceramic, monolayer ceramic, tantalum electrolytic, aluminium electrolytic, polyester film, mica), inductors (multilayer, wire-wound), mini-mould diodes, mini-mould transistors and IC chips (mini-flat packages, ceramic chip carriers). With these active as well as passive components, nearly every (low power) task can be accomplished. These devices usually have simple configurations with small flat-base terminations or short duckfoot-like pads for soldering.

In the case of capacitors, a wide variety of square chip-like or cylindrical forms (MELF - metal face bonded electrodes) have been developed. The materials for these capacitors vary according to the required capacitance range or other operating demand.

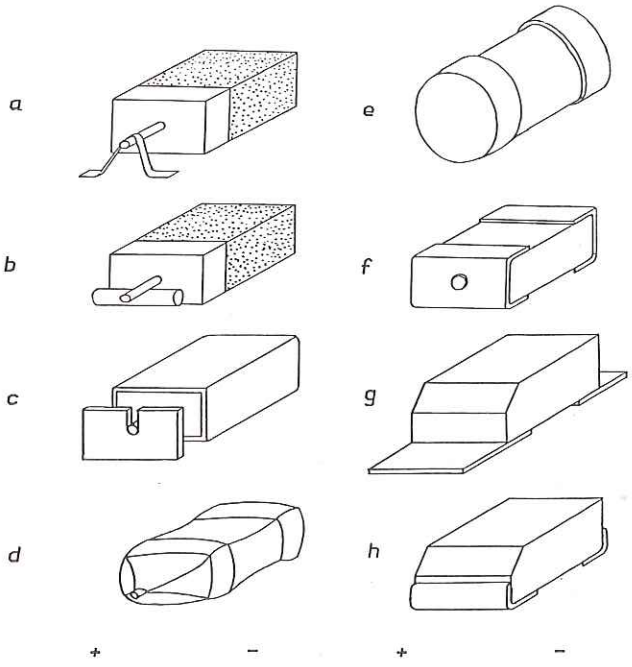
A rough comparative view on the relationship between maximum capacitance and the corresponding chip volume (a rated voltage of 35 volts or higher was applied) follows :



These curves demonstrate the unique position of tantalum chip capacitors relative to the volume efficiency of the capacitance. The same statement can be made considering the CV product per volume.

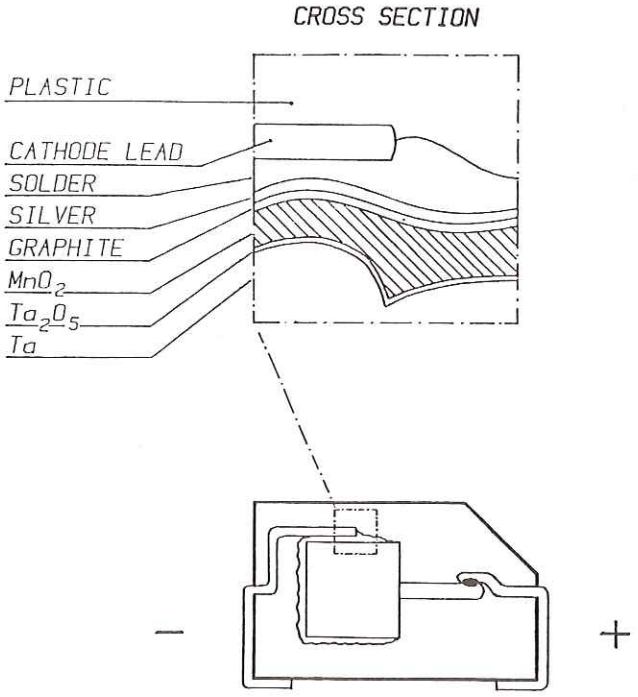
TANTALUM CHIP CAPACITORS

Tantalum chip capacitors have been known for many years and, meanwhile, a wide variety of configurations have been developed, some of which are :



There are early T-bar designs (a-c), end-cap configurations (d-f) and square moulded versions (g,h). The end-cap versions are widely used in hybrid IC technology. Their only disadvantage seems to be the lack of well defined flat surfaces which are indispensable for accurate automatic assembly operations. The moulded version does not have this disadvantage but it is somewhat larger in size.

A cross section of a moulded tantalum chip capacitor shows a porous tantalum body providing the skeleton for the dielectric layer. On the other side the layer is successively contacted with MnO_2, graphite and a solderable silver coat.



Production is usually divided into two main areas :

1. The front end where the actual capacitor anodes are made.

— Pressing and sintering fine tantalum powder onto a tantalum wire to produce the anode body,
— Welding the anodes onto processing bars,
— Forming the dielectric layer by electrochemical oxidation of the tantalum surface, the thickness of the oxide being directly proportional to the formation voltage (about 1.8 nm/V), 3 to 4 times the rated voltage of the final capacitor,
— Dipping the tantalum body into a Mn-nitrate solution and then pyrolyzing it in an oven at a temperature between 200 and 300 °C to make the MnO_2 cathode, repeating the procedure several times to ensure an adequate internal fill and external protection,
— Carrying out one or more re-formations in order to compensate for the deterioration of the dielectric caused by the pyrolysis, and
— Applying a graphite layer and a coat of silver.

2. With the capacitor anode now ready for encapsulation, additional steps from assembly through testing are accomplished :

— Transferring the anodes from the process bars into an assembly carrier system achieved by cutting the anodes from the process bars, welding the anode wire and soldering the anode body into the carrier which already contains the solder-coated anode and cathode pads,
— Encapsulating the anodes in these carrier systems by transfer moulding,
— Applying finishing steps like deflashing, marking and opening of the carrier system so that a voltage for aging can be applied,
— Totally separating the capacitors from the carrier system and shaping the electrode pads, and
— Testing and packaging (bulk, tape or magazine).

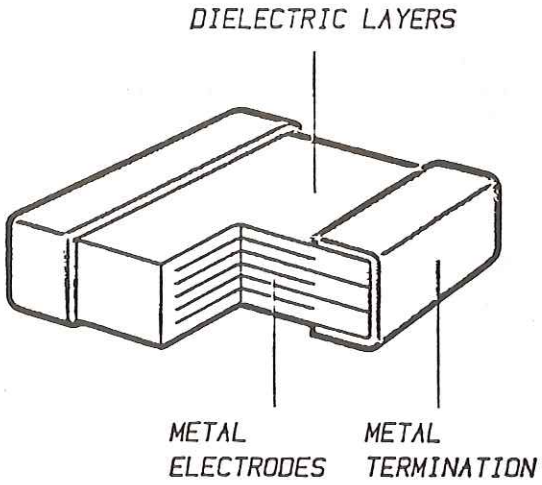
Now the chips are ready for the end-user.

The moulded tantalum chip capacitor is robust against mechanical and thermal stress and has an excellent protection against humidity and solvents. These features, together with the electrical properties which are very similar to those of the bigger leaded types, give the moulded tantalum chip a promising future.

OTHER TYPES OF CHIP CAPACITORS

Some examples of other types of chip capacitors are;

Ceramic Chips — The most important type is the ceramic chip capacitor which is already widely in use. Ceramic chips do not have as many configurations as tantalum chips but their design features are basically chip-like. The cross-section illustrates how they are produced :



Multiple layers of metallized dielectric material ribbons are stacked to achieve the desired capacitance values and are fused in a furnace to form a monolithic block. The block is then cut into individual capacitor chips. Metallic terminals are applied to connect the interleaving electrodes. With this technique, depending on the properties of the ceramic material, a wide range of capacitance values can be achieved.

Some typical properties of ceramic chip capacitors are

PROPERTIES	TANTALUM	CERAMIC			ALUMINIUM	FOIL
		C0G	X7R	Z5U	(WET E'LYTE)	(POLYESTER)
CAPACITANCE	0.1 ... 100 µF	0.001nF .. 15nF	0.1nF .. 150nF	0.001µF .. 1.5µF	0.1 .. 22µF	1 .. 100nF
RATED VOLTAGE	4..50 V	50 V	50 V	50 V	6.3 .. 63V	50 V
OPERATING TEMPERATURE	−55°C .. 125°C	−55°C.. 125°C	−55°C.. 125°C	10°C .. 85°C	−40 .. 85°C (−55 .. 125°C)	−55°C .. 100°C (125)°C
VOLUME EFFICIENCY µC / cm³	1000 .. 4000	0.25.. 1	2.5 .. 10	25 .. 100	500 .. 1000	~40
SOLDERING	260°C / 10 sec	260°C / 20 sec			230°C / 10sec (260°C / 5sec)	260°C / 5sec

Two kinds of dielectrics are used for ceramic capacitors, Class I dielectrics which have excellent temperature stability characteristics and Class II dielectrics which, by contrast, have higher dielectric constants contributing to higher volumetric efficiency but with a rather high capacitance change with temperature.

Aluminium Chips — Aluminium chip capacitors are a double encased wound-foil unit consisting of aluminium anode and cathode foils with paper separation and liquid electrolyte. The typical properties are a capacitance range from 0.1 μF to 22 μF with a rated voltage from 6.3 to 63 volts d.c. They range in size from 7.4 × 3.8 × 3.8 mm to 8,0 × 4.6 × 4.6 mm. The volume efficiency is 500 to 1000 μF/cm³. The operating temperature ranges from − 40 to + 85 °C and they can withstand soldering temperatures of 230 °C for 10 seconds or 260 °C for 5 seconds.

The low material cost and the chance to cover at least part of the range of tantalum chips make the aluminium chip very interesting but, at present, the aluminium chip has not reached a break-through. Its greatest handicap is the liquid electrolyte. In addition, production is rather complex. Also, the restricted thermal capabilities of the electrolyte, even if a high-temperature formulation is used, cannot be totally compensated by design provisions. The overall result is a rather big aluminium chip capacitor which will hardly pass the usual solder requirements of 260 °C and 10 seconds. The electrical properties, too, are below the standard of tantalum chips.

A dry aluminium chip version with MnO_2 as electrolyte is feasible. A wound-foil unit with glass fibre as separator or a porous sintered aluminium body can be used. In both cases the results are thermally stable chips with relatively good electrical characteristics. The production of the MnO_2 type is very similar to that for tantalum capacitors, but, so far, this chip style is not available.

A further interesting aluminium chip version with an organic semiconductor compound as electrolyte may be possible. It would have excellent electrical data compared to other aluminium versions. However, the thermally sensitive organic semiconductor is not well suited for soldered chips.

Film Chips — A further component which has not yet reached a break-through is the plastic film chip capacitor, which offers these properties :

Dielectric material	metallized polyester (e.g. mylar, hostaphan)
Film thickness	1.5 to 3 μm
Encapsulation	transfer moulded epoxy
Capacitance (typical) per dimensions (mm)	47nF/6.8 × 3.8 × 2.4 100nF/7.8 × 6.8 × 2.4
Rated voltage	50 V d.c.
Volume efficiency	40 μC/cm³
Operating temperature	− 55 to 100 (125) °C
Soldering	260 °C/5 sec.

Metallized polyester (P.E.T.P.) or another suitable plastic film material is used as dielectric. Winding up the foil, attaching the electrode connections and the final mounting are well known techniques. However, special care in designing is needed to provide a good heat barrier for the sensitive dielectric material. Because of the thermal problems and the rather poor volume efficiency, the film chip capacitor, at this point, cannot be considered a real competitor for the tantalum chip.

CONCLUDING REMARKS

A comparison of chip capacitors can be made with some typical technical data :

MATERIAL	FEATURES	OPERATING TEMPERATURE	CAPACITANCE CHANGE WITH TEMP.	CAPACITANCE (50 VWV)	SIZE, mm EIA-CODE	VOLUME EFFICIENCY $\mu C/cm^3$
C0G (NP0) CLASS I	HIGH STABILITY, LOW LOSS	-55 .. +125°C	± 30 ppm/K	1pF .. 15nF	2.0x1.3x1.3 0805	0.25 .. 1
X7R CLASS II	STABLE DIELECTRIC CONSTANT	-55 .. +125°C	+/- 15%	100pF .. 150nF		2.5 .. 10
Z5U CLASS II	HIGH DIELECTRIC CONSTANT	+10 .. +85°C	+22 .. -56 %	1nF .. 1.5µF	5.7x5.1x2.0 2220	25 .. 100

There is some overlap in the lower tantalum capacitance range with aluminium and ceramic chips. Yet, considering other relevant data, both are not really competitors. In the case of ceramic chips, the capacitance stability is poor and, in addition, in this range ceramics are more costly than tantalums. In the case of aluminium chips, the lower quality standard has already been mentioned.

For tantalum chips there is now a remarkable situation : the efforts toward further miniaturization in electronics open for tantalums a new field of applications. Thanks to its high volume efficiency, tantalum has a distinct advantage over other competitive materials. The demand for tantalum chips will increase in the same proportion as circuits using devices with leads are converted into surface mounted layouts. Eventually, shares formerly lost to miniature leaded aluminium capacitors may be regained by tantalum chips.

As to future trends relative to tantalum chip capacitors, the following can be stated :

— There is no doubt that the highly competitive market will put more pressure on the chip price. A well-trimmed, fully mechanized production line and the use of higher CV/g tantalum powders (15,000 to 20,000 μC/g) will be the answer. This includes reasonable and stable tantalum material costs.

— The high speed PC board assembly technique will call for moulded chips with flat surfaces and small tolerances.

— The combined assembly — leaded components on one side of the PC board and leadless components on the other side — will require low profile chip components. The maximum height will be in the range of 2.5 mm.

— Finally, the competitors in the capacitance range typical of tantalum chips will further improve their electrical and thermal standards and at the same time try to minimize the size of their chips.

T.I.C. data

The T.I.C. data for the production and shipments of tantalum-bearing concentrates and tin-slags for 1983 are as follows, with the total production and shipments for 1980, 1981 and 1982 for comparison :

(figures given in lbs. Ta_2O_5 contained)

1980	Slags	Concentrates	Total	
Production	1,383,704	792,528	2,176,232	
Shipments	1,589,729	728,480	2,316,209	
1981				
Production	1,228,246	926,241	2,154,487	
Shipments	1,020,598	738,628	1,759,226	
1982				
Production	1,210,140	685,845	1,895,985	
Shipments	957,802	442,184	1,399,986	
1983				
Production				
1st quarter	304,840	87,228	392,068	A
2nd quarter	303,398	51,497	354,895	B
3rd quarter	395,454	83,154	478,608	C
4th quarter	276,576	146,956	423,532	D
Total			1,649,103	
Shipments				
1st quarter	125,003	75,684	200,687	A
2nd quarter	7,100	43,844	50,944	B
3rd quarter	154,688	61,899	216,587	C
4th quarter	360,837	133,042	493,879	D
Total			962,097	

A : 25/29 companies reported
B : 22/29 companies reported
C : 24/27 companies reported
D : 26/27 companies reported

Processing : Data for shipments made by processors are :

(figures given in lbs. tantalum contained)

1983		
1st quarter	368,773	E
2nd quarter	443,833	F
3rd quarter	529,280	G
4th quarter	(not available)	

E : 16/19 companies reported
F : 16/19 companies reported
G : 18/19 companies reported

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