TANTALUM PRODUCERS INTERNATIONAL STUDY CENTER

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Seminar on Tantalum Source Material Supply

Following the Eleventh General Assembly seventy participants attended a seminar covering various aspects of the current supply situation of tantalum source materials. Formal speeches were offered, followed by general discussion open to all participants.

- Speaker : Mr I.R. McLeod, M. Aus. I.M.M.
  Chief Mineral Economist,
  Bureau of Mineral Resources, Canberra
  Subject : Australian Tantalite Deposits
  by N.D. Knight and I.R. McLeod
- Speaker : Mr J. Linden, B.Sc. (Hons), A.I.M.M.
  Managing Director,
  Greenbushes Tin NL.
  Subject : Future Tantalite Production
  from Western Australia.
- Speaker : Mr B. Reynolds
  Manager, Tin and Special Metals,
  Billiton International Metals, The Hague
  Presenting a paper written by
  Mr Graham B. Brown :
  Subject : Tantalum in Southeast Asia.
- Speaker : Mr T.C. Barron
  Emory Ayers Associates, New York
  Subject : An Update on Statistical Data.
- Speaker : Mr A.C.A. Howe, B.Sc., P. Eng. A.R.S.M.F.I.M.,
  A.C.A. Howe International Limited
  Subject : Tantalite in Africa and South America.

Mr McLeod felt that, with the emergence of strong and consistent demand, there is potential for significant future discoveries of tantalite in Australia and that annual production output will be enhanced as a result. Mr Linden supported this view by assessing the future tantalite production in Western Australia. Mr Reynolds' presentation described the various types of tantalum source materials produced in Southeast Asia, demonstrating that this area is the source of more than 50 per cent of the world supply of tantalum raw material. Mr Barron added updated information to the study of the tantalum demand-supply situation prepared in 1976 by Emory Ayers Associates for the T.I.C. Mr Howe dealt with tantalum exploration with particular emphasis on activity in Africa and South America.

During the discussions which followed, the processing and consuming industry members expressed their concern about the availability of raw material on a competitive basis to meet rising demand and combat threats of substitution. The mining community, however, expressed confidence in being able to respond favourably to this challenge through new and expanded exploration and development efforts which will ensure an adequate long term supply. All agreed that the statistical work and the continued dialogue between all sectors of the tantalum industry provided by the T.I.C. is of major importance to assure improved conditions in the future.

The papers presented at the Seminar will be printed in condensed form in the T.I.C. « Bulletin ». The first of these is included in this issue.

T.I.C. ELEVENTH GENERAL ASSEMBLY

The Eleventh General Assembly of the Tantalum Producers International Study Center was convened in the Sheraton Hotel in Perth, Western Australia, on Monday, May 14, 1979. Mr. Joseph C. Abeles, President of T.I.C., presided. Thirty-three of the thirty-seven member companies were represented at the Assembly.

Four new members were elected to membership of the T.I.C.

— Charter Consolidated Metals and Ores.
— Metallgesellschaft AG.
— Metallurg.
— Straits Trading Co.

The normal business of the T.I.C. was conducted, including a review of the activities of the past year. Dr. George Korinek of Hermann C. Starck Inc., New York and of NRC Inc., was elected to the vacant fifth seat on the Executive Committee.

The official meeting was followed by a seminar on tantalum source material supply. An official banquet was held for members and guests in the evening. The assembly was addressed by The Honorable G.C. MacKinnon, Minister of Tourism for the West Australian Government.

On the following day, Tuesday, May 15, the participants visited the mining and processing facilities at Greenbushes Tin N.L., located at Greenbushes, W.A., about 250 km. south of Perth. They were impressed with the extent and mechanization of the operations and gained an appreciation of some of the special efforts and problems encountered by the mining industry.

The Twelfth General Assembly will be held in Brussels at 9 a.m. on Monday, October 29, 1979. The exact location will be advised later.

Tin Slag and Concentrate Production by T.I.C. Members

The members of T.I.C. continue to report their production of tin slags and concentrates on a quarterly basis. The data accumulated for 1975 through 1978 are as follows :

Tantalum production (lb. Ta_2O_5 contained)

	Tin Slags	Concentrates	Total
1975	879,252	691,185	1,570,437
1976	905,733	701,622	1,607,355
1977	1,003,246	755,886	1,759,132
1978			
1st. quar.	306,710	179,855	486,565
2nd. quar.	241,983	138,907	380,890
3rd. quar.	180,373	153,726	334,099
4th. quar.	236,005	183,343	419,348
Total	965,071	655,831	1,620,902

The data for 1978 have been obtained from thirteen mining company members of the T.I.C. with one company not reporting.

The mining company membership of T.I.C. is now fourteen companies.

The tin slag production in 1978 has remained essentially constant, only 3.8 % below the 1977 production. The first quarter level is within 2,000 lb. Ta_2O_5 of the best quarter (2nd. quar. 1977) ever reported, but the third quarter level is a new quarterly low, being about 3,000 lb. below the previous low in the second quarter of 1975. The wide swing in production from the first quarter to the third quarter is not explainable as no cyclical pattern is visible during the four years for which data have been gathered.

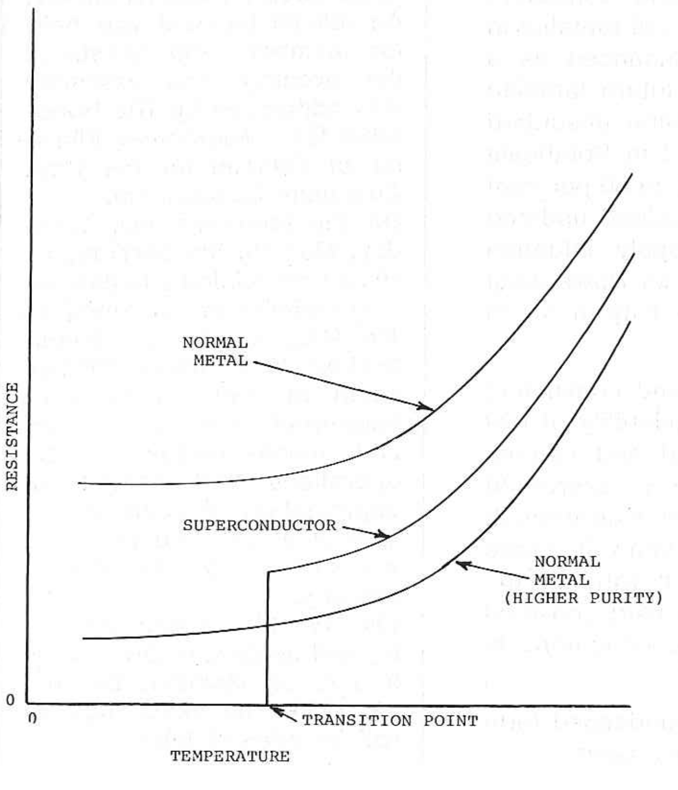
The decrease of almost exactly 100,000 lb. Ta_2O_5 in concentrate production represents a fall-off of 13.3 %. The total is the lowest for the four years. Since there are few members which produce as much as 100,000 lb. Ta_2O_5 per year, it is unlikely that the one company not reporting for 1978 would bring the total up to the 1977 level. In any case, the total reported tin slag plus concentrate production is 7.9 % below the 1977 production. The proportion in slag is about 60 %, an increase on the 57 % proportion in 1977. Thus, the dependency of tantalum supply on tin production is again emphasized. It should be noted that after a very low level of production in the second and third quarters, the large increase in the fourth quarter provides hope for a strong production in 1979.

Once again, based on recent estimates of the total free world production for 1978, the output of T.I.C. members represents about 75 % of the total world output.

A Promising Use for Columbium : Superconductors

For many years the use of columbium metal has remained essentially static, varying from somewhat more than 100,000 lb. to almost 250,000 lb. per annum. There have been various applications but generally they fall by the wayside before a substantial market develops. Throughout the last decade, however, there has been one consistent use, even though actually consuming little columbium, that holds great hope in the future : superconducting alloys.

Superconductivity is a particular physical phenomenon shared by several metals and alloys. All metals and alloys have a specific electric resistivity, that is, a resistance to the flow of electric current when they are used as conductors. In every case, the electric resistivity changes with temperature, becoming greater at higher temperatures and lower at lower temperatures. Generally, at very low temperatures nearing absolute zero (— 273° C), the resistance levels out. But with some metals and alloys there is a sudden drop to zero resistance at a few degrees above absolute zero. Then at temperatures lower than this critical point, the resistance remains at zero and electric current can flow indefinitely without any energy loss. This condition is known as « superconductivity ».



The phenomenon was originally discovered in 1911 by H. Kamerlingh Onnes of the University of Leiden, about three years after he succeeded in liquifying helium at 4.2° C above absolute zero (designated as 4.2° Kelvin or, more simply, 4.2° K). The study of superconducting phenomena remained in the laboratory for many years as associated phenomena prevented complete understanding and consistent results, particularly results which would permit some use of superconductivity in a practical way. However, about 24 elemental metals were identified which displayed superconductivity. For most of them, the critical temperature was too close to 0° K. Of the more commonly available metals columbium had the highest critical temperature at 8.0° K.

After the development of a fundamental theory of superconductivity in 1957, an understanding of the phenomena involved has led to development of some applications with considerable prospect of more. To explain the advantage of superconductors, a comparison can be made. A superconductor wire, of the same size as a copper wire which would carry 10 ampères, will carry a current of 25,000 ampères when kept at the temperature of liquid helium (4.2° K). In addition, the 25,000 ampère current can flow indefinitely without any significant resistive loss. One other major advantage is that this superconductor can be used in a coil as the energizer of a magnet, producing magnetic fields of 5 to 10 times the density of conventional iron-core magnets. An early example for use in tuning a radio telescope antenna required a complete assembly of only 75 pounds including an eight-hour helium supply. The permanent magnet built as a « back-up » weighed 1,500 pounds.

Elaborate systems are required to maintain extremely low temperatures close to absolute zero, and the closer to 0° K, the more elaborate and costly. So a search was begun for alloys which would have higher critical temperatures. The first practical development came in 1960 when wire was made successfully of niobium-tin (Nb_3Sn), a brittle compound for which the critical temperature was 18° K. After considerable work with columbium-zirconium, a very ductile alloy, most applications today are using columbium-titanium which has a critical temperature of 10° K.

In order to correct many problems associated with the building of high-intensity magnets based on superconductor, it was found that the wires had to be made up of many, many extremely fine columbium-titanium filaments embedded in a matrix of normal metal such as copper or aluminium. To achieve this, a process has been developed along the following lines :

- Columbium-titanium alloy is produced by conventional means and rolled and drawn into rods about 6 mm. in diameter. These rods are cut into pieces about one meter long.
- The Cb-Ti rods are inserted into hexagonal shaped copper tubes of the same length.
- These hexagonal tubes are stacked, honeycomb fashion, and put into a round copper can which is then capped on each end and welded shut to provide a billet from 25 to 30 cm. in diameter. The billet will thus contain from 1,500 to 2,500 Cb-Ti rods equally separated by copper.

- The built-up billet is extruded with a reduction ratio of about 16 to 1 to a rod 6.5 cm. to 7.5 cm. diameter. At this stage the Cb-Ti rods have been reduced to only 1.5 mm. diameter and the length of the rod is about 16 meters.
- By further working, cold rolling and drawing, the rod is reduced to a wire as small as 0.4 mm. At this size the individual filaments are now only 0.09 mm. in diameter. The finished wire will be over 4,000 meters long.

This fine composite wire containing 2,000 or more superconducting filaments is wound into the coils needed to energize the high-density magnets.

After many years of development, superconducting applications are still mostly in the laboratory. Today less than 10 % of the columbium metal produced (30,000 to 40,000 lb.) is consumed for this purpose. There are, however, many development projects underway which seem to forecast large-scale use before the end of the century, perhaps within the 1980 decade. The principal hold-up has been the hesitance to use large volume chambers for the liquid-helium coolants required to maintain the near absolute-zero temperatures. Original practice was to immerse the coils in large vats of boiling helium which required constant replenishment and were always on the verge of explosive evaporation. But now forced circulation systems which will handle liquid helium at stable pressures have been developed and practical equipment for cooling can be designed, somewhat similar to conventional refrigeration systems.

Thus the application of superconductivity for industrial use can now progress. To date the application has been almost entirely limited to generating the magnetic fields for bubble chambers, devices which trace the sub-atomic particles produced by high-energy accelerators. The industrial applications being currently researched include

1. Magnets for use by the medical profession to remove particles from eyes, to guide magnet-tipped catheters through blood vessels into the brain and other body locations not accessible with modern surgery.
2. Motors and generators are natural applications for superconductors as their size would be greatly reduced (up to 10 times) and heat losses would be cut by more than half. A 3,000 hp. motor has been built in England as well as a one megawatt motor generator system for ship propulsion. In the United States, the Electric Power Research Institute has just recently joined forces with Westinghouse Electric Corp. to design and build the world's first commercial superconductor generator to be rated at 300 megawatts. When the machine is complete by late 1983, it will be installed on-line in a selected utility power plant. Following extensive reliability tests, it is expected that orders will be placed for generators ranging from 800 Mw to 1,200 Mw. Since it is estimated that a 1,000 Mw generator will save over 100,000 barrels of oil a year due to improved efficiency, the energy problem could accelerate the use.
3. Power transmission by superconductors is being explored. There are at least a dozen projects underway throughout the world. The elimination of transmission-line heat loss, the principal cost of shipping electric energy over long distances, would make possible increasing the capacity of the lines by a factor of ten and would increase the range of power station distribution many times. It is believed that by the year 2000 as much as 10 % of all new transmission installations will be superconductive.
4. Mineral processing could benefit from the use of superconductors. Magnetic separation is quite common in the mining industry. Since many materials, including most oxides are paramagnetic and respond only to very great field strengths, ordinary magnets cannot magnetize them enough effectively to separate them from other materials. But with high density magnets produced by superconductivity, the application of high-intensity separation can be broadened effectively over a greater range of mineral processing.
5. Power generation is perhaps the field in which large volume superconductivity will first be used. Both the magnetohydrodynamic (MHD) and fusion generators require high-density magnetic fields for success. MHD is an advanced combustion technology in which electrical energy can be extracted directly from a super-heated combustion gas. The charged particles in the gas are attracted out of the gas to conductors by magnetic fields. Superconductivity makes the required magnetic field economically possible. A pilot generation plant is « on-stream » in Russia and extensive development work is being carried on in the United States. Fusion generators, in which light elements are forced into combination into heavier elements with a release of energy (the hydrogen bomb, as an example), require very high density magnetic field to contain the plasma at temperatures equal to those within the core of the sun. Both MHD and fusion are in laboratory stages of development, but many experts believe that both will reach the demonstration stage by 1990 with commercial application shortly after the year 2000.
6. There are many miscellaneous programs in various stages of development. These include a levitation train in operation in Japan, a train without wheels supported by strong magnetic fields so that it floats along its track without friction.

If all of these programs were to materialize, the demand for columbium would be beyond imagination. As it is now, the development work and pilot projects are estimated to reach a demand level of 250,000 to 300,000 lb. by 1985, a growth rate of almost 30 % per year. When a single break-through occurs, consumption of columbium metal could easily reach 1,500,000 to 2,000,000 lb. per year. Many forecasters expect such by 1995.

Tantalum in Southeast Asia

(A paper presented at the Eleventh General Assembly of T.I.C. on May 14, 1979 in Perth, Western Australia)

Introduction

Southeast Asia comprises a rather small proportion of the earth's surface, but it is the world's largest producer of tantalum source materials. In the entire area, cassiterite is the most important economic mineral. The principal minerals associated with it in the alluvial deposits are ilmenite, monazite, and zircon, but in local areas there are concentrations of wolframite, xenotime, columbite, tantalite and gold. The major tantalite associations are in Thailand which gradually shift toward columbite associations further south in Malaysia. At the ends of the belt, north in Burma and south in Indonesia, virtually no tantalite or columbite exists.

Independent deposits of tantalite and columbite are not known to exist anywhere and they are extracted only as by-products of tin processing either during concentration or in tantalum/columbium-rich slags at the tin smelters. It is important, therefore, to recognize the dependency of this production on the world demand for tin. The tantalum value in the ores is not great enough, even at today's prices, to mine and process the ore just to recover the tantalum. There must be a market for the tin or the production of tantalum source materials will fall.

Thailand and Malaysia represent the major free world source of tantalum materials. The importance has been gradually increasing from 41.5 % of total production in 1974 to 53.6 % in 1977. When 1978 data are totally available, they will probably show a continued increase to perhaps as much as 55 %. In pounds of Ta_2O_5 contained, the actual production in the area has increased by 43 % in the period of four years, an average annual increase of 9.4 %. Of the total production in the area, 65 % to 70 % is generated in Thailand, 30 % to 35 % in Malaysia.

The production of source materials is in a great variety of forms. The great bulk is in tin slag from both countries, tantalite principally from Thailand, columbite principally from Malaysia, and a new product in recent years, struverite, an ilmenite containing commercial quantities of tantalum and columbium, from both countries.

The General Processing in the Area

Although the end products vary from area to area within Southeast Asia, the processing is generally the same. Tin ore, after mining, is concentrated by the normal methods. These methods, however, will not separate out the small fraction of free columbite and tantalite, which is not intercrystalline with the tin. Those ores which contain some unassociated columbite and tantalite can be processed by high-tension separation to yield most of the tantalite and columbite.

The great bulk of the tin ores does contain some columbium and tantalum which, when smelted, results in tin slags which contain columbium and tantalum. Thus the total content can be obtained for commercial use in one form or another.

Reprocessing of mine dumps extracts further columbite and tantalite but also results in another product which had always been left behind, one type of ilmenite, struverite, which contains up to 30 % combined Ta_2O_5 and Cb_2O_5. Recovery has become widespread and it now accounts for 5 % to 7 % of the tantalum values shipped from Southeast Asia.

Production in Malaysia

During a geological survey made of Malaysia in 1966, only two areas were found in which deposits contained high tantalum and columbium content, but these deposits were too small to be economically exploited. In general, most of the cassiterite deposits contain some tantalum and columbium. Those with the better tantalum content are on the western side of the north-south central mountain range, but there is no uniformity of content. The distribution is erratic and often occurs in patches within the same location.

The volume of columbite production has generally followed the price level, from about 50 m.t. per year in the mid-1960's to 89 m.t. in 1967, but only 24 m.t. were produced in 1971. After a large buildup to the 90 ton level from 1972 through 1974, production has again dropped to the 50 to 60 ton level, not as a result of price, but due to the depletion of deposits containing separable columbite. The grade of columbite varies and contains from 10 % to 15 % Ta_2O_5. Today, the columbites from Malaysia are supplying about 20,000 to 25,000 lb. Ta_2O_5 into the world market annually.

The tin slag produced at Penang is of much greater importance. Prior to the construction of the smelter in Phuket, most of the Thai tin ores were smelted in Penang. Since these ores are richer in tantalum content than the Malaysian ores, the slags produced averaged from 4 % to 4.5 % Ta_2O_5 content. Now, however, the average content has dropped below 3 %.

All of the Malaysian cassiterite is sold to the two smelters at Penang : Datuk Keramat Smelting, Bhd. and Straits Trading Co., Ltd. Datuk Keramat segregates ores in relation to their tantalum content. Whenever possible, ores from the mines known to contain tantalum are smelted together in batches of 40 to 50 tons. The resultant slags fall into three grades ranging from less than 2 % up to 3.5 % and they are stocked and sold by this grade classification. At Straits Trading tin ores are smelted without regard to tantalum content. Straits finds it uneconomic to hold ores with higher tantalum content until a furnace batch has been accumulated. Since Straits receives hundreds of deliveries from as many mines weekly and has no control over the mine delivery patterns, trying to stockpile deliveries by tantalum content would result in unmanageable furnace programming.

It is difficult to total the annual production of tin slag in Malaysia. The production at Datuk Keramat has averaged from 2.5 % to 2.8 % and the total poundage of Ta_2O_5 content has ranged from about 150,000 lb. in 1968 to slightly more than 300,000 lb. in 1973. Since that time the extraction of more tantalite and columbite by miners and the general reduction in supply of tin ores with significant tantalum content has reduced the production of usable tin slags to about 150,000 lb. contained Ta_2O_5. Production at Straits Trading also varies, with an occasional lot as high as 10 %. In general, the average grade of usable slag probably runs around 2 % to 2.5 %. Production in total provides about 150,000 lb. Ta_2O_5 per year.

The new factor in tantalum source material from Malaysia is the production of struverite. BEH Minerals of Lahat in the state of Perak was established in 1970. BEH acquires feed stock from the old discard dumps at mines and processing plants which are methodically stripped of their mineral content through the employment of wet gravitational, pneumatic, and magnetic/electrostatic methods of ore separation. Commercial grade ilmenite, monazite, zircon and xenotime are produced. BEH developed the method to strip struverite from the ilmenite. This tantalum rich rutile typically contains 12-13 % each of Ta_2O_5 and Cb_2O_5. Production of the first commercial lot occurred in 1972 and regular production began in 1975. Output was about 250 m.t. in 1978, about 65,000 to 70,000 lb. Ta_2O_5. During the past two years, other Malaysian processors have begun to extract struverite and their total production about equals that of BEH Minerals. Thus, well over 100,000 lb. of contained Ta_2O_5 is being provided by Malaysian ore processors.

It can be expected that total columbite and slag production from Malaysia will continue to decrease, but turning to old mine dumps as sources of columbite and struverite should maintain the total supply at about the current level of 400,000 to 425,000 lb. of contained Ta_2O_5 per year.

Production in Thailand

With the advent of Thaisarco in 1967, Thailand became the world's largest producer of tantalum source materials. About 15 % of the tantalite in tin ores is separable. Thai ore processors recover free tantalite and produce a grade which runs as high as 35 % to 40 % Ta_2O_5 and 25 % to 30 % Cb_2O_5. Annual production is approaching 100,000 lb. Ta_2O_5 per year, probably close to the maximum obtainable at current mining levels.

The slag produced at Thaisarco is a very fine quality, ranging from 11 % to 14 % Ta_2O_5 and 7 % to 9 % Cb_2O_5. The volume has been consistent with the production of tin. At present, slag production is approaching 700,000 lb. contained Ta_2O_5 per year.

In Thailand, also, the processing of mine dumps began in 1977. During 1978 production of struverite is believed to have reached almost 200 m.t. containing as much as 50,000 lb. Ta_2O_5. Further expansion is expected.

The total production of tantalum source materials from Thailand is probably at present in the range of 800,000 to 850,000 lb. Ta_2O_5. It can be expected that this level will be maintained as long as the tin market continues its present level of demand.

Conclusions

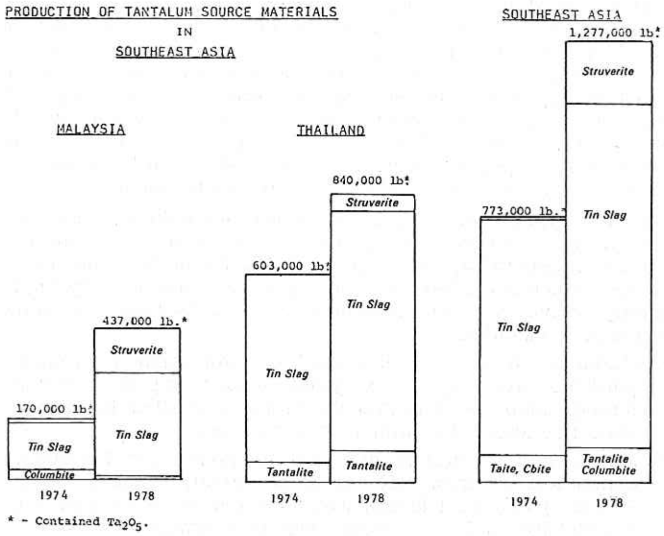


Exhibit I

The exhibit summarizes the tantalum source material production in Southeast Asia, comparing 1974 production to the probable 1978 production, and it reaffirms that this area is the only area in the free world in which there has been a significant growth in the output of tantalum-bearing minerals. Other than for the introduction of the struverite, growth has been as a result of increased tin production. Total struverite production could be increased by much as 40 to 50 %, authoritative sources estimating that a production of 1,000 m.t. could be maintained for at least ten years. This would realize from 250,000 to 275,000 lb. of Ta_2O_5 per annum.

The area has attained reasonable political and economic stability. There are not any serious threats of this nature strongly visible. Continuation of such stability along with a thriving tin market will assure that Southeast Asia will provide the major portion of the tantalum required by the world economy.

NEW MEMBERSHIP

At the Eleventh General Assembly the following companies were elected to membership of the T.I.C. :

Charter Consolidated Metals and Ores Limited,
40 Holborn Viaduct,
London EC1P 1AJ, England.

Metallgesellschaft AG,
Reuterweg 14,
D-6000 Frankfurt am Main 1, West Germany.

Metallurg, Inc.,
25 East 39th Street,
New York, N.Y. 10016, U.S.A.

The Straits Trading Company Limited,
P.O. Box 2,
Butterworth, Malaysia.

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