Non-ferrous metals in India

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SYNOPSIS

A brief survey of India's non-ferrous resources, estimated requirements, present capacity of production, envisaged expansion of production facilities and possibility of starting indigenous production of scarcer non-ferrous metals, has been attempted in the article. Certain suggestions have been made vis-a-vis meeting the country's requirements of non-ferrous metals in general and certain scarce metals.

THE past two decades have witnessed a multifold increase in the production of metals in India which are basic to any venture for industrialisation of a country. Once the basic approach to the planned development of the country was finalised, in order to give the teeming millions of our country a reasonable living standard—minimum requirement of which is food, cloth and shelter for every living being—it was the natural corrollary then to exploit all the available natural resources of men, minerals and materials that our planners set out to achieve. The three Five-Year Plans were a result of this thinking and the country has gone quite some distance towards achieving its planned goals inspite of two wars with powerful neighbours and in the wake of two serious droughts faced by the country. Basic industries have been established and the production capacity achieved for iron and steel and aluminium amounts to a considerable increase achieved in few countries in such a short time. The production of copper has lagged behind but serious and strenuous efforts are being made to set up the second smelter and refinery in the country at Khetri, in the public sector, at an early date. Due to certain contingencies faced by the country in the past few years named above, the starting of the Fourth Plan has been delayed and is now proposed to begin in April, 1969.

Production of various non-ferrous metals achieved during the past few years is given in Table I.

TABLE I Production of non-ferrous metals (tonnes)

Year	Aluminium	Copper	Antimony	Lead	Zinc (concentrates)
1964	56 182	9 475	840	3 624	10 699
1965	63 742	9 360	848	2 905	9 591
1966	83 627	9 428	876·5	2 478	8 900
1967	96 352	8 904	901	2 474	10 029

In view of known scarcity of the resources of copper, lead, zinc, nickel, molybdenum, etc. bearing minerals in the country, an 'Opration Hard-Rock' was launched in July, 1967, under U.S. AID programme with the primary objective of locating base metals ore deposits utilising electromagnetic, magnetic, radioactive, geophysical surveys. This project envisages an aerial survey covering parts of Andhra Pradesh, Rajasthan and Bihar to be followed by ground geological, geophysical and geochemical investigations. A similar proposal for air-borne survey of areas in Mysore with some adjoining areas of Madras and Andhra Pradesh, Gujarat and Rajasthan and Madhya Pradesh with French collaboration is under scrutiny. Assistance from Soviet Union for undertaking an air-borne magnetometric survey over Dandakaranya (Madhya Pradesh) and Sambalpur-Bolangir (Madhya Pradesh, Orissa, Andhra Pradesh) has been accepted. The Geological Survey of India, in addition, has an intensive base metal survey programme in hand for regional mineral assessment now being vigorously pursued and planned for the Fourth Plan period.

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Aluminium

Resources

India has considerable known deposits of bauxite and the investigations conducted and completed so far by Geological Survey of India and other agencies in Madhya Pradesh, Maharashtra, Gujarat, Mysore, Madras, etc. indicate that our existing reserves estimates amount to 162·3 million tonnes of all grades (more than 45% alumina) and of high grade bauxite amount to 94 million tonnes (more than 50% alumina), thereby indicating an encouraging rise in the earlier figures.

Production

After iron and steel, aluminium production in India during the last decade has seen a phenomenal growth and the present installed capacity of its production stands at over 1 17 000 tonnes/annum. This rapid growth and the envisaged further three-fold expansion of the present capacity already planned for the next few years can be primarily attributed to :

(i) large quantity of indigenous bauxite reserves in the country
(ii) the wide regional distribution of the bauxite reserves throughout the country
(iii) comparatively much less quantity of known ore reserves of other base metals such as copper, zinc, lead, etc.
(iv) inherent properties of aluminium which make it and its alloys technologically acceptable as suitable substitutes of scarcer metals such as copper, zinc, lead, for many electrical, engineering, structural and house-hold purposes
(v) usefulness and economic advantages of aluminium and its alloys for multifarious applications in its own right.

These factors have been mainly responsible for the hitherto rapid planned growth of aluminium production in the country.

However, some factors have been responsible to pose hindrances in the way of maximum utilisation and exploitation of our aluminium potentials and unless attended to at an early date will stunt its growth and thereby hinder our attempts to fruitfully utilise possibilities of its substitution for scarcer metals such as copper, zinc, lead and tin, etc. These factors include our high production costs/ton of aluminium indigenously produced as compared to world production costs. This may be due to adverse factors such as :

1. high rates of power in various states where the plants are located compared to power rates in other major aluminium producing countries
2. higher capital cost of the plant and equipment purchased from foreign countries
3. costs of design, know-how, royalties, etc. to foreign collaborators
4. continued import of raw materials such as cryolite, aluminium fluoride, fluorspar, petroleum coke, pitch, electrodes, etc. and
5. the smaller size of some of our plants.

Table II gives the present and planned aluminium production plants, their existing capacity and projected expansion data.

It will be seen that the new plants are all projected to have higher than 20 000 tonnes/annum capacity in each case, and largest planned capacity is of 100 000 tonnes/annum for one single plant. It is hoped that with the increase in size of individual plants the economics of per ton production costs will improve. In addition, efforts must be made from the initial stages of the negotiations for setting up new plants and the expansion of existing plants for maximum utilisation of indigenous design, consultation and fabrication facilities for purchase of plant and equipment thereby effecting maximum saving of foreign exchange. Attempts should also be continued at all levels, including State and the Centre, to provide power at cheaper rates to this power intensive industry. The production of cryolite, aluminium fluoride should be expedited to meet the entire requirements of the proposed aluminium capacity by the end of the Fourth Plan period. Similarly provision of calcined petroleum coke, soft and hard pitch and production of prebaked cathode blocks/plates should be taken up from indigenously developed materials. Provision has to be made for production of super-purity grade of aluminium to meet the requirements of electrical and electronic industries. The requirement being comparatively small some incentive to the prospective producer for the super-purity grade may have to be given in the initial stages. The fabrication of this material to foil will also need to be developed by our foil manufacturing industry.

It is understood that negotiations for technical consultancy for the Koyna Project of Bharat Aluminium Co. are being finalised in view of earlier proposal of V.A.W. of West Germany having been rejected. It is heartening to note here that the programme for setting up the Korba Aluminium plant of Bharat Aluminium Co. of 1 00 000 tonnes per year capacity with Hungaro-Russian collaboration for alumina and aluminum stages respectively is proceeding according to plan.

Demand

In 1967 the consumption of aluminium in India was 130 000 tonnes and is expected to increase to 155 000 tonnes in 1968/69 ; 265 000 tonnes by 1973/74 and to 415 000 tonnes by 1978/79. The total metal availability is expected to be 149 000 tonnes by 1968/69 and is likely to increase to 361 000 tonnes by 1973/74 based on the expansion of aluminium production facilities planned in the country and from scrap arisings (latter estimated at 10% of expected production figures).

Steps are being taken to open up possibilities of exporting aluminium and its products and provision has been made for export of aluminium in the expansion of this industry thereby lessening to some extent the burden of foreign exchange incurred in its establishment. If the projected capacity materialises in time it will make our country self-sufficient for our aluminium requirements and we would be in a position to export aluminium to overseas countries.

Magnesium

The versatile light metal which is used in the engineering industries for various castings in the form of magnesium base alloys for light structural components and also as an alloying element for a number of aluminium base light alloys used in the cast and wrought forms, was hitherto imported in the country. It also finds wide application in the powder form for incendiary purposes in defence ordnance manufactures. The National Metallurgical Laboratory has developed suitable process know-how at labotatory and pilot plant scales for the

TABLE II Installed capacity and production of aluminium metal (tonnes)

		Existing capacity Aug. 1968	Production 1967–68	Expansion approved/ licensed	Remarks
1. Indian Aluminium Co. Ltd.	Alwaye (Kerala)	15 850	17 337		
	Hirakud (Orissa)	20 300	18 661		
	Belgaum (Mysore)	—	—	30 000 licensed	Under construction—likely to materialise by end of 1969, later to expand to 1 00 000 tonnes
2. Hindustan Aluminium Corporation	Rihand (U. P.)	60 000	45 661	60 000	To be taken up for implementation of expansion in stages up to total ultimate 1 20 000 tonnes capacity
3. Madras Aluminium Co. Ltd.	Mettur (Madras)	12 500	10 224	12 500	Expansion to 25 000 tonnes to materialise by 1971-72
4. Aluminium Corp. of India	Asansol	8 750	7 899	3 750	12 500 tonnes to materialise by 1969-70
5. J. K. Industries	Kerala	—	—	30 000 letter of intent	Proposed to change to Orissa now
6. Bharat Aluminium Co. (Public sector)	Koyna (Maharashtra)	—	—	50 000	Expected to start production in 1972-73
7. do	Korba (M.P.)	—	—	1 00 000	do

Source : Non-ferrous Advisory Council, 1968

production of magnesium metal from indigenous dolomite ore through silico-thermal reduction process. Based on intensive research investigations the National Metallurgical Laboratory team of scientists is now engaged in setting up a semi-commercial plant for the manufacture of 250 tonnes per annum of magnesium metal (the capacity can be expanded to 500 tonnes/annum on a later date) at Jamshedpur, without borrowing any technical foreign know-how. The plant is under active installation and will go into production by 1970. This plant will meet, to a considerable extent, the requirements of magnesium metal of the country. Another plant for the production of magnesium metal by the electrolytic process developed by C.E.R.I., Karaikudi, has been recommended by an experts committee. This plant at Karaikudi will have initially a capacity of 75 tonnes per year and will be raised in the second stage to 300 tonnes per year of magnesium metal.

Copper

Copper in its pure or alloyed form is a material of vital national importance for use in electrical industries, for heat transfer equipment, bearing materials, castings and other industrial and consumer uses. It is a vital ingredient for traditional handicraft ware which brings big foreign exchange earning to the country.

Demand

Recently much thought has been given for assessment of the country's requirements of non-ferrous metals. Using the end-use method and assuming that priority industries will work at the full rated capacity, the planning sub-group of the Ministry of Mines and Metals has concluded that demand for 1969–70 will be of the order of 97 669 tonnes of copper and will go up to 127 726 tonnes annually by 1973–74. Assuming a growth rate of 10% for each year after 1965–66 (when demand for copper was 58 000 tonnes) the demand figures arrived at for 1969–70 are 84 918 tonnes and for 1973–74 the demand will rise to 1 24 328 tonnes/annum.

Production

In the public sector, Hindustan Copper Limited have been assigned the following projects/schemes for the development of copper deposits :

The Khetri Copper Project (Rajasthan)

It is proposed to produce 31 000 tonnes of copper metal per annum (21 000 tonnes from Khetri mines and 10 000 tonnes from adjacent mine at Kolihan). The Khetri project is expected to commence production from 1970–71.

Agnigundala Copper Project (Andhra Pradesh)

Government have approved, in principle, the development and exploitation of these deposits.

Dariba Copper Project (Rajasthan)

A project report for the development of the copper deposits for the production of 1 400 tonnes of copper per annum has been prepared and is under consideration.

Rakha Copper Project (Bihar)

A scheme for the exploitation of the Rakha Copper deposits to yield 3 500 tonnes of copper per annum has been prepared and is under consideration of the Government.

In the private sector, the Indian Copper Corporation are engaged in the production of copper. The production during 1966 and 1967 were 9 333 and 8 904 tonnes respectively. They have been granted an industrial licence to set up a flash smelter of a capacity of 16 500 tonnes of blister copper metal. The copper flash smelting plant is expected to be completed by mid 1970. This would replace the existing reverberatory smelter and two thirds of the equipment will be supplied indigenously.

It is expected that the public sector copper plant at Khetri will reach 70% of its target capacity of 31 000 by 1973–74 and the capacity of the Ghatsila flash smelter reaching 16 500 tonnes and with refining production remaining at 8 400 tonnes per annum, there will be a big gap in the production and demand figures for copper amounting to about 81 000 tonnes by 1973–74.

Zinc

Zinc continues to be primarily used for galvanizing, die-casting production for automobiles etc., alloying for production of copper base alloys mainly brasses, as rolled sheets and strips for dry batteries, photo engraving and for lithography. Zinc is also used as oxide for paints, as dust in paper making, etc.

Demand of zinc by the end-use method is estimated at 1 86 000 tonnes/annum by 1973–74, and on the growth rate basis of 10% per annum the demand of zinc in 1967–68 (of 80 000 tonnes) would be 141 725 tonnes in 1973–74 rising to 2 25 000 tonnes per annum by the end of Fifth Five-Year Plan in 1978–79.

Production

In the public sector, Hindustan Zinc Ltd. commenced production from January, 1968, in their zinc smelter near Udaipur, which has a capacity of 18 000 tonnes of zinc metal per annum. The smelter has already reached its rated capacity. In addition, the company has also taken steps to prove additional ore reserves in the lead-zinc deposits in Zawar and Dariba-Rajpura areas in Rajasthan with a view to increasing the production of zinc metal substantially.

It has been decided to double the capacity of this plant to 36 000 tonnes of zinc per annum. The project report is likely to be ready shortly. This expansion programme is expected to cost Rs 5 crores and if sanctioned could be completed by 1970.

The most valuable bye-products from this plant are sulphuric acid and super-phosphate fertiliser, the production of the fertiliser would be about 80 000 tonnes per annum.

The other bye-product recovered in the Udaipur zinc plant is cadmium as cathodes. This is the first time India has produced cadmium which is used to prepare its salts, electrical contacts and for alloying with copper and aluminium. Uptil now this metal and its salts were being imported from Australia and Europe. Again at the present estimated demand of about 75 tonnes the annual production would be of 130 tonnes per annum of cadmium cathodes. Surplus production would be exported to earn foreign exchange. The cadmium cathode manufactured is of 99·95 per cent purity and is to be marketed in the form of balls and pencils.

The Government are also considering setting up a zinc smelter at Visakhapatnam of 30 000 tonnes per annum capacity based on imported concentrates. As a first step in this direction, the foreign consultants for this project have been asked to complete the preparation of the detailed project report.

In the private sector M/s Cominco Binani Zinc Ltd. were granted an industrial licence for the setting up of zinc smelter, based on the imported concentrates, at Alwaye (Kerala) for 20 000 tonnes of zinc metal per annum capacity. The smelter commenced production in 1967 and is expected to reach its rated capacity in 1968.

Taking into account that the plant under consideration at Vishakhapatnam, based on imported concentrates also, is set up and reaches its capacity by 1972–73 or at the end of the 4th plan period and the public sector plant at Zawar doubles its capacity to 36 000 tonnes with Cominco's Alwaye plant capacity doubled to 40 000 tonnes per annum, there will remain a gap of 36 000 tonnes per annum by 1973–74, total production at that stage being assumed at 1 06 000 tonnes per annum.

Lead

Lead finds important use in cable sheathing, paint, pigment and non-ferrous alloy industries.

Based on detailed data collected on its end-uses the demand for lead has been worked out at 102 534 tonnes per annum by 1973–74. On the basis of assumed growth rate of 10% on the consumption level during 1966–67 (50 000 tonnes) the demand is estimated at 66 550 tonnes in 1969–70 and will rise to 97 430 tonnes in 1973–74.

Production

In the public sector, Hindustan Zinc Ltd. are producing lead metal from their lead smelter at Tundoo (Bihar) from the concentrates obtained from their lead-zinc mine in Zawar area in Rajasthan. The production of lead metal in 1967 was 2 536 tonnes. The production was below the rated capacity of the plant. The short-fall in production is attributed to the falling lead content of the ore extracted at Zawar. Efforts are being made to increase the production from the present level by importing lead concentrates, if possible. The expansion of production will be considered depending on proving further deposits in the Zawar area.

In order to bridge the enormous gap between the production and indigenous demand of lead in the country, techno-economic feasibility of adopting the 'Imperial Smelting Process' in this country should be studied and considered for expansion of Zawar public sector zinc plant also. This process is amenable for simultaneous production of zinc and lead directly without the need for setting up separate concentrator plants for zinc and lead concentrates. Thus possible ores like Zawar, particularly in Rajpura-Dariba areas, which have combined zinc and lead minerals could be profitably treated simultaneously in this process. Consideration must also be given to import of concentrates of lead and zinc which could be treated in the country to augument the production of lead at least to 30 000 tonnes per annum capacity.

Cadmium

The demand for 1969–70 based on end-use method—may be taken as feasible demand being relatively small—is estimated at 78·5 tonnes and 95 tonnes for 1969–70 and 1973–74 whilst the production as a bye-product from existing zinc smelters would be about 150 tonnes in 1969–70 and about 260 tonnes in 1973–74. There would therefore be a surplus in these years which could be gainfully exported.

Antimony

Antimony concentrates are imported and the local demand of antimony metal is met by the only producer in Bombay with a production capacity of about 1 000 tonnes/annum. The capacity is proposed to be expanded to 1 500 tonnes/annum by 1970–71. The demand of antimony metal is approximately 1 000 tonnes/annum and will rise to 1 200/1 300 tonnes by 1970–71 and to 1 500/1 600 tonnes/annum by 1973–74. Thus the refinery after expansion will be able to meet the country's requirements. Occurrences of antimony ores have been reported but so far no efforts have been made to exploit these. Reclamation of scrap and reprocessing the same can be possibly taken up to augument its availability. In addition to exploration for indigenous resources of the antimony ore India should explore the possibility of buying interests in antimony mines in Iran or other countries having potential resources.

Tin

Tin finds extensive use in the tinplate manufacture in non-ferrous alloys—such as tin solders, bearing metals, bronzes, gun metals, painting metals, etc. and tinning of utensils, bare copper wires and strips. Present demand in the country is estimated between 5 000–5 500 tonnes/annum which is entirely met from imports. Total existing capacity for manufacture of tinplate of 340 000 tonnes is to be expanded to 440 000 tonnes/annum. If this capacity is expanded as proposed, the demand for tin will rise in proportion. The demand of tin is accordingly estimated to increase to approximately 6 500 tonnes in 1970–71 and to 8 000 tonnes/annum by 1975–76. Tin is so far not manufactured in the country but small quantities of secondary tin metal is recovered

TABLE III Installed capacity of production of non-ferrous metals

		Existing capacity Aug. 1968	Production 1967–68	Expansion approved/ licensed	Remarks
COPPER					
1. Indian Copper Corporation	Ghatsila	9 960	9 257	16 560	Expansion expected to be completed by 1970
2. Hindustan Copper Ltd. (Public Sector)	Khetri	—	—	31 000	Likely to materialise by end of 4th plan
LEAD					
1. Hindustan Zinc Ltd. (Public Sector)	Tundoo	6 000	2 336	11 000	Expansion will be taken up with availability of concentrates
ZINC					
1. Hindustan Zinc Ltd.	Debari	18 000	4 717	—	Started production in January 1968
2. Cominco-Binani Zinc Ltd.	Kerala	20 000	4 632	—	Based on imported concentrates, started production in May 1967.
ANTIMONY					
1. Star Metal Refinery Pvt. Limited	Bombay	1 000	870	500	Expansion likely by 1969–70
SILICON					
1. Indian Metals and Ferro-Alloys Limited	Orissa	—	—	3 000	Under implementation

Source : Non-ferrous Advisory Council, 1968

TABLE IV Installed capacity and production of non-ferrous semis and alloys

		Number of units	Installed capacity tonnes/annum	Production 1967–68 tonnes	Remarks
1. (a)	Aluminium foils	3	6 000	4 575	
(b)	Aluminium container sheets	1	1 200	1 010	
(c)	Aluminium sheets, circles, strips, etc.	12	60 600	32 438	including some manufacturers licensed for brass/copper sheets, circles as diversification allowed by Government
(d)	Aluminium rods, sections, hollows (extruded)	3	9 756	6 889	
(e)	Aluminium powder	1	804	612	
2.	Brass/copper sheets, strips, circles, coils	17	38 000	16 220	
3.	Brass/copper solids, hollows (extruded)	7	23 160	5 854	
4.	Rolled brass rods for non-electrical purposes	1	120	20	
5.	Lead sheets/strips	3	3 320	1 130	excluding M/s Hindustan Zinc. Ltd. production
6.	Lead pipes/tubes	1	2 060	205	
7.	Zinc photo-engraver sheets/plates	1	600	442	
8.	Arsenical copper rods	1	960	65	
9.	Brass wires for bicycle spokes, nipples, etc.	2	950	750	
10.	Phos-bronze strips/wires	2	1 200	nil	one unit with 600 tons capacity started production in 1968, other under implementation
11.	Nickel/cadmium and other anodes rolled/cast	1	600	160	
12.	Nickel-chrome (bare) wires/strips	1	100	4·36	
13.	Thermostatic bi-metal strips	1	60	nil	likely to commence production in 1969–70
14.	Non-ferrous alloys and castings	11	75 000	35 000	as per availability of foreign exchange for import of raw material
15.	Sintered parts	2	84 lac. pieces	77 lac. pieces	

Source : Non-ferrous Advisory Council, 1968

from tin scrap. Tin occurrences have been reported in some locations in Gujarat, Mysore and Rajasthan but none of these are yet assessed as workable deposits. In the circumstances it is imperative that suitable incentives should be given for collection and processing of tinplate scrap for secondary tin metal recovery in order to tap this vital growing indigenous source of tin metal.

Silicon

Silicon metal is used in manufacture of aluminium base alloys, a considerable extent in castings and to a smaller extent in aluminium alloy semis. Present demand of the metal is estimated at about 1 000 tonnes per annum and is likely to increase to 3 000 tonnes/annum by 1973–74. So far pure silicon is not produced in the country and our entire requirements are met through imports. The import figures for years 1965-66, 1966-67 and 1967-68 were 484, 772 and 791 tonnes respectively. An Indian firm (Indian Metals and Alloys Ltd.) has been given a letter of intent to produce metallic silicon up to about 3 000 tonnes/annum. The capacity is not likely to materialise before 1972–73. Steps should be taken up immediately to ensure the setting up of indigenous capacity at an early date in view of the increasing demand of silicon for the aluminium castings industry. Estimated figures for use of ferro-silicon, silicon-chrome, silicon-manganese for steel industry are given under chromium and manganese.

Non-ferrous semis and alloys industry

The indigenous installed capacity for non-ferrous semis and alloys is given in Table IV as compiled by the Non-ferrous Advisory Council in 1968 and the figures quoted show that in general the installed capacity is being only partially utilised and depends on the allocation of import quota of virgin non-ferrous metals. Thus, in the past few years in general only about 45% of the available capacity has been utilised. During the Fourth Five-Year Plan the country's requirements of non-ferrous semis and alloys could be mostly met by the present installed capacity which need not be expanded in this period. However, any diversification for the production of specialised items by this industry should be allowed and encouraged, minor alterations and/or additions of machinery and equipment could be allowed for this purpose.

Scarce metals of interest to electronics, defence atomic energy and space technology include:

Selenium and tellurium

Selenium and tellurium are usually obtained as bye-products in copper production. The electrolytic refining slimes from copper refinery can be processed for their reclamation. So far these have not been processed at Indian Copper Corpotation refinery. In the processing of copper refineries, in this plant and at Khetri, suitable steps should be taken to recover these metals needed in the electronics industry.

Tantalum

Tantalum metal is also used in the electronics and the chemical industries. Bhabha Atomic Research Centre has developed the technology for processing the ore, preparation of the metal and production of the slugs. The rising demand of electronics and chemical and engineering industries cannot be met by indigenous resources. It is therefore necessary that indigenous sources for tantalum and columbium metals should be located through urgent prospecting and exploration.

Germanium

Germanium is widely used in the semi-conductor industry. Bharat Electronics Ltd. is importing about 1 200 kg of germanium dioxide for further processing into germanium metal. It can also be processed from sludges and scrap and a regular recovery plant is to be set up soon. By 1975 the requirments of germanium metal are expected to rise to about 2 000 kg/annum for electronics industry. Sources of fly ash and flue dust from coals should therefore be systematically looked into.

Silicon

Silicon metal is also used for the manufacture of semi-conductors. Bhabha Research Centre are planning to set up a plant for production of polycrystalline silicon which may partially meet the requirements of Bharat Electronics Limited. The requriement of polycrystalline silicon bar by 1969 is estimated at about 100 kg on the anticipated production of 10 million pieces in 1971 and 0·5 tonnes in 1975 has been assessed by the Bhabha Committee on electronics industry.

Beryllium

Beryllium with its remarkably high modulus of rigidity combined with low density (1·816 gm/cc) has attracted considerable attention as a special structural material. In 2–2·5% beryllium copper alloys it is commercially used as high wear and fatigue resistant alloy, with its amenability to precipitation hardening it is also added in small amounts in aluminium and magnesium alloys.

As metal and also as an oxide beryllium is also used in nuclear reactors as a moderator on account of its low neutron absorption cross-section. The Bhabha Electronics Committee estimated the demand of 6 tonnes/annum of 2·5% Cu-Be alloy by 1975 mainly for contacts and springs in moving coil meters. B. A. R. C. and N. M. L. have proposals to jointly produce Be0 (at B. A. R. C.) and Cu-Be master alloy at N.M.L.

Zirconium

Zirconium is needed as zircaloy for the fuel-canning and structural material in nuclear reactors of the type under construction in India under the nuclear power programme which aims at 1·2 million kilowatts by the end of 1973–74 reaching 3·0 million kilowatts at the end of 5th Plan period. Annual production of 50 tonnes of zircaloy (mainly containing 1·2 to 1·7% tin) is expected to meet the demand. A plant of this capacity is being established at Hyderabad and the capacity will be expanded as required. Several other zirconium alloys are needed in the industry. Zirconium iron and ferro-silicon-zirconium containing 4–6% zirconium are used in steel industry as master alloys for deoxidation and scavenging and control of grain size. Zirconium is an important metal used in grain refining several magnesium base alloys. It is also used as a getter element in power, radio and television tubes and flash bulbs and compares favourably with tantalum in many applications. India has adequate resources of zircon a product from beach sand separation of monazite, ilmenite, rutile and sillimanite. Beach sands in South India contain 5 to 7%

zircon which is largely used in refractories, vitrous enamels and foundries, etc.

Titanium

Rutile and ilmenite can be used for production of titanium. Titanium finds many industrial uses in space applications, air-craft and chemical processing industries due to its high strength to weight ratio, excellent high temperature strength and corrosion resistance. Recently some industrial firms have shown interest in setting up, in foreign collaboration an integral plant to produce, based on our ilmenite deposits of Kerala beach sands, titanium slag, containing 10% titanium dioxide used in production of titanium pigment and production of 300 tonnes of titanium sponge. These proposals are under consideration by the government. In case indigenous know-how is to be preferred, a pilot plant will be needed to obtain necessary design data for scaling-up prior to setting up a commercial scale unit.

Metals which find major applications in manufacture of ferro-alloys, alloys and special steels in addition to non-ferrous applications

Nickel

Nickel is an important metal used in manufacture of numerous ferrous alloys, laboratory ware, electrical storage batteries, Edison type electrodes for certain radio valves, for coil springs, television tubes, food processing plant, etc. Important ferrous alloys include : stainless and other heat resistant steels, alloy cast irons and steel castings ; in non-ferrous alloys as cupro-nickel alloys, nickel-silver spring alloys ; nickel-chromium alloys for electrical heating elements, engine valves, etc. Nimonic alloys for air-craft industries and other nickel alloys for chemical industries, condenser tubes for marine power plants, coinage alloys, etc. and for magnetic alloys, electro-plating, nickel salts, etc.

The present demand for nickel is estimated to be approximately 3 000 tonnes/annum which is expected to rise to 6 000 tonnes/annum by 1973–74. At present there is no production of nickel in India. Some promising deposits have been located recently by Geological Survey of India in Kansa area, Orissa. Recently Hindustan Copper Corporation has been set up to exploit copper and nickel deposits in the country.

Nickel deposits, located so far include the deposit of Sukinda in Cuttack district of Orissa. The content of nickel in this deposit analyses from 0·5% to 1·83% and the cobalt content ranges from 15 ppm to 2500ppm in some areas. In the Naushahi Keonjhar belt the indicated nickel content is about 4%. In Udaipur district in Rakhabdev-Kherwara areas some nickeliferous serpentinous rocks have been located, also in Kalighati in Alwar district, copper ores have been located with some nickel and cobalt contents. Other areas reported are in Manipur near Burma border, in the North Arcot district in Madras and in Jhabua district in Madhya Pradesh. Assessment and evaluation of all these deposits have to be expedited in order to open up avenues for the exploitation.

The problem of substitution of nickel in its various uses has been considered for some years now and suggestions have been made to change the use of electroplating of nickel by anodised aluminium. Durgapur Alloy Steel Plant is actively engaged in looking into the feasibility of producing NML developed nickel-free stainless steel. Similarly, nickel-free heating elements may be manufactured in the country as developed by National Metallurgical Laboratory. NML has also developed soft ferrite magnets for use in magnetic material applications. One to five paisa coins have already been put in circulation in the country based on aluminium base alloys.

Chromium

Chromium is mainly used in the manufacture of various alloys and special steels and in the electroplating industry. Chromite ores are used in the manufacture of various refractories. Chromium salts are extensively used in chemical industries. Ferro-chrome is used normally for additions to manufacture various alloy, stainless, special and heat resistant steels.

The demand of ferro-chrome, chromium metal is estimated as :

	1975–76
As ferro-chrome and silicon chromium as estimated by NCAER	13 800 tonnes
Ferro-chrome for defence purposes	300 tonnes
Metal chromium	60 tonnes

Adequate capacity for production of low-carbon ferro-chrome has been licensed to meet the requirements of the country by 1975–76. Known workable deposits of chromium are located in Andhra Pradesh, Bihar, Madras, Maharashtra, Mysore and Orissa. The chromite deposits in Orissa are of high metallurgical grades while those in other areas are of refractory grades. Estimated reserves of the chrome deposits in the country are assessed at about 6·4 million tonnes of which proved reserves of metallurgical grade are only 1·30 million tonnes. As the Orissa deposits only are of the metallurgical grade these should be reserved for use in metallurgical applications.

Manganese

India is comparatively rich in manganese deposits which is widely employed as a common deoxidiser in steel-making in the form of ferro-manganese, spiegeleisen, silico-manganese or silico-spiegeleisen. Manganese metal is also used in some bronzes, brasses, aluminium base alloys, monel, nickel-chrome resistance alloys, etc. Manganese is also used in the manufacture of various alloy steels including Ni-free NML developed stainless steel. The National Metallurgical Laboratory has also developed a process for production of electrolytic manganese metal which may shortly be utilised for commercial production in the country. Manganese dioxide is used in dry battery manufacture and a process for its manufacture has also been developed from low grade manganese ores at NML and leased out for commercial scale manufacture.

The demand for ferro-manganese and manganese metal estimated by the NCAER in 1968 is given below:

	1970-71	1975-76	1980-81
Fe-Mn 70%	132 000	176 000	227 000
Electrolytic Mn metal	1 000	1 500	2 000
If use of silicon-manganese is also introduced partly in place of Fe-Mn then demand will change as:			
Si-Mn 20% Si, 6·5% Mn	22 000	31 500	46 000
Fe-Mn	102 000	148 000	187 000
Fe Si	22 000	31 500	46 000

Production

Seven ferro-manganese plants are in production in the country having a total capacity of 184 680 tonnes/annum, mostly the plants manufacture high carbon ferro-manganese.

Vanadium

Vanadium is mostly used in the production of variety of alloy steels and smaller amounts in non-ferrous metals. It is also used in production of various chemical compounds. In steels, it reduces the grain size, increases tensile and torsional strength. It is also added in certain cast irons to cause formation of uniform graphite flakes. It is also added in a magnetic alloy 'Permedur' having Fe 49, Co 49, and V 2% composition. The NCAER has estimated its demand as 300 tons in 1970-71 and 450 tons by 1975-76. National Metallurgical Laboratory has developed a process to produce V_2O_5 (vanadium pentoxide) used in production of ferro-vanadium based on the vanadiferous magnetite ore in Mayurbhanj, Orissa. These deposits are estimated by Geological Survey of India at 23 million tonnes with 0·5 to 3% vanadium oxide. The firm Koyna Ferro-alloys Limited has a licence to produce 500 tonnes of ferro-vanadium and the Vanadium Corporation of India has a licence to produce 500 tonnes of ferro-vanadium, vanadium pentoxide, and vanadium pig iron.

Tungsten

Major uses of tungsten are in the form of ferro-tungsten for special alloy die and tool steels, tungsten carbide and for production of ductile tungsten and its chemicals. Certain alloys of chromium, cobalt and tungsten are also used for magnets, tungsten is used as electrodes in welding, as wire in electric lamp filaments, heating elements in electric tube furnaces, etc. Hardfacing non-ferrous alloys with tungsten are also manufactured. Tungsten requirements are placed at 1 400 tonnes by 1970-71 and 1 900 tonnes by 1975-76 for manufacture of high speed and other steels by the NCAER's 1968 study.

Major occurrences are as wolframite and scheelite minerals located at Bankura district, West Bengal, Degana in Nagaur district in Rajasthan and Agargaon in Nagpur, Maharashtra. Some occurrences have also been located in Kolar Gold-field, Mysore, and Chittor district in Andhra Pradesh. Early exploitation of economic resources and production of ferro-tungsten and tungsten metal in the country should be taken up and a detailed assessment of all the reserves has to be expedited in view of the strategic importance of the metal. It is understood that the Rajasthan State Government is considering a proposal to set up a concentrating plant to treat 25 tonnes of concentrates per day.

Molybdenum

Molybdenum is an important metal used in the manufacture of special alloy steels as ferro-molybdenum. Metallic molybdenum is also used in the production of radio and power valves, mercury vapour lamps, heating elements for furnaces. Molybdenum wire is also used in filament supporting in electric lamps, radio valves etc., chemical industry utilises various molybdenum compounds for multifarious uses. Molybdenum disulphide is used as dry lubricant in high temperature uses. NCAER has estimated its demand as ferro-molybdenum at 450 tonnes by 1970-71 and at 675 tonnes by 1975-76. From the uranium bearing deposits in Bihar the Uranium Corporation is trying to recover molybdenum as a bye-product. Molybdenite has been located in areas such as Hazaribagh in Bihar with lead-zinc-copper ores; in Madurai district, Madras; Godavari, Karimnagar and Madek districts in Andhra, Krishengarh in Rajasthan and Quilon in Kerala. In view of the strategic importance of this metal, it is imperative that all our deposits should be studied in detail and wherever feasible, its recovery from associated ores attempted to meet indigenous essential requirements.

Ferro-alloys

It may be pointed out here that the National Metallurgical Laboratory has conducted comprehensive studies over the past years and successfully developed the technical know-how for the production of various special ferro-alloys based on alumino-thermic processes. Commercial scale exploitation of these processes has been licensed and three firms located at Amedabad, Calcutta and Amritsar have been in production for the past few years utilising, where available, indigenously available concentrates as also imported concentrates of these metals to meet essential requirements of defence ordnance and our growing alloy, special tool and die steel mnufacturers. Ferro-alloys thus produced in the country include :

Fe-Cr, Fe-W, Fe-Ti, Fe-Mo, Fe-Va, Fe-B, Mn-Cr, etc.

Import substitution of major non-ferrous metals

In view of the lack of known resources of the major non-ferrous metals needed for multifarious defence, electrical, engineering and consumer industries, the increasing demand of these metals and their alloys with increasing industrialisation under the Five-Year Plans and acute shortage of foreign exchange earnings to justify free imports, the government and the industry have long since accepted the view that all possible avenues of research, development and innovation should be explored to find suitable and acceptable substitute metals, alloys, processes and products based on indigenously available raw materials. All-out efforts in this direction so far have brought good dividends and enabled the country to use and utilise the available non-ferrous metals (indigenously available and imported) for such requirements where technological alternatives could not be established so far.

Thus considerable substitution of copper by aluminium has taken place already in the electrical industry. ACSR and AAC overhead conductors only are being produced without use of copper in this field. Since 1965 all underground cables and VIR and PVC cables have been substituted by aluminium. All new railway coaches are being fitted with aluminium cables. Main cables for traction, motor, control panel to generator have been replaced by aluminium. Return conductors of overhead traction wires have also been replaced by aluminium. A number of motor manufacturers (up to 30 H.P only) have switched over to die cast aluminium rotors in place of rotors with copper strips ; lamp caps are now being manufactured only in aluminium strips. Considerable degree of substitution of copper has been made with production of aluminium bus bars.

In coinage alloys, copper and nickel have been replaced up to 1-5 paisa coins. Efforts to make aluminium base bearing alloys suitable to replace bronze bearings are making headway. Bronze bearing shells for carriages and wagons have been replaced by railways by S.G. iron shells. Some thirty-four items of boiler mountings in steam locomotives made so far of gun metal have been replaced by S.G. cast iron. Allocation of copper and zinc has been stopped for manufacture of building hardware like door, window, fittings, etc. No allocations are being made of these metals for manufacture of household utensils either.

Lead sheathing in cables has been replaced by PVC sheathing up to 1·1 kV cables and will be achieved up to 11 kV from July 1969.

Zinc substitution by aluminising of ACSR core wires has been under examination and has been recommended by the Development Council for Non-ferrous Metals as technically feasible and economically adaptable. Efforts to produce these ACSR aluminised core wires and steel sheets on a pilot basis are already underway. Similarly buckets and hardware can be effectively aluminised instead of galvanising and this has been proved and demonstrated by NML developed process.

It is expected that with the effective restrictions for foreign exchage allotment for zinc imports, the small scale producers will eventually switch-over to aluminising. Aluminising is also expected to be progressively adopted in the field of transmission tower steel pipes and tubes. Further investigations and progress are yet to be made in aluminising of steel strip, pipes and tubes.

Various other fields in which developments are awaited are, air-conditioning, refrigeration and fastener industries. Replacement of tin plate continues by aluminium containers, plastic or paper containers ; alternative block steel sheets with suitable chromising or other coatings and lacquers, etc. are major possible fields in which technological developments regarding jointing problems, corrosion resistance, toxicity to food products, etc. have to be awaited or know-how borrowed from abroad to expedite measures to check the rising demand for tin. Concerted efforts on government level are also necessary to check any misuse of these scarce metals for end-uses which have been accepted for substitution and at the same time to see that import quotas allowed to importers of non-ferrous metals are judiciously used for specific, essential defence and engineering applications where no indigenous substitutes are available. In cases where laboratory or pilot plant scale feasibility of substitution has been established, necessary encouragement and steps must be taken up immediately to expedite their commercial scale adoption, through government assistance where no entrepreneurs could be found, so that use of the scarce metals in such fields could be checked and minimised.

Non-ferrous metals required in bulk quantities

In order to augment the production of copper in the country beyond the present planned capacity, necessary efforts have to be made from now on in the following directions :

The capacity planned for Khetri Copper Plant of the Hindusthan Copper Corporation is 31 000 tonnes. The possibility of raising the capacity to 50 000 tonnes /annum should be fully explored. In this connection full assessment of the deposits in Rajasthan should be made to ascertain whether the higher production could be sustained by these deposits. India should explore the possibility of participating in the exploration of non-ferrous ores including copper, zinc, lead, etc. in friendly countries including Far-East, Middle-East, Africa, etc. It is felt that import of concentrates even on a long term contract basis may give a copper smelter only marginal foreign exchange savings benefit and hence unless we undertake equity participation in ore exploration, exploitation in prospective producer countries these imported concentrate based smelters (particularly in case of copper) will not be of much assistance to the country, especially in view of the changing market conditions regarding procurement of ore concentrates. Thus possibilities of joint ventures with developing countries should be explored and where feasible preferred.

Possibility of currently constituted smelter plants utilising small regional pockets of copper, zinc and lead ores should be looked into. Mining lease for exploitation of small deposits could be given to mine owners to expedite their exploitation.

Needless to emphasise that exploration of these minerals and assessment of located ores should be done with a high priority and early development and exploitation of the located areas should be taken in hand.

Scarcer strategic metals

The requirements of high purity (of four nines plus) metals like indium, lead, tellurium, tin and tantalum by the electronics industry could be met indigenously by setting up small scale pilot plant production at our research establishments (BARC) which could later on perfecting the know-how, be stepped up for commercial scale production to make our country wholly self-reliant in this field. However, know-how for manufacture of high purity metals, required by the electronic industry, such as antimony, arsenic, bismuth, gallium, gold, selenium, silver and zinc has already been worked out by BARC and their requirements can be met by indigenous production.

The know-how for certain metals production, to meet the requirements of defence, electronics atomic energy as per their specifications has been developed at some of our research establishments and in other cases this has to be worked out. Where necessary such production could be started at pilot plant level in the first place. Metals like nickel, molybdenum and tungsten could, after developing suitable technology be produced and fabricated at the plant to be set up at Hyderabad for production of pure metals for electronic industry, the alloying and fabrication facility to meet the required shapes and sizes could be undertaken at a centralised facility. In case of non-ferrous metals this specialised facility may be located at a centralised place.

Recommendations have similarly been made for setting up titanium sponge pilot plant, BeO and Ba, Ta, Ge at BARC while for manufacture of Be-Cu master alloy and Ca at NML. The copper refining plants should be asked to recover Se, Te in their refineries.

Technical consultancy

The setting up of a central design and consultancy institute for non-ferrous metallurgy as also an aluminium institute or cell is an urgent necessity to assist in setting up new facilities and provision of consultancy to existing units. Liaison with existing units and solution of their problems as also giving technical information and know-how should be strengthened for the non-ferrous and aluminium industries through setting up a 'liaison cell' at the National Metullurgical Laboratory.