THE PROSPECTS OF ALUMINIUM IN INDIA

P. Dayal

ALUMINIUM the most abundant of all the metallic elements found in the earth's crust was at one time more precious and rare than silver and gold, but in less than 100 years it has become one of the most important metals in the world. It was successfully produced commercially for the first time only a decade before the turn of century. Since then its production has rapidly increased from 12,000 tons in 1905 to over 4 million tons at present and has attained a position second only to steel. It is a young and virile industry and has surpassed lead and zinc and wrought copper as revealed in Table I. It is observed that during the period 1948 to 1958, aluminium's share of the four major non-ferrous metals increased from 18 to 28 per cent while copper dropped from its share of 33·4 to 28·5 per cent.

TABLE I*

World production of aluminium, copper, lead and zinc.
(in thousand metric tons).

	1948	1953	1958	Remarks
Aluminium	1,130	2,180	2,890	Excluding China and Russia (Primary aluminium only).
Copper	2,110	2,490	2,930	Excluding China and Russia (Primary copper only).
Lead	1,350	1,700	1,900	Excluding China and Russia (Primary lead only).
Zinc	1,570	2,120	2,370	Excluding China and Russia (Primary zinc only).
Total	6,160	8,490	10,090	

* Statistical Year Book—1959 (United Nations).

Growth of aluminium industry

The growth of aluminium industry in the world has been very phenomenal. The production of primary aluminium and total consumption in some countries of the world for 1949, 1954 and 1959 are given in Table II. It will be observed that Canada and Norway are the main exporters and U.S.A., U.K. and West Germany the main importers. In U.S.S.R. the planned capacity for aluminium for 1960 has been reported to be 1,470,000 tons. Thus the largest producers are U.S.A., U.S.S.R. and Canada which together account for about 80 per cent of the world production. The average rate of consumption during the post-war period 1948 to 1955 in U.S.A. and Europe has been at 12·7 and 10·9 per cent per year respectively. During the period of 10 years (1949 to 1959), the consumption of aluminium in West Germany increased by 475%, in U.S.A. by 200%, in France by 180%, in Japan by 140%, in Sweden and U.K. by about 100%. The demand is expected to grow at an avergae rate of 8 per cent per year in Europe and at about 10 per cent in the rest of the world. It is estimated that the world demand for primary aluminium would double by 1967 and treble by 1975. An idea of the rise in consumption in some of the countries of the world can also be had from the increase in *per capita* consumption during the years 1935–38, 1955 and 1959 as given in Table III.

Like all other industries, aluminium also has faced periods of surpluses and shortages. For some years although the industry was expanding greatly, the production of primary aluminium could not keep pace with the increasing requirements of the fabrication. In 1959, the industry faced a severe recession, as demand lagged behind the production capacities. The producers of primary aluminium in Canada worked only to 65 per cent of the full rate and U.S.A. to about 85 per cent. The demand is now catching up again and the aluminium units all over the world are expanding very rapidly. In Asia, the main producers are Japan, China and India. It is reported that Japan is planning for a capacity of about 220,000 tons by 1962–63, China for 180,000 tons by 1965–66.

Production of aluminium in India

The production of aluminium ingot and semis increased only slightly during the First Five Year Plan, but the industry has made a marked progress during the Second Five Year Plan. The target for aluminium ingots for the Second Five Year Plan was fixed at 30,000 tons per annum. The installed capacity so far achieved is 17,500 tons per annum. Further licences

Dr. P. Dayal, Development Officer, Metals Directorate, Development Wing, Ministry of Commerce and Industry, Government of India, New Delhi.

TABLE II

Growth of production and consumption of aluminium in some industrialised countries.

(Short tons)

Country	Production			Consumption		
	1949	1954	1959	1949	1954	1959
Australia	—	—	14,600	—	20,350	43,300
Canada	369,500	560,900	598,700	55,500	73,500	100,300
France	59,600	132,300	190,700	70,600	140,500	199,400
Germany (West)	3,200	142,400	166,700	58,600	216,900	337,800
India	3,900	5,500	18,000	16,100	19,400	45,000
Japan	23,400	58,500	93,400 (1958)	55,400	67,400	128,400 (1958)
Norway	39,300	71,700	159,700	15,600	15,700	19,400
Sweden	4,300	11,700	17,100	22,700	32,200	44,600
Switzerland	23,000	28,800	36,400	23,800	28,600	41,100
United Kingdom	34,000	35,400	27,500	207,400	304,900	391,000
United States	603,500	1,460,600	1,953,000	776,700	1,527,500	2,434,500

TABLE III

Aluminium consumption by country.

(Pounds per head of population)

	1935–38	1955	1959
Australia	—	5·2	8·1
France	1·4	6·9	8·9
Germany (West)	4·1	10·7	13·3
India	—	0·2	0·2
Italy	1·0	3·9	4·6
Japan	—	1·3	3·4
Sweden	—	9·3	11·9
United Kingdom	2·1	14·3	15·3
U.S.A.	2·0	23·6	27·4

TABLE IV

Production capacities for aluminium ingots and semis.

(in tons)

	1950-51	1955-56	1960-61	1965-66
Aluminium ingot	4,000	7,500	17,500	82,500*
Sheets and circles	11,400	17,000	19,000	50,000
Aluminium wire rods for ACSR	4,000	10,000	22,000	30,000
Extruded sections	—	1,000	1,200	10,700
Aluminium foils	1,100	1,200	2,000	7,500

* As included by the Planning Commission in the Draft Third Five Year Plan and is under consideration for upward revision.

have been granted by the Government for creating an additional capacity of 65,000 tons which include the expansion of Indian Aluminium Co's Hirakud Smelter from 10,000 tons to 20,000 tons and Aluminium Corporation's Asansol plant from 2,500 tons to 7,500 tons and setting up of three new smelters viz. (*i*) Hindustan Aluminium Corporation at Pipri (U.P.)—20,000 tons; (*ii*) Tendulkar Industries at Koyna (Maharastra)—20,000 tons and (*iii*) Madras Aluminium Co. at Mettur (Madras)—10,000 tons. This brings the total licensed capacity for aluminium ingots to 82,500 tons. Most of these projects have progressed to a marked stage and are expected to be completed by 1962–64. In addition, further proposals for expansion of the existing units and for setting up new units are also under consideration of the Government. Sufficient capacity for manufacture of aluminium semis, viz. flat products, wire rods, extruded sections and foils, etc., is also being established. The position of the aluminium industry during the first two Plans and the estimates to be achieved during the Third Plan are given in Table IV.

Present demand of aluminium in India

The demand of aluminium in the country has been progressively increasing from 15,000 metric tons in 1951 to 27,000 tons in 1955–56 and 45,000 tons in 1960. A break-up of the consumption of aluminium industrywise for 1955 and 1960 is given in Table V. From the Table it can be seen that aluminium in the past had been chiefly used for household utensils, but the metal has now come out of the kitchen shelf and is being used mainly for the electrical industries, transportation, building and construction, canning and packing, food and farming and other miscellaneous industries.

As the indigenous production of aluminium has been insufficient, the demand is being met by imports from Canada, U.K., U.S.A., West Germany, etc. The data for production, imports and total consumption of the metal in the country for the last ten years are given in Table VI.

TABLE V

Consumption of aluminium industrywise for 1955 and 1960.

	1955 (tons)	1960 (tons)
Electrical industry ...	8,980	16,000
Household and commercial supplies ...	11,650	11,000
Transportation ...	2,350	7,000
Building and construction ...	480	3,000
Canning and packaging ...	2,580	3,000
Food and farming ...	15	1,000
Other industries ...	1,345	4,000
	27,400	45,000

TABLE VI

Production, import snd consumption of aluminium in India (1951–1960).

Year	Production (tons)	Import (tons)	*Total consumption (tons)
1951	3,840	10,500	15,000
1952	3,590	7,100	13,000
1953	3,760	4,800	12,500
1954	4,890	12,400	20,000
1955	7,225	15,800	27,000
1956	6,500	14,000	26,000
1957	7,780	17,300	33,000
1958	8,180	19,200	35,000
1959	17,250	19,000	40,000
1960	18,000†	17,000†	45,000†

* Includes secondary production from scrap.
† Estimated.

Trend in future demand

In view of the restriction on the imports of aluminium, the present consumption has been stifled and the demand is being satisfied to only about 65 per cent of the requirements. During the period 1951–56, the average rate of increase in the consumption of aluminium has been 14 per cent per year. During the period 1956–61 in spite of the restricted imports, the same rate has been maintained. With the availability of indigenous aluminium in the country, the consumption is expected to increase at a higher rate of about 15 to 20 per cent per year during the course of next 10 to 15 years. The main factors which are likely to favour the vast expansion in the consumption of the aluminium in India are given below :

(*i*) Potentiality of aluminium to replace copper particularly in the electrical industries and other non-ferrous metals and steel and its stabilised prices over a relatively long period.

(*ii*) Inadequate deposits of ores for non-ferrous metals like copper, zinc, lead, etc. and the restricted imports in view of the tight foreign exchange position.

(*iii*) Extensive bauxite deposits in the country and possibilities of achieving self-sufficiency in the aluminium industry.

(*iv*) Increasing tempo of electrification and industrialisation in the country and large demand for aluminium conductors of various types for power distribution and the favourable price factor.

(*v*) The present low *per capita* consumption of aluminium and the rising living standards of people.

It has been estimated that our requirements of other major non-ferrous metals by 1965–66 will be as follows :

Copper	... ...	170,000 tons
Zinc	... ...	185,000 ,,
Lead	... ...	65,000 ,,
Tin	... ...	10,000 ,,

Due to limited reserves of the ores it does not seem to be possible to achieve self-sufficiency in these metals for a long time to come. In order to save foreign exchange, efforts are being made to discourage the use of copper and zinc for non-industrial purposes. The industry is also being encouraged to replace copper, zinc and lead by aluminium in all fields, whenever it is technically and economically feasible.

During the past few years, aluminum as a conductor material has proved as good as copper in most of the fields. In fact, for carrying the same load, aluminium is required only about 48 per cent by weight of copper and in the case of all aluminium conductors, the price saving is of the order of 35 to 45 per cent. In view of the consideration of cost and other advantages, the Central Water and Power Commission has advised gradual switching over of all lines from the the lowest to the highest voltage for power transmission and distribution to all aluminium conductors in the low and intermediate ranges and A.C.S.R. in the higher ranges. During the Third Five Year Plan, the installed generating capacity for power is to be increased from 5·8 million kW to 11·8 million kW as per the Draft Outline of the Plan and additional transmission lines will have to be laid. The demand for all-aluminium conductors and A.C.S.R. is estimated to be 30,000 tons by 1963 by the Tariff Commission and is expected to rise to about 45,000 tons by 1965–66. In addition, aluminium conductors may also be required for the railway electrification programme and the telegraph overhead communication circuits. Insulated aluminium wires for house service connection and internal wiring are also now being made in the country. The cable industry is being encouraged by the Government to change over from copper to aluminium. It is, therefore, expected that the use of aluminium in the electrical industries alone would increase very considerably during the next few years.

In the field of domestic and household supplies, aluminium is being increasingly used. In view of the shortages of copper and zinc and the growth of population, consumption of aluminium is bound to increase. In the transportation industry, aluminium due to its

lightness permits a greater load carrying capacity over steel and in view of these properties aluminium is likely to make a big headway in road and rail transport and in the marine field. For the aircraft industry, aluminium and its alloys are the most essential materials. For building and construction, it has been mentioned that aluminium will face a serious competition from steel. It has, however, been established that though the initial cost of aluminium is higher but the maintenance and replacement costs are much lower than those of steel. Besides the canning and packing and food and farming industries, the use of aluminium is increasing in the manufacture of engineering equipment, textile machinery, plant and equipment for the food and chemical industries, scientific instruments and other miscellaneous items.

The consumption of aluminium in the world is about 28 per cent of the total consumption of all non-ferrous metals. In India at present it forms only about 20 per cent of all the non-ferrous metals consumed and the *per capita* consumption is only 0·2 per pound against 27·4 pounds in U.S.A. and 15·3 pounds in U.K. In view of the circumstances mentioned above, the demand of aluminium in 1965–66 is estimated to be 130,000 to 150,000 tons per year as per break-up given in Table VII.

TABLE VII

Demand of aluminium by 1965-66

Industry	Estimated by the Development Council for Non-Ferrous Metals in December, 1959 (tons)	Revised estimates of the Development Council in August, 1960. (tons)
Building and construction	5,000	6,000
Transportation and aluminium alloys ...	15,000	20,000
Domestic utensils and other commercial supplies ...	20,000	30,000
Electric industries ...	35,000	50,000
Food, farming and sugar industry ...	2,500	5,000
Canning and packing ...	7,500	10,000
Miscellaneous ...	5,000	9,000
Export of aluminium goods and alloys ...	10,000	20,000
	100,000	150,000

Raw material resources of India

The main raw materials for the Aluminium Industry are : bauxite, electric power, cryolite, petroleum coke and caustic soda. The following quantities are required for production of one ton of aluminium :

Bauxite	— 4 to 5 tons
Calcined petroleum coke	— 0·5 tons
Cryolite	— 0·1 ton
Aluminium fluoride	— 0·036 ton
Caustic soda	— 0·2 ton
Electric energy	— 20,000–22,000 kWH

Bauxite

The world's bauxite reserves have been estimated at 3,416 million tons as per break-up given in Table VIII.

TABLE VIII

*Estimates of the world bauxite reserve**

Continent	Country	Million long tons
Asia	India	250
	China	50
	Federation of Malaya	10
	Sarawak	5
	Turkey	10
	Vietnam	(.)
	Total	325
Africa	Ghana (Gold Coast)	229
	Guinea	600
	Mozambique	(.)
	Total	829
Oceania	Australia	600
	Palau Islands, Ponapa, Manus	3
	Total	603
North America	Dominican Republic	40
	Haiti	23
	Jamaica	550
	U.S.A.	50
	Total	663
South America	Brazil	30
	British Guiana	80
	Surinam	200
	Total	310
Europe	Austria	1
	France	70
	Greece	84
	Hungary	250
	Italy	111
	Rumania	20
	Spain	7
	U.S.S.R.	100
	Yugoslavia	128
	Total	671
Grand Total :	3,416 million tons	

* U.S. Bureau of Mines.

India possesses sizeable deposits of bauxite totalling over 250 million tons, almost half of which is considered to be of high grade suitable for manufacture of aluminium. The Indian bauxite deposits are fairly evenly distributed all over the country. These occur principally in Ranchi district of Bihar, Katni, Jabbalpore, Bhopal and Amarkantak of Madhya Pradesh ; Belgaum in Mysore; Kolhapur and Ratnagiri in Bombay and Salem in Madras State. Deposits in Kashmir though rich in alumina (60 to 70 per cent Al_2O_3) cannot be worked by the normal Bayer process, as these are principally diasporic and high in silica.

Power

The cost of power is one of the biggest determining factors for the production of aluminium. India possesses ample power potential especially hydro-electric. A preliminary survey of the hydro-electric power resources of the country made by the Central Water and Power Commission has revealed a utilisable potential of over 35 million kW. Apart from this, India has 40,000 million tons of known reserves of steam and non-coking coals.

The target for power for the Third Plan has been kept at 11·8 million kW and its upward revision is under consideration. At present the development of aluminium industry is hampered on account of the shortage of power. However, some of the entrepreneurs have proposed setting up of their own power projects, hydel or thermal, subject to the sanction of the Government.

Petroleum coke

Next to bauxite and electric power, carbon electrodes are important raw materials for production of aluminium. Petroleum coke is required for the manufacture of Soderberg Electrode Paste which forms the anode in the electrolytic reduction furnaces. For every ton of metal produced, the paste consumed is 0·65 ton and this in turn calls for 0·75 ton of green petroleum coke or 0·5 ton of calcined petroleum coke. Our requirement of green petroleum coke by the end of Third Plan may be of the order of about 100,000 tons per year. At present, petroleum coke is indigenously manufactured only by the Assam Oil Company located at Digboi, Assam. Their residuum coke has a high silicon content and is not acceptable to the aluminium industry producing conductor grade metal. Other refineries in the private sector are not producing coke. It is, however, understood that the two proposed oil refineries being set up in the Public Sector at Gauhati and Barauni will produce raw petroleum coke with a capacity of 39,000 tons and 67,000 tons per year, and are expected to come into production in 1962 and 1963 respectively. It is desired that the raw petroleum coke should be calcined at the refineries in order to take advantage in freight savings. Also, it would not be economical for each aluminium works to have their calcining facilities.

Cryolite and aluminium fluoride

At present, both these items are being imported to meet the requirements for the existing aluminium industry. There are no cryolite deposits in the country, but synthetic cryolite could, however, be manufactured from fluorspar. Deposits of fluorspar in substantial quantities are reported from Dungarpur, Rajasthan ; Chincholi, Nandgaon, Drug District, M.P. ; Ambedunagar in Chotta Udaipur Taluk, Baroda District, Gujerat. These are of low grade containing a high silica percentage which, however, could be upgraded by flotation methods. A concerted and well-directed effort is now needed to work out the deposits, upgrade them and take up the manufacutre of synthetic cryolite in the country. Fluorspar could also be used for manufacture of aluminium fluoride and once the production of synthetic cryolite is started, the aluminium fluoride could also be manufactured in the country.

Caustic soda

There are at present eighteen factories producing caustic soda with a total production of one lakh tons per year. The target of production by 1965–66 has been kept at 3 lakh tons per year. It is expected that the indigenous production would be able to meet the demand of the expanding aluminium industry.

Export possibilities

At present, India is exporting aluminium semis worth Rs. 120,000 and domestic utensils for about Rs. 45 lakhs per year to South East Asia, Middle East and African countries. As is well known the internal demand is being met by the import of aluminium from other countries and, therefore, the exports cannot be achieved as desired. Another handicap in the way of export has been the cost of production of aluminium in the country which, so far, had been about 30 per cent higher than the price ruling in other countries. The high cost of production is chiefly due to small size plants. Tariff Commission in their 1960 report on the aluminium industry have indicated that for a 10,000 tons plant the cost of production of aluminium ingot is 18·04% higher than the c.i.f. price of imported aluminium ingot, while the aluminium sheets and circles do not need any tariff protection now. With 20,000 tons units going into production, the price of aluminium ingot may be quite competitive with regard to the imported aluminium. The manufacturing cost can further be reduced from a combination of the following measures :

(*i*) Increase in the existing ingot capacity of individual units to a capacity of 50,000 tons per year : It has been estimated that the difference in unit capital cost for 50,000 tons smelter (plus ancillaries) and a 20,000 tons plant may be of the order of 15 per cent.

Operating cost would also be correspondingly reduced.

(*ii*) Reduction in the cost of power : The cost of power is a major element in the cost of aluminium production as about 20/22,000 kWH is required for one ton of aluminium ingot. The present rate of power in India for the aluminium industry is as high as Rs. 165 per kW year as compared to Rs. 85 to Rs. 125 per kW year in other countries. The incidence of power alone comes to about Rs. 415 per ton of ingot. The aluminium industry may perhaps be given a preferential rate as this is a power-intensive industry.

(*iii*) Improved transport facilities and reduction in freight rates on raw materials : This question is being examined by the Ministry of Railways.

(*iv*) Application of one of the new processes of production of aluminium now under pilot-plant trials in other countries : Two main processes, viz., (*i*) reduction of Al_2O_3 by carbon and (*ii*) electrolysis of aluminium chloride directly obtained from bauxite, are under investigation. The latter will be more suitable under Indian conditions as chlorine is available as a by-product from the caustic soda plants and is expected to reduce the cost of production of aluminium appreciably.

It is, therefore, expected that with the units of 50,000 tons per year and other facilities made available to the industry, the cost of production should further go down and exports of aluminium semis/alloys and other products should be possible. In order to earn foreign exchange which would be required for import of other non-ferrous metals, exports of aluminium semis/alloys should be developed even with a slight amount of subsidy, in case the cost of production is higher than the world market prices.

Conclusions

Aluminium is finding new applications day by day and new techniques are being developed for manufacture of specialised products. Our vast raw material resources and the continuously rising demand justify a spectacular expansion of aluminium industry in the country. Our bauxite deposits could easily sustain a large aluminium industry of about 500,000 tons per annum for nearly 100 years. The bauxite deposits of Belgaum area and a large portion of Amarkantak region have not yet been earmarked for any particular project either in production or under implementation. Proposals to utilise these deposits are also being examined by the Government. So far a capacity of 82,500 tons has only been planned. As mentioned earlier, an internal consumption of about 85,000 tons per year may be reached by 1963 and our requirement for aluminium may increase to 130/150,000 tons by 1965-66, 275/300,000 tons by 1970-71 and about 500,000 tons by 1975-76.

In order to achieve self-sufficiency in the metal and to have some exportable surplus, it would be essential to increase the production of aluminium during the Third Five Year Plan substantially. A new unit from the time of its inception takes nearly four to five years before it comes into production. Steps should, therefore, be taken now to set up additional capacity for production of aluminium in the country by installing new units or by expansion of the existing plants. So far the trend in the industry has been to import the technical know-how for the installation of each new unit at the cost of considerable amount of foreign exchange. After having established four to five units, there appears to be justification to go on importing the know-how for the conventional type of processes. It is, therefore, strongly felt that steps should also be taken now to set up a design and training institute for the aluminium industry in the country.

DISCUSSIONS

Mr. K. D. Agarwal, Research and Development Orgn., Ministry of Defence, New Delhi: Aluminium and its alloys are of special significance to us. Simultaneously with the increased production of aluminium envisaged, all efforts should be made to make available the various aluminium and light metal alloys, especially in the form of bars, tubes, sheets, strips, powder, extruded, forged and wrought shapes and castings, required for armaments use and I would like to mention in brief some of the armament requirements as under :

1. Aluminium alloy based plates : These are used for mounting mortar barrels and should be capable of withstanding the impact when mortar is fired. When fabricated in a suitable aluminium alloy, e.g., a 24″ dia.

base plate, these will result in the saving of weight to the tune of about 25% compared with steel base plates weighing about 34 lb, which in turn offers a great advantage to a soldier in the field as his mobility will be greatly increased and fatigue reduced.

2. Thin walled and rigid aluminium alloy tubes are required for use in range finders, etc. to make the instrument light weight.

3. Extruded sections of aluminium alloys are required for tail units of mortar bombs, and for mass production, it is desirable that suitable sections are made available which will reduce the cost, will ease machining, and will be time saving.

4. In one design of high velocity missile, aluminium-zinc-magnesium alloy is used in the form of tubes of 59/32" outer dia. ×42/32" inner dia. ×3 ft long, mainly from the light weight and strength point of view. Such high strength aluminium alloy tubes should be developed.

5. Aluminium alloy cylinder blocks for water cooled engines, gear box casing, pistons, instrument panel boxes, rotary base junction castings, fans of approximately 30" dia. etc. are required for armoured fighting vehicles, engines, etc.

There is no doubt that with their availability in India, light metal alloys will find a much wider application in the field of armaments. At the moment, the designers and development men are handicapped to a great extent because the light alloys in various shapes and forms available for their use are very few. Naturally, where they could use light alloys conveniently, they have no other choice but to use other ferrous or non-ferrous alloys. The requirement on the other hand is to lighten the weapons and equipment by using light metal alloys wherever possible. It is, therefore, emphasised that various light metal alloys for armament use be developed in the country.

Dr. P. Dayal (Author): While assessing the future requirement of aluminium, the Development Wing of the Ministry of Commerce and Industry takes into account the demands of the various industries including those of Government Departments. As regards the indigenous manufacture of the aluminium alloy tubes for Range Finders, etc., special efforts have to be made to induce the industry to take up these items as the cost of production is high due to limited demand. One of the manufacturers has, however, agreed to produce these items.

Mr. G. S. Warrier, Alcan Asia Ltd., Calcutta: I must compliment Dr. Dayal for the excellent and thorough study he has made of the aluminium industry in India. The consumption of aluminium in the country has been rather restricted and, as a consequence, the aluminium production capacity has not increased. Due to several reasons, aluminium in India is much more expensive than in any other country in the world. The price of aluminium can be brought down only by increase in consumption in the country simultaneously with increase in the industrial production capacity. Both these are taking place but the increase in consumption is very much restricted due to lack of metal, artificial throttling of consumption by imposition of all kinds of duties, e.g., the excise duty imposed last year in addition to the heavy duties that are already there. These factors are not conducive to the fast growth of the industry. The Development Wing itself has revised the target of production of aluminium during the last one to one and a half years and I am of opinion that the target production by 1966 will not be achieved if consumption does not grow up quickly.

As regards the new process mentioned by Dr. Dayal, especially the aluminium chloride process circumventing the Bayer Process, I would like to mention that our group have put up the first plant in the world to produce aluminium by this revolutionary process. Even though the basic essentials of the process were known for a long time, a lot of work had to be done to make the process economic. The initial capacity of the plant being set up in Canada will be around 8,000 tons at a cost of about 12 million Canadian dollars. It is too premature to say definitely whether this process will be more economical than the conventional one.

Dr. P. Dayal (Author): The cost of production can be brought down only by increasing the capacity of the existing aluminium plants and by other suitable measures mentioned in the paper. As regards the imposition of excise duty, etc., I would like to mention that these come under the purview of the Finance Ministry and I understand that this question has already been discussed by the representatives of the aluminium industry with the Finance Minister.

Mr. K. K. Sarin, Planning Commission, New Delhi: I would like to compliment Dr. Dayal on his estimates regarding the future demand of aluminium. He has mentioned that the demand for aluminium by 1965–66 as estimated by the Development Council for non-ferrous metals in December 1959 will be 100,000 tons and according to the revised estimates of the Development Wing the demand is expected to be about 150,000 tons. Dr. Dayal has also indicated that taking into account the export possibilities and substitution of copper the capacity for aluminium may have to be increased to about 200,000 tons per year by 1965–66. In view of such divergent estimates regarding the future demand of aluminium, it would be more appropriate to study the demand industrywise instead of projecting the demand from the total consumption data. We have to identify the consuming industries in much more detail, determine the input of aluminium, i.e., consumption "norms" for each unit and relate them with the production targets as envisaged in the Five Year Plans and arrive at the total demand. This, I feel, will enable us to arrive at a realistic estimate of our future demands.

Dr. P. Dayal (Author): The details of the industry-wise requirement of aluminium are being worked out in the Development Wing. In this connection, I may mention that the Tariff Commission estimated six months back that the consumption of aluminium during 1960 would be 45,000 tons and 75,000 to 80,000 tons by 1963. When the demand for aluminium by 1965–66 was estimated at 100,000 tons in 1959 and at 150,000 tons six months later in 1960, no serious consideration was given to the substitution of copper and

other non-ferrous metals. In view of the lack of adequate resources of the other non-ferrous metals, particularly copper, the cable industry is being encouraged by the Government to change over to aluminium. Possibilities of export of aluminium ingots/semis/fabrications are also being examined in order to earn foreign exchange. In the light of the new observations the target for the production of aluminium may have to be revised upwards.

Mr. U. P. Mullick, Institution of Consulting Engineers, Calcutta: I would like to know whether the Government of India, especially the Railways and Transportation Department, have considered the question of increased use of aluminium and its alloys in railway wagons and coaches so that the "Tare" of the coaches and wagons can be reduced and the saving in load thereby could be used in handling more goods and passengers within the same train loads.

Considering the rich bauxite belt from Amarkantak up to Lohardaga, probably the heaviest single deposit in India, would not there be heavier concentration of aluminium plants in this area, subject to availability of power ?

Dr. P. Dayal (Author): It is understood that the Railways are examining the possibilities of building the wagons and coaches in aluminium and its alloys to increase the pay-load. As regards the bauxite deposits of Amarkantak area referred to by the speaker, a detailed survey of the bauxite deposits has yet to be made. A part of the area has already been taken up by Messrs Hindustan Aluminium Corporation for their smelter at Rihand (Uttar Pradesh). The supplies of bauxite from Lohardaga area are already feeding the smelters at Asansol (West Bengal) and Hirakud (Orissa). The question of concentration of a large capacity in one area, therefore, does not arise.