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GROWTH PATTERN OF IRON AND STEEL INDUSTRY IN INDIA'S ECONOMIC DEVELOPMENT

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SUMMARY

The current annual production of finished steel is just over 4 million tons in India. The growth pattern of Indian iron and steel industry from current production figures to a production capacity of over 20 million tons of crude steel at the end of the Fourth Five Year Plan, has been outlined stage by stage and rationally analysed. The individual expansion pattern of different steel Plants currently operating in India has also been outlined in relation to estimated requirements of finished steel by 1970 71.

Likewise, the growth pattern of foundry pig iron from the current production of just over a million tons a year to over 4 million tons annual capacity to be established by the end of the Fourth Five Year Plan, has been outlined whilst highlighting current shortfalls of foundry pig iron in the country.

The establishment and projected growth of alloy, tool, special and stainless steels industry in India have likewise been analysed in relation to its growth pattern to be followed till the end of the Fourth Five Year Plan. The estimated short term and long range requirements of the diverse ranges of ferro alloys to cater to the needs of the alloy, tool, special and stainless steel industry have been outlined in relation to Third and Fourth Five Year Plans including the financial implications of the ferro alloys' requirements.

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The role of Indian raw-materials such as iron ore and flux, their inherent shortcomings and optimum remedial, beneficiation treatments required have been discussed in relation to their indispensability in satisfying the growth pattern of Indian Iron and Steel Industry. The role of small foundry iron production plants has been specifically highlighted in relation to integrated iron and steel complexes in the background of Indian conditions and projected developments.

It has been shown that even though the iron and steel industry is highly capital intensive, it cannot be left to the vagaries of international trade both in times of peace and that of war to satisfy the almost unlimited applications of iron and steel product mix in light, medium and heavy engineering and consumer industries. The paper outlines the current planning of Indian iron and steel industry and its steady growth during the successive Five Year Plans to assist the country to attain the economic "take off" stage. Of necessity, such an upward growth of the basic heavy steel industry entails its inevitable toil and sweat, success and pitfalls and yet the ultimate objectives of attaining Indian self sufficiency in iron and steel industry is undisputed, provided however, metallurgical problems of the raw-materials, installation and maintenance of iron and steel plants at their peak operational efficiency are squarely faced and effectively overcome and not lost sight of in the mase of endless discussions and explanations.

INTRODUCTION

1. The hard core of long-term planning in India as embodied in our successive Five Year Plans has been the establishment of "heavy" industry in its diverse phases including the growth of integrated iron and steel complexes and net work of small plants based on resources of men and materials essentially indigenous. Whilst the capital outlay for the establishment of pillars of heavy industry and tandem growth of medium and light industries have followed certain characteristic patterns influenced by constraints imposed by our balance of payments and thereby based on friendly aid wherever possible, the reliance on capital fundamentally indigenous has been basic.

2. The main objectives of economic planning in India are to raise the standards of living of India's multitude, provision of adequate opportunities for the development of indigenous talent and economic industrial growth in the ultimate analyses on "ones own legs". These short term and long range purposeful, sustained and titanic economic planning and growth have not been without the inevitable toil and sweat and problems arising in the maze of rapidly expanding horizons of research and technology, of technical education and mass literacy and deepening challenges of war against poverty within and a foe beyond. Such then is the broad-based spectrum of the ancient and modern India; the ancient still standing true and majestic and the modern shimmering into industrial nationhood.

Modern Technology and Steel Production:

3. The impact of modern technological developments in the metallurgy of iron and steel production, has been square and ever-lasting on Indian iron and steel industry. The metallurgy of iron and steel is based on processes that have essentially remained unaltered in essence over the past century but have undergone spectacular changes in the scale of operations and efficient processing of raw materials and "refining" techniques based essentially on contemporary developments in engineering technology. It is now well established that iron and steel are basic to heavy industrialisation in any country. The problems that confront India are complex relating chiefly to difficulties of foreign exchange, raising of productivity potential, shortage of technical trained personnel and insular shortages of indigenous capital goods and maintenance spares. In spite of vast good grade iron ore proved reserves of

over 20,000 million tons, the heavy expansion of steel industry has revealed some basic deficiencies in the raw materials; high alumina contents and unfavourable Al_2O_3/SiO_2 ratio of Indian iron ores particularly in the ore fines aggravating by heavy monsoon rains, high ash contents of Indian metallurgical coals, shortage of steel-making quality limestone flux etc. are characteristic of the situation. The reserves of metallurgical coal are not only limited but also concentrated in eastern India and generally have high ash contents that make their expensive washing "a must". The basic steel making flux i.e. Indian limestones are exceedingly high in "insolubles" tending to change the "steel-making" into "slag-making" from a metallurgical "metaphor" to an undesirable reality. The conjoint ill-effects of such problems are obvious considered in the context that India's annual ingot steel production capacity which is now being expanded from 6 million to about 9-10 million tons at the end of the Third Five Year Plan (1965-66), is further projected to yield at the end of the Fourth Five Year Plan (1970-71) an annual production of 18 million tons of ingot steel necessitating the establishment of a steel-making capacity of 20-21 million tons a year, thereby yielding 13.6 - 14 million tons of finished and rolled steel products. These developments have been planned on the basis that at no time during the Third and Fourth Five Year Plans is there any possibility of supplies exceeding demands, despite the current emphasis on exports. A demand of 6.9 - 7 million tons per year of rolled and finished steel products at the end of Third Five Year Plan (1965-66) has been established corresponding to over 9 million tons of annual ingot steel production to be achieved on the basis of the following break-up:

Existing Steel Plants	Million tons per year (ingot steel)
Tata Iron and Steel Works	2
Indian Iron and Steel Works	1
Bhilai (Hindustan Steel Ltd.) (after current expansion in hand)	2.5
Rourkela (Hindustan Steel Ltd.) (after current expansion in hand)	1.8
Durgapur (Hindustan Steel Ltd.) (after current expansion in hand)	1.6
Miscellaneous small units	0.1
	9.0

The maximum actual output from the existing Plants and their current expansion plans under execution may yield 6.86-6.9 million tons per year of finished steel equivalent to over 9 million tons of ingot steel, provided the attainment of almost 100% production of the rated capacity, is physically achieved at the end of the Third Five Year Plan, which however in actual practice could be problematical. In these schemes, a million tons per year of ingot steel output from the projected Bokaro Steel Plant at the end of the Third Five Year Plan had to be excluded; the Third Plan had originally been planned to yield an ingot steel production of over 10 million tons per year during 1965-66 subject of course to actual steel production and installed capacity fully matching each other. Those Plans have now been supplemented by additional targets of about 6.75 million tons of rolled and finished steel to be accounted for at the end of the Fourth Five Year Plan (1970-71) corresponding to 8.8 million tons annually of ingot steel and adding up to a total of about 18 million tons of ingot steel per year, or about 13.6-14 million tons annually of finished rolled steel. These plans, formidable under Indian conditions of scanty capital goods, trained men and materials, yet dynamic judged by any yardstick, have to be fulfilled through expansion by the end of the Fourth Five Year Plan (1970-71) of production capacities on the following basis:

Steel Plants	Million tons /year ingot steel
Bhilai (Hindustan Steel Ltd.)	3.25
Durgapur (Hindustan Steel Ltd.)	3.0
Rourkela (Hindustan Steel Ltd.)	2.5
Tata Iron and Steel Works	3.0
Indian Iron and Steel Works	2.0
	13.75 m tons capacity of ingot steel

Actual ingot steel production to be physically obtained from the above Plants during 1970-71 may however be somewhat less than 13.75 million tons. To the above total, may be added 3 million tons a year of ingot steel production from the projected Bokaro Steel Plant decidedly to be established on the basis that an annual capacity of 4 to 4.5 million tonnes of ingot steel production for Bokaro Steel Plant would possibly have been created by 1970-71. Additionally the South Indian Iron and Steel Plant based on the use of Salem magnetite and Neyveli lignite may be expected to yield 0.5 million tons of ingot steel annually during the Fourth Five Year Plan. Even apart from the South Indian Steel Plant, an annual ingot steel production of 16.75 m. tons has thus been planned. To meet however, the projected figure of 18 million tons a year of ingot steel production by 1970-71, additional steel capacity would need to be set up, specifically more so, since to physically attain 18 million tons of ingot steel annual production, a production capacity fairly in excess thereof would be necessary on the premise that actual steel production and the rated capacity will not always and at least during the initial "teething" periods fully match each other. To meet these requirements, two additional Steel Plants at new locations currently under study would be established, each with an annual ingot steel capacity of 1.5 million tons; this would give an annual total of 19.75 or say about 20 million tons of crude steel production capacity projected by 1970-71. In this connection, the Hindustan Steel have started survey of the Bailadilla (Madhya Pradesh) Vishakapatnam belt whilst Government of India's noted Steel Consultants, Messrs. Dastur and Company are likewise actively surveying the Bellari (Andhra Pradesh) Hospet (Mysore) belt and Goa Coastal area for future Steel Plants to be set up during the Fourth Five Year Plan. These Steel Plants though designed for an initial annual production of 1.5 million tons of ingot steel by the end of the Fourth Five Year Plan, would also be capable of expansion to an annual capacity in each case of 3 - 4 million tons of crude steel. The establishment and growth of coastal Plants such as at Goa may also favourably consider the import of high grade metallurgical coking coal or coke to be balanced against the export of iron ore pellets made out of beneficiated iron ore fines from Goa mines at a price of about 12 dollars a ton. It is a welcome feature of current Indian planning that the establishment of new Steel Plants is distinctly more "raw materials-oriented" rather than solely "equipment oriented". Among the items to be produced in these Steel Plants, the flat products would predominate since the deficit is particularly noticeable in diverse flat products. The magnitude of planning and scale of operations, it would be appreciated, are truly titanic more so when the production has to be systematically rationalised and oriented to optimum end product mix based on advance yet comprehensive market surveys. Current thinking also favours the building up of stocks of say 1 - 1.5 million tons of steel by 1970-71 to withstand the strains of war and stresses of peace such planning is in conformity with the rationale of India's accelerated steel development plans so that India can not only hope eventually to become the "Workshop of the East" linking her exports of multitude end-products with assured physical supplies of home-made steel but would also attempt to regain the position she once had as the cheapest steel producer in the world.

Ambitious Planning and the Problems:

4. Before however, these plans can physically mature, complicated and difficult problems will have to be tackled, such as breaking new grounds in respect of raw materials' bases and their speedy development following the now well-established criterion that the raw materials will need optimum processing and sizing and possibly additional economic beneficiation treatments. The physical transport of raw materials by rail is one of the most formidable problems which can seriously stand in the way of economic planning particularly in attaining steel production targets. The shortage of technically trained man-power, skilled artisans and competent supervisory managerial personnel completes the picture, particularly when it is realized that the period of useful technical training can only be abridged marginally considered on its ultimate utility. These then are some of India's steel hopes and ambitions, physical difficulties and chronic shortages, which however unsurmountable at first sight, would need to be and are being effectively met and overcome as challenges to Indian ingenuity and skill. The serious intensity of the entire forward planning and current problems would be judged from the position that production of finished steel during 1962-63 was 3.9 million tons, a 100,000 tons less than the target. The 4.3 million tons target for 1963-64 may however, be achieved whilst production targets for subsequent years would suffer due to the delay in putting up the Bokaro Steel Plant for instance the target for 6.8 m. tons of finished steel for 1965-66 would be reduced by 900,000 tons owing to delay in putting up the projected Bokaro Steel Plant.

5. In the ultimate analysis, there may also be some adjustments necessary such as possible doubling up of Durgapur Steel Plant's annual capacity from 1.6 million tons of crude steel to 3.2 million tons by the end of the Fourth

Five Year Plan. It is also planned that Bokaro Steel Plant will be initially designed for an ultimate annual production capacity of 4 to 4.5 million tons and may attain an operational capacity of 3 million tons per year by the end of the Fourth Five Year Plan - to this could be added at lease 1.5 million tons /year from each of two proposed Steel Plants to be set up during the Fourth Five Year Plan, whilst the maximum planned capacity of these two new Steel Plants, other than the Bokaro Plant, would be 4 million tons per year of crude steel in each case.

6. Whilst the foregoing reviews the planning data, the role of research and development themes in Indian steel industry including long ranged study of Indian raw-materials for their exploitation by techniques conventional or higherto unknown, imposes additional yet welcome responsibilities on indigenous research talent - these aspects of advance planning are being effectively handled at the National Metallurgical Laboratory in the fields of raw-materials' beneficiation and processing, burden preparations based on sizing, classification, agglomeration and sintering etc. in relation to conventional and alternative iron and steel production techniques that are to-day the symbols of increased productivity and lowered operational and production costs.

7. Figures 1 and 2 show the map of India indicating the principal iron and steel production centres and resources of raw materials including projected Steel Plants as also the projected Alloy Steel Plants etc.

8. It would be only right to realistically introduce an urgent element of "realism" in the execution of our long range and short term Steel Plants based on closest possible co-ordination and urgent sense of responsibility at all levels of Projects' planning and their implementation; it is however, not always so easy in fast developing countries such as India wherein the multiple planned demands of a free human society are enormous indeed in their scope and still more so in their effective implementation. And yet the challenge must be met, clear and square by the free Indian Society.

Foundry Pig Iron

9. The current annual availability of foundry grades of pig iron is estimated at 1.1 million tons whilst the approximate present demand as estimated by trade bodies is of the order of 2.5 million tons per year - an earlier estimate of 2.0 million tons of foundry pig iron per year is based on 1.1

million tons for centrally listed foundries and 0.9 million tons for State list foundries. The available 1.1 million tons a year foundry pig iron is distributed in the following order: Steel Works maintenence 100,000 tons, railway sleepers 300,000 tons, spun pipe 187,000 tons, direct ordnance demands 60,000 tons, export promotion 50,000 tons, castings needed by Directorate General, Supplies and Disposals 50,000 tons, railway maintenance and other Government departments 50,000 tons, foundries engaged on Ordnance contracts 20,000 tons, Central list foundries 176,000 tons and State listed foundries 120,000 tons and reserve stock 7,000 tons.

Estimates and Planning

10. Whilst estimates made by different Indian industrial and trade bodies for total current requirements of foundry grades of pig iron and those projected at the end of the Third and Fourth Five Year Plans somewhat differ, it has been generally accepted that by the end of the Third Five Year Plan, the demand would be over 2.006 million tons per year and 3.462 to 4 million tons per year by the end of the Fourth Five Year Plan whilst the annual established capacity of foundry grade pig iron at the end of the Third Five Year Plan may not exceed 1.5 - 1.75 million tons thereby making imperative to raise an additional capacity of over 2 million tons per year of foundry iron chiefly during the Fourth Five Year Plan. The production capacity expected by the end of the Third Five Year Plan would be based on supplies from the existing plants and the small foundry iron plants for which several industrial licences have already been granted to account for 0.6 0.8 million tons annual output if all the licences are actually operated during the period, this would however, mean that an additional annual capacity of 2 million tons of foundry grades of iron would need to be established by the end of the Fourth Five Year Plan. The heavy shortfalls in foundry iron production figures to day and during consecutive Plan periods provide enough food for thought and action and a challenge indeed to be met. Whilst it may be that this shortfall has been inherited from one Plan to other, it is however, most necessary for us to break away from this "heritage". The estimate of 3.5 million tons of foundry iron made by National Council of Applied Economic Research for the end of the Fourth Five Year Plan is however now recognised as low and plans are underway to establish a capacity of 4 million tons of foundry iron annual output by 1970 71. The National Council of Applied Economic Research estimates are based on the following**.

** Reappraisal of Steel Demand, Vol.1, 1963, National Council of Applied Economic Research, New Delhi.

		Estimated Requirements	
		1963-66	1970-71
1.	Pig iron for iron castings including steel pipe fittings	1,377,000	2,232,900
2.	Pig iron for cast iron pipes and specials	628,900	1,229,000
	Total:	2,005,900	3,461,900

11. Current production figures for saleable pig iron during 1961 and 1962 are given in the following Table No.I[**]

Plant	1961	1962
Tata Iron and Steel Co.	20,868	21,112
Indian Iron and Steel Co.	267,873	204,298
Mysore Iron and Steel Works	9,934.	..
Rourkela (HSL) Plant	99,370	60,246
Bhilai (HSL) Plant	393,442	334,390
Durgapur (HSL) Plant	314,792	325,016
Kalinga Works (Barbil)	30,255	28,469
Total:	1,136,534	973,531

Alloy, tool, special and stainless steels:

12. Estimates for the requirements of alloy, tool, special and stainless steels have received due attention by Indian planners for establishment of requisite production capacity. The author had made some estimates way back in 1955-56 at the International Symposium organised by the National Metallurgical Laboratory on "Production, properties and applications of alloy and special steels" that the minimum requirements of the special alloy steels in relation to 10 million tons of mild and plain carbon rolled and structural steels per year would be at the very minimum 0.5 million tons which were adjudged distinctly to be on the lower side. It has been argued that if India were to take her rightful place in the comity of nations as a modern powerful and heavily industrialised republic, as justified by her mineral potential and resources, it was appropriate to err on the higher side of the estimates. It should not be overlooked that India can be potential exporter of alloy and special steels to South Eastern

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[**] Annual Report of the Ministry of Steel and Heavy Industries, 1962-63, Dept. of Iron and Steel.

Countries, East Asian and Far-Eastern Countries, where such specialised products should prove valuable bargaining counters for the import of material resources of which India is so short. As such, a target of a million tons of alloy, tool, special and stainless steels at the start of the Fourth Five Year Plan should be set. Since at the end of the Fourth Five Year Plan, a production target of 18 - 20 million tons of non-alloy steel is to be attained, corresponding annual target for alloy, tool, special and stainless steels would be 1.8 to 2 million tons and even this may prove to be somewhat on the lower side in the highly industrialized requirements of the era to come.

13. The following Table No.II gives a break-up of the alloy, tool, special and stainless steels estimates which form the basis of current planning till the end of the Fourth Five Year Plan.

TABLE NO.II

	Finished tonnages per year (tons)
a) Alloy constructional steel	250,000
b) Stainless and heat resisting steels	80,000
c) Electrical steel sheets	180,000
d) High speed steel, tool steel and die steel	86,000
e) Spring steel	134,000
f) Free cutting steel	200,000
g) Low alloy high strength steels	200,000
	1,130,000 tons

or say 1,130,000 corresponding to annual ingot production of 1.89 million tons.

14. At the same time, however, it has rightly been put forth that the production of low alloy high strength steels should be planned on integrated steelworks and not classified as special steels for the purpose of above estimates. On that basis, the estimates of alloy, tool, special and stainless steels to be established by the end of the Fourth Five Year Plan would be 990,000 tons of annual finished alloy steel output, equivalent to 1.55 million tons of ingot alloy steel output per year.

15. At the Durgapur Alloy Steel Plant of the Hindustan Steel Limited (Government of India), in the initial phase, 14,500 tons of tool steel, 25,000 tons of constructional steel; 18,000 tons of Stainless and heat resisting steel and 2,500 tons of other alloy steels - giving a total of 60,000 tons of finished steel, corresponding to a total of 100,000 tons of ingot alloy steels would be produced annually. Durgapur Alloy Steel Plant would ultimately be expanded to 300,000 tons per year when the product mix would be 25,000 tons of tool steel, 75,000 tons of constructional steels, 60,000 tons of stainless steels mainly in sheet form and 20,000 of other special steels, giving an annual total of 180,000 tons of finished alloy steel production. The production of substitute alloy, tool and stainless steels based on indigenous alloying elements will also be taken up at some of the alloy steel plants, such as of the nickel free austenitic stainless steels developed at the National Metallurgical Laboratory and other substitute compositions like 202 stainless series etc., Likewise, research and development themes on substitute tool steels, creep resistant alloys etc. are actively being pursued at the National Metallurgical Laboratory.

16. Mysore Iron and Steel Works at Bhadravati currently under conversion to an Alloy Steel Plant would annually produce about 70,000 tons of finished alloy constructional steels. Total tonnage of alloy steels for which Industrial Licences have been granted by the Government of India amounts to about 0.48 million tons output a year at present.

Ferro-alloys:

17. Estimates of demands of ferro-alloys have been drawn up on the basis of requirements for plain carbon mild and structural steels and separately for alloy, tool, special and stainless steels; so far as the requirements for the former are concerned, these would relate chiefly to ferro-manganese and ferro-silicon as follows:

Period	Annual ingot steel output	Ferro silicon tonnages needed annually	Ferro manganese needed annually
End of Third Five Year Plan	10 million tons	25,000 tons	125,000 tons
End of Fourth Five Year Plan	18, illion tons	45,000 tons	225,000 tons

a. Fe-Si grade would contain 75%

b. Approximately 25 lbs. of ferro-manganese needed per ton of steel

c. Approximately 5 lbs of Ferro-silicon needed per ton of steel.

Likewise, the estimated requirements of ferro-alloys for non-alloy iron and steel foundry requirements are given below:-

Demands for non-alloy iron and steel (plain carbon) foundry requirements

Ferro-manganese and Ferro-silicon

At the end of the Third Five Year Plan	Non alloy Iron Castings including malleable grade 2 m/ tons /yr and plain carbon steel castings 110,000 tons per year
Ferro-manganese	2,500 tons per year
Ferro-Silicon	1,500 tons per year
At the end of the Fourth Five Year Plan	Iron castings including malleable grade - 4 million tons / yr and steel castings 300,000 tons /yr.
Ferro-manganese	5,200 tons per year
Ferro-silicon	3,500 tons per year

	Requirements for ferro chrome for non-alloy iron and plain carbon steel foundry requirements
At the end of the Third Five Year Plan	950 tons /year
At the end of the Fourth Five Year Plan	2,000 tons /year

The above figures will include some quantities of ferro alloys needed for indigenous production of exo thermic compounds used in iron and steel foundries.

17.1 Consumption of other ferro alloys for non-alloy iron and plain carbon steel foundries, such as of ferro molybdenum, ferro-titanium etc. would be at best marginal in character and is omitted from these estimates. For ferro phosphorus, however, some provision could be made for the above applications viz., 300 tons and 550 tons by the end of the Third and Fourth Five Year Plans respectively.

17.2 The importance of the establishment of ferro alloy industry to feed the alloy, tool, special and stainless steel industry hardly needs to be emphasised when it is realised that to meet the annual requirements of 0.5 million tons a year of alloy, tool, special and stainless steels, the corresponding ferro-alloys requirements would be of the order of 120,000 to 125,000 tons per year, including special types of ferro-manganese but excluding all general purposes ferro manganese and ferro silicon needed for the production of plain carbon mild and structural steels.

17.3 It would, therefore, be appreciated that unless a ferro-alloy industry is now established, the requisite ferro alloys will have to be imported entailing tremendous foreign exchange expenditure, the estimated amount could well exceed Rs. 700 million a year to import the ferro alloys' requirements for a 0.5 million tons a year output of alloy steels to be provided for by the end of the Third and at the start of the Fourth Five Year Plans. It is felt that a ferro alloy plant capable of producing 25,000 tons of different grades of ferro alloys per year should be immediately set up and it should be increased in stepped up phases up to a capacity of 110,000 to 125,000 tons per year when the alloy steels' annual production would be expected to be of the order of 500,000 tons.

17.4 Excepting nickel, molybdenum and cobalt, resources of which hardly exist in India, all other ferro alloys can be produced from indigenous resources on an industrial scale provided requisite technical 'know how' suited to indigenous raw materials is readily developed. In this task of formulating indigenous technical 'know how' consistent with acceptable economics of production and requirements of quality output, the National Metallurgical Laboratory is now actively engaged both on laboratory as also pilot plant scale research investigations. With this basic objective of developing indigenous 'know how' for the production of diverse ranges of ferro alloys and for formulating electric smelting techniques for the indigenous ores, a pilot sub merged arc ferro alloy furnace was commissioned at the National Metallurgical Laboratory with a capacity of 1 - 2 tons of different types of ferro alloys output per day.

17.5 The author has given some estimates of the ferro alloy requirements for alloy, tool, special and stainless steel industry at the International Symposium organised by the National Metallurgical Laboratory in February 1962[1], excluding the requirements for plain carbon, mild and structural tonnage steels as follows:

TABLE III

Ferro alloys	Alloy, tool, special and stainless steels capacity 200,000 tons per year	Alloy, tool, special and stainless steels capacity 375,000 tons a year
	(tons/year approx)	
Ferro chrome (65% Cr)	26,000	50,000
Ferro silicon (50% Si)	7,000	15,000
Ferro-manganese (special grades)(75% Mn)	3,000	5,000
Electrolytic manganese (99% Mn)	3,500	6,000
Ferro tungsten (70% W)	2,500	5,000
Ferro molybdenum (70% Mo)	450	950
Ferro vanadium (50% V)	300	650
Others	500	1,000
Total:	43,250	84,600

17.6 Requirements of carbon-free ferro-alloys and alloying elements are given below. These estimates have been included in the above Table No.III for an annual output of 375,000 tons of alloy, tool, special and stainless steels per year.

TABLE IV

1.	Carbon free ferro chrome	1,000 tons
2.	Ferro-vanadium	650 "
3.	Ferro-titanium	200 "
4.	Ferro tungsten	5,000 "
5.	Ferro boron	50 "
6.	Ferro-zirconium	less than 50 "
7.	Chromium metal (95%)	100 "
8.	Manganese metal (95%)	100 "

9.	Ferro-chrome manganese	Regular demand of nitrogen bearing ferro chrome and nitrided manganese alloy will be established after the production of nickel free austenitic stainless steel has been initiated in the country on the basis of researches undertaken at the Nat.Met.Laboratory
10.	Ferro-molybdenum	950 tons

17.7 It would thus be seen that a clear scope exists for the production of carbon-free special ferro alloys by alumino-thermic reaction, to meet the requirements of the alloy steel industry. The demand will gradually increase to 10,000 tons a year or more when the annual production of alloy and special steels rises to 0.5 million tons.

17.8 The estimated requirements of different types of ferro-alloys including carbon free ferro-alloys as stated above are given in the Table V for respective estimated output of alloy, tool, special and stainless steels excluding the plain carbon mild and structural steels.

TABLE V

Ferro-alloys	Alloy, tool, special and stainless steels capacity 500,000 tons per year equivalent to present licensed capacity (Tons)	Alloy, Tool, special and stainless steels capacity 1 million tons per year at the end of the 3rd and start of the 4th Five Year Plans (Tons)	Alloy, Tool special and stainless steels capacity 1.8 - 2 million tons per year at the end of the 4th Five Year Plan (Tons)
Ferro-chrome (65% Cr)	70,000	14,000	260,000
Ferro-silicon (50% Si)	25,000	50,000	95,000
Ferro-manganese (special grade.)(75% Mn)	10,000	20,000	35,000
Electrolytic manganese (99% Mn)	8,000	16,000	30,000
Ferro-tungsten (70% W)	7,000	14,000	27,000
Ferro-molybdenum (70% Mo)	1,500	3,000	5,000
Ferro-vanadium (50% V)	1,000	2,000	3,000
Others	2,500	5,000	10,000
Total:	125,000	250,000	465,000

A more detailed and separately prepered estimate of the ferro alloys requirements including the total expenditure involved is given in Table No. VI.

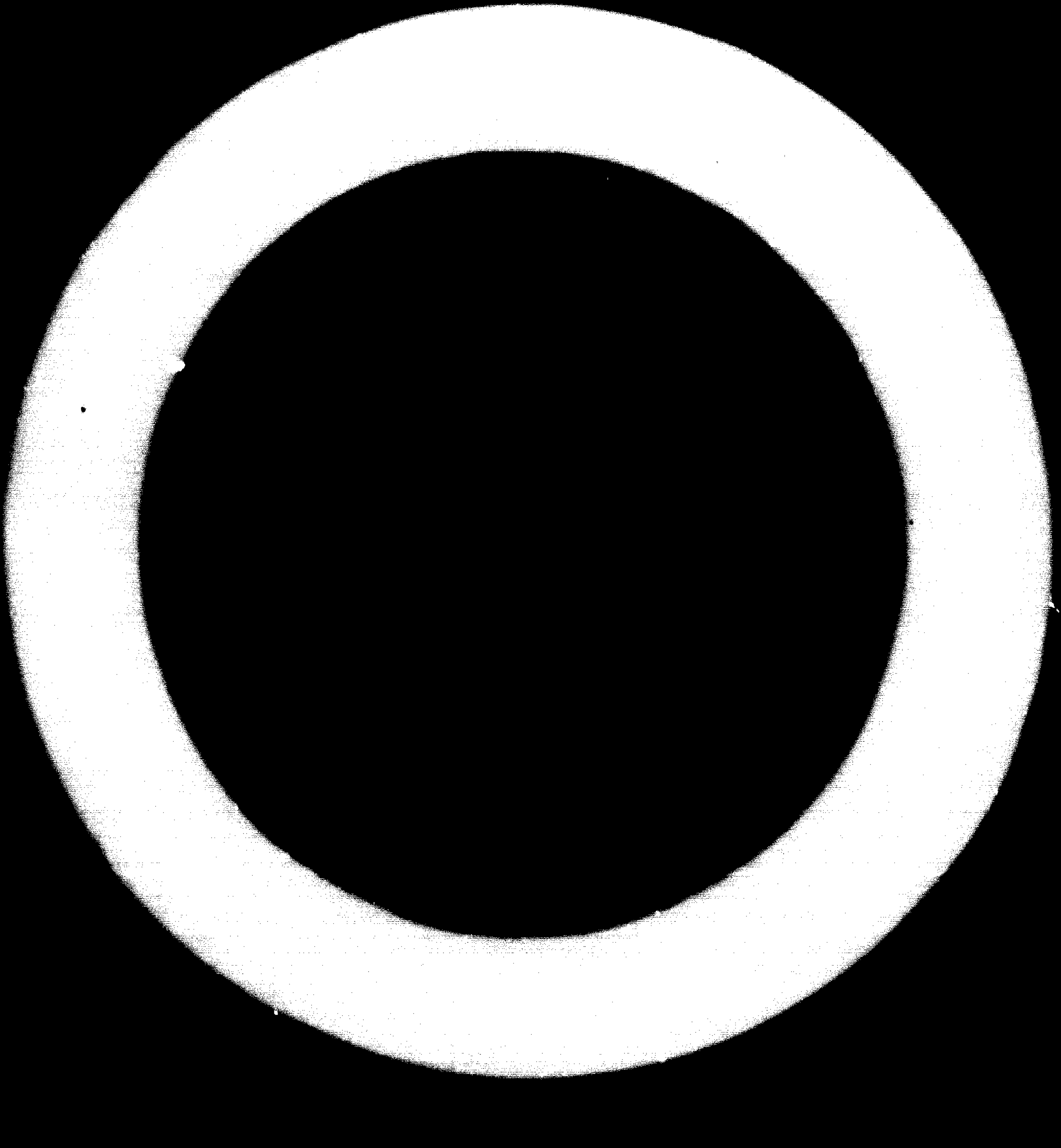
17.9 A pertinent query may be raised that whilst the projected plans for the development of alloy, tool, special and stainless steels and of ferro alloys have been outlined, what exactly is the current production of these materials in the country. Several Industrial Licences for the production of alloy, tool, special and stainless steels have been granted and most of the plants are in the process of feverish planning and establishment; as such, it would be difficult to precisely estimate current production of alloy and special steels - the position is rather fluid and rapidly changing. As such, exact present production estimates would not be plausible whilst it may safely be stated the production of alloy steels would be far below 0.1 million tons per year at the present stage of planning. So far as the ferro alloys are concerned, except for the production of different grades of ferro manganese and ferro - silicon as indicated in Table V, there is hardly any current production of other ferro alloys although industrial licences thereof have been granted by the Government of India.

Indian Raw Materials for Iron and Steel Industry:

18. The problems of an iron and steel industry inevitably and continually revolve around its basic raw materials, production techniques, operational skill, efficient plant maintenance etc. The basic raw materials for an iron and steel industry are iron ore, fuel, the fluxes, iron and steel scrap etc. In this review, references will be only made to Indian iron ores and steel making quality limestone flux since the position of Indian coal and coke is now well known over the last decade or two. For Indian iron ores and steel making quality flux, the metallurgical story has unfolded only during the last few years, indicating specifically their deficiencies and remedial measures absolutely essential; the impact of such revelations has been rather sudden but it goes to the credit of all concerned that the acceptance of remedial measures formulated on the basis of painstaking laboratory and pilot plant scale researches undertaken at the National Metallurgical Laboratory, has been equally quick. Details of these metallurgical research investigations and their economic implications were discussed at the last International Symposium on Iron and Steel making with special reference to Indian conditions held at the National Metallurgical Laboratory in February 1963[2].

Iron Ores:

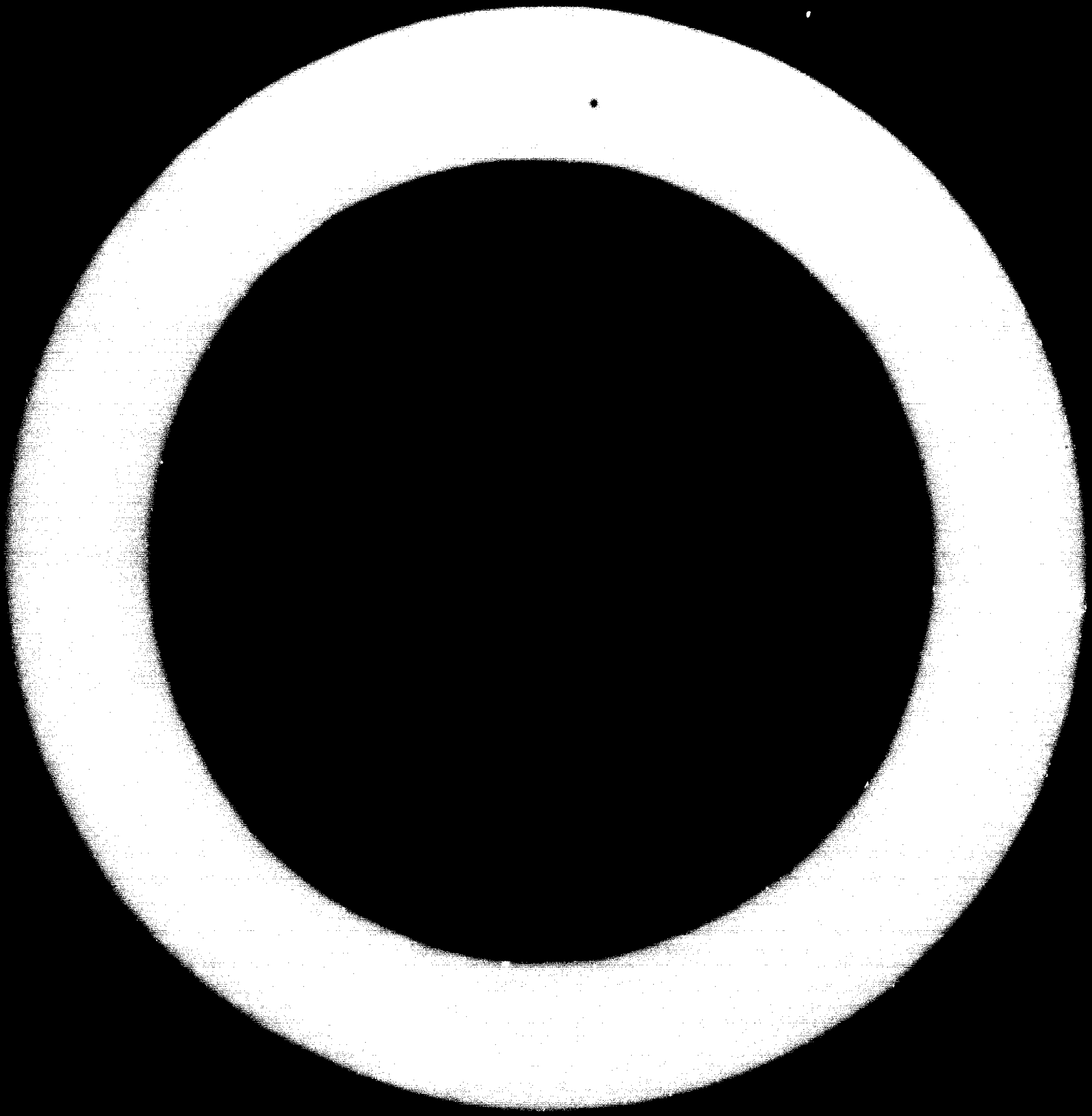
19. Despite somewhat opposing views, it has now been acknowledged in responsible quarters that Indian iron ores to be classified as one of the classic rich iron ores of the world may not be



TA

Ferro-Alloys	Price per/Ton	REQUIREMENT Of 100,000 T/yr of Special Steels	Of 375,000 T/yr of Special Steels
(A) To be Manufactured by Alumino thermic Process	0	1	2
1) Ferro-Vanadium(50%V)	40000 (Cont.V)	150	650
2) Carbon free Ferro-Chrome	4500	500	1000
3) Ferro-Titanium	3126	50	200
4) Ferro-Boron	9450	15	50
5) Ferro-Zirconium	2920	15	50
6) Chromium Metal	—	30	100
7) Manganese Metal	—	30	100
SUB-TOTAL		790	2150
(B) By Electro-Thermic Process			
1) Ferro-Chromium (High C) (65% Cr)	3000(Cont.Cr.)	4000	16000
2) Ferro-Chromium (LC) 65% Cr	4500(Cont.Cr.)	6000	25000
3) Ferro-Manganese (80% Mn) (LC)	4000(Cont.Mn)	850	3200
4) Ferro-Tungsten (70%W)	20000(Cont.W)	1300	5000
5) Ferro-Molybdenum (70%Mo)	23000(Cont.Mo)	250	950
SUB-TOTAL		12400	50150
(C) Being manufactured in the country			
1) Ferro-Silicon (50%)	1000	2600	15000
2) Ferro-Manganese (75%)	1000	800	3500
SUB-TOTAL		3400	18500
(D) Cannot possibly be manufactured. No Indigenous supply.			
1) Nickel Pallets (99.8%Ni)	8300	3000	11000
2) Cobalt Pallets (98%Co)	25000	25	80
SUB-TOTAL		3025	11080
(E) Electrolytic Manganese (95%Mn)		2500	6000
GRAND TOTAL		21115	87880

* (Estimates drawn up by the Ferro-alloys group based on current prices of ferro-all

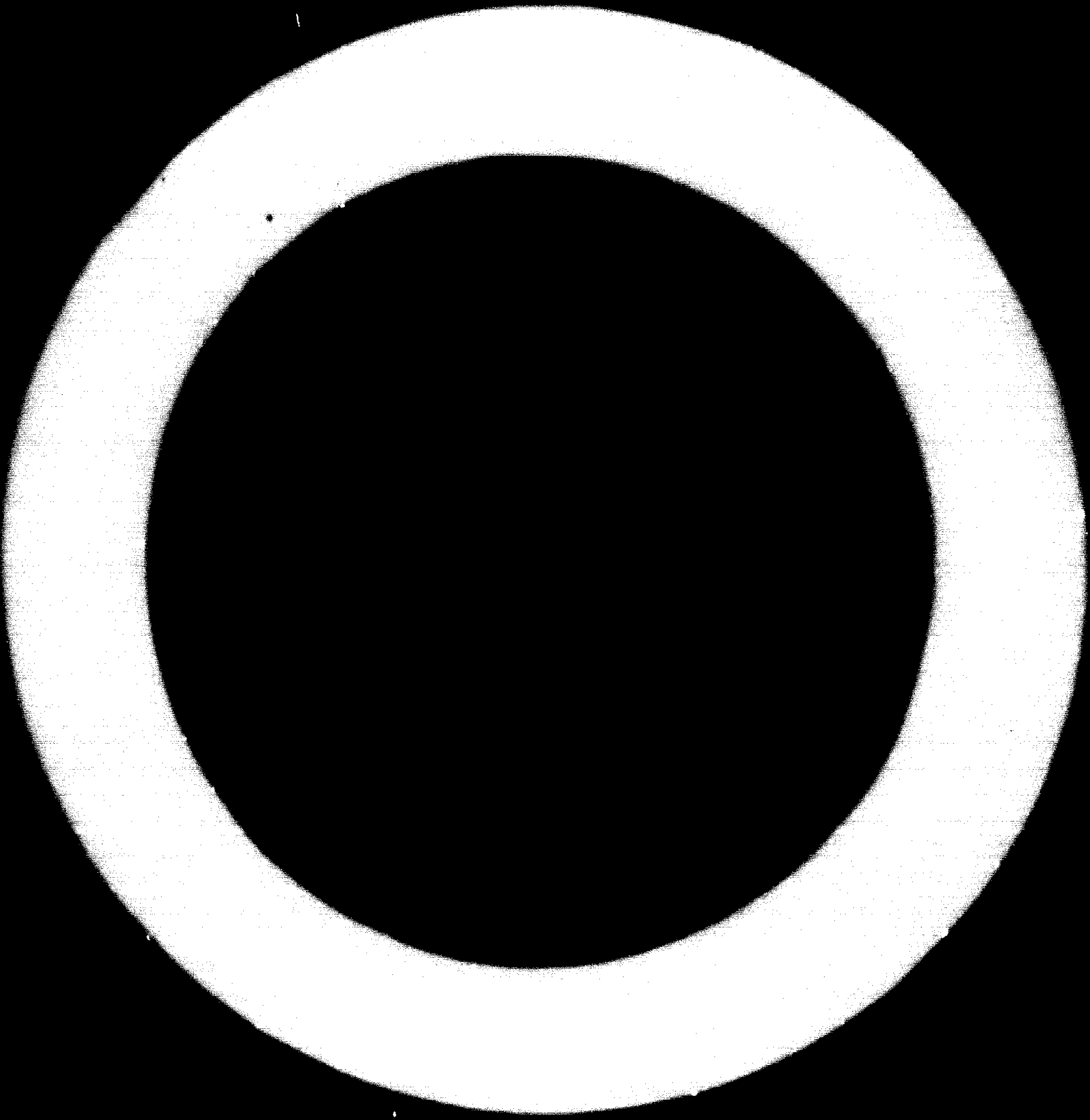


- VI

FERRO-ALLOYS

0,000 of Special Steels	Of million T/yr of Special Steels	Cost of Ferro-Alloys in Rupees Millions			
3	4	1	2	3	4
800	1500	3.000	13.000	16.000	30.000
1500	3000	2.250	4.500	6.750	13.500
300	500	.156	.625	.938	1.563
70	120	.142	.472	.662	1.134
70	130	.044	.146	.204	.379
140	250	—	—	—	—
140	250	—	—	—	—
3020	5750	5.592	18.743	24.554	46.576
24000	48000	7.800	31.200	46.800	93.600
36000	70000	17.550	73.125	105.300	204.750
4800	8500	2.720	10.240	15.360	27.200
7000	14000	18.200	70.000	98.000	196.000
1500	2500	4.025	15.295	24.150	40.250
73300	143000	50.295	199.860	289.610	561.800
25000	48000	2.600	15.000	25.000	48.000
5000	10000	.800	3.500	5.000	10.000
30000	58000	3.400	18.500	30.000	58.000
15000	30000	24.900	91.300	124.500	249.000
125	300	.625	2.000	3.125	7.500
15125	30300	25.525	93.300	127.625	256.500
8000	15000				
129445	252050	84.812	330.403	471.789	922.876

s)



wholly plausible in a strictly metallurgical sense. The metallurgical characteristics of a classic rich iron ore will basically depend on the nature and characteristics of the ingredients constituting its gangue and the latter's physical mode of distribution and structural association with metallic values of the ore and the gangue's selective presence in different ore size fractions. The gangue content of some of the Indian iron ores resides in the finer ore fractions such as in -1/2" which under the heavily mechanised iron ore mining conditions now introduced in India can constitute between 1/3rd to 1/2 of the total iron ore thus mechanically extracted. The full impact of the problem with which India is faced, with relating to the release, storage and utilisation of the masses of iron ore fines to be mined during our successive Five Year Plans will multiply to a magnitude that it will defy scientific solution unless adequate attention is focussed on this important subject and effective steps are introduced to utilise such iron ore fines. Table No.VII gives some data on the projected developments in iron ore requirements for home use and export.

20. The above classification is based on expected output of 40 - 41 million tons a year of iron ore for domestic consumption and 25 million tons a year for export by 1970-71. It is therefore stressed that utilisation of iron ore fines has to be rationally and comprehensively examined for exploitation of what would one day perhaps constitute the biggest national waste of assets and which no other country is likely to permit in view of the practical availability to-day of advanced technology for their utilisation.

Indian iron ore fines:

21. Utilisation of iron ore fines in India is complicated by the Indian weather conditions. The subject was quite simple when hand-mining was resorted to and selective mining yielded lump size iron ore materials from which the fines were discarded in situ. However, with the introduction of heavy mechanised mining, separation of the ore fines by manual methods from the lumps cannot be attempted or successfully accomplished. It is thus obvious that all the iron ore fines would thereby be sent to the ore handling and screening plant along with the lumpy material which can cause severe complications under Indian weather conditions of heavy tropical rain. It has been the experience in India of the Steel Plants that under Indian tropical weather conditions, the screening and the handling systems become completely blinded and choked due to the muddy conditions caused by the action of tropical rain on the admixture of iron ore fines with the lumpy material. It is in this context that the entire subject would have perhaps assumed somewhat less significance and importance, had it not caused serious difficulties and plant dislocations in ore handling and movement caused by blinding of the screens during heavy monsoon rainy

TABLE VII

PROJECTED DEVELOPMENTS IN IRON ORE REQUIREMENTS FOR HOME USE AND EXPORT

Year	Steel capacity installed	Iron ore require-ments for home use	Home consumption Approximate installed capacity at large mines (All figures in million tons per year)						For export Kiriburu and Bastar/Raipur, Bailadila, Goa, etc.
			Rourkela Barsua	Durgapur Bolani	Bhilai Rajhara	Misc. Various captive mines	IISCO Gua	Bokaro Largely Kiriburu and new mines Taldih, Meghahatuburu and Basanidih	
1960-61	6.00	9 to 10	2.00	1.00	2.00	3.10	2.00		3.40
1965-66	10.00	15.00 to 20.00	3.50	3.00	4.50	3.50	2.00	Up to 3.00 (from Kiriburu about 1.5 million tons fines)	12 million tons
1970-71	20.00	30.00 to 31.00	(Currently under detailed study for (formulating expansion plans					))	25.00 million tons

22. In the absence of suitable ore handling, screening and beneficiation methods to prevent the blinding of the screens, such as through wet screening and scrubbing the iron ore followed by dewatering classifier treatment (the slime containing at times upto 25 - 40% insolubles), a modern ore handling and screening plant involving capital outlay of several crores of rupees can be ultimately even though majestically brought to a stand-still. As such, the establishment and operation of a sinter production plant which naturally consumes these iron ore fines, is seriously hindered, if not altogether blocked. It is thus of paramount importance that all avenues should be explored (1) to separate the fines from the lumpy iron ore materials both in fair and rainy weather and (2) to utilize the iron ore fines thus separated to the maximum national advantage for home smelting. Comprehensive investigations have been undertaken at the National Metallurgical Laboratory on pilot plant beneficiation investigations on Bolani iron ores for Durgapur Steel Plant, Barsua iron ores for Rourkela, Kiriburu iron ores for the National Mineral Development Corporation, iron ores for the Tata Iron and Steel Works and Rajhara iron ores for Bhilai Steel Plant etc. Further investigations will cover iron ores from Bailadilla, Taldih, Sasungdah and other captive mines of Hindustan Steel Limited and of private sector Steel Plants in the country.

23. Perhaps the most important method of utilization of iron ore fines is the use of sinter including self-fluxing sinter. The use of sinter in iron smelting both of self-fluxing or non-fluxing is no longer a field merely of academic interest presenting any unusual features that are at least unknown. All the world over, iron production plants are operating with as much as in most cases 100% sinter charge with considerable increase in iron productivity based on low fuel rates. These sintering techniques utilize almost the entire iron ore fines released during mechanized mining and offer acceptable solution in two ways: one being the effective utilization of the iron ore fines which otherwise will present serious disposal and storage problems and the other, effectively increasing the metal iron output by extracting the metallic values of the ore fines involving reduced fuel rates through the medium of the sinter. It stands to reason that of 100 units of mechanized mined iron ore, if 40 units of iron ore fines are to be discarded, the cost of mining operation will be high. It is therefore necessary from considerations based on cost of mining alone to utilize these 40 units of iron ore fines by all possible techniques acceptable under Indian conditions of weather and operational facilities.

24. Even where ores of good quality are available, such as in the USSR, sinter production is resorted to ensure ores of uniform quality and yield a self-fluxing burden to theblast furnace. In the case of lumpy iron ores being fed into the blast furnaces in India during rainy season, considerable amount of iron ore fines tenaciously adhere to the ore lumps. If theseiron ore fines are removed from the lumpy material by simple treatment such as washing and scrubbing and wet screening, the lumpy iron ore materials would present to the blast furnace maximum burden permeability yielding increased productivity.

25. Research investigations undertaken by the National Metallurgical Laboratory during the last few years have undoubtedly aroused the interest of Indian iron and steel industry in not only fully appreciating the desirability but also the scientific necessity of adopting optimum beneficiation techniques in the context of Indian weather conditions coupled with characteristic nature and quality of Indian iron ores being exploited. It has been shown that a Sinter Plant operating with unbeneficiated iron ore fines will not yield the performance expected of it. This is distinctly apart from the position that even should it be possible to handle and screen natural iron ore fines in Indian rainy weather, the sinter produced from natural untreated iron ore fines will be metallurgically of little value in terms of increased iron productivity, lowered coke and flux rates apart from ensuring smooth and hanging-free furnace operations. It is not merely necessary to produce sinter at any cost and of any grade but in order to obtain from its use full iron output potential, it should be of a good metallurgical grade with distinct well established benefits arising through its application. It should also be borne in mind that it is necessary to incorporate return sinter fines in the sinter mix, which following also requisite additions of high-ash coke breeze will make the acid contents (alumina and silica combined) abnormally high in cyclic sinter feeds. Such successive incorporation of return sinter fines in the sinter mix made up of unbeneficiated ore fines, will continuously build up the acid contents of the sinter feed to an alarming extent which in cyclic operations will render the resulting self-fluxing sinter of poor physical strength and metallurgical value to be acceptable. These undesirable factors exercise cumulative deteriorating effects when the sinter plant goes into continuous production yielding weak, friable and poorly reducible sinters made out of unbeneficiated iron ore fines.

Limestone (Steel-making quality)

26. Limestone is the most important flux used in iron and steel-making. When the steel output in India was small, limestone with less than 5% insolubles could be obtained. With the heavy demands of the expanding iron and steel industry both in the public and private sectors on limestone, the quality of the latter has deteriorated rapidly with insolubles therein rising to 12 - 13% causing heavy deficiencies in the fluxing power of the limestone for steel-making turning it into "slag making" both literally as also metaphorically. Realizing the importance of the subject the National Metallurgical Laboratory has during the last few years undertaken series of investigations for optimum economic beneficiation and agglomeration of limestone for steel-making. For limestone to be used as metallurgical flux in steel-making, maximum availability of base CaO is necessary and for that purpose silica content of the limestone should be low so that its CaO base is not used up in fluxing its own silica at the expense of the acids arising out of the oxidation of metalloids in a steel-making bath, such as silica and P_2O_5 which have, of necessity to be fluxed into the slag. Limestone for use in steel-making should contain very low silica contents preferably of the order of 1 - 2%, even though the open-hearth grade Indian limestone is specified to contain not more than 6% acid insolubles, corresponding to about 7.5% total insolubles. The quality of the Indian limestones used in steel-making vis-a-vis their silica content is deteriorating and the insolubles in limestone for steel-making are now of the order of 12-15%. With these poor grades of limestone, production in the Steel Plants can be adversely affected apart from the operational difficulties arising, such as of poor heat-exchange between the furnace gases and the steel bath causing damage to the furnace roof thereby, high consumption of the limestone itself in order to meet flux needs of the acids resulting from the oxidation of metalloids, danger of reversion of phosphorus from slag to metal during steel-refining due to lack of stabilizing base in the slag and dangers of off-heats etc. The limy slag cover itself is a good heat insulation over the molten metal bath and with increase in its thickness, the inadequacy of effecting maximum heat-exchange so necessary in open-hearth steel-making, will become apparent causing loss of steel output and higher production costs, heavy maintenance expenses, etc.; the cumulative effects of these factors can be far more adverse than is fully realized. Limestone used for calcination to yield burnt lime is specified to contain a total of 10% acid insolubles corresponding to 12% total insolubles. The burnt lime is also used in the open-hearth steel-making to meet inevitable deficiences of the base CaO during

refining stages of open-hearth steel-making. If, however, through suitable limestone beneficiation, silica contents of the limestone can be reduced to about 2%, adequate CaO base would thus be available and as such, addition of burnt lime during steel-refining may not be necessary, which would naturally mean savings in the flux costs considering that the burnt lime costs approximately three times that of limestone.

27. The severity of the problem will be realized when the steel production in India, projected at 20 million tons of steel per year at the end of the Fourth Five Year Plan has to be physically attained - the contrast will become sharper with increasing deterioration in the quality of metallurgical grades of limestone and lack of its adequate indigenous resources. It would therefore be appreciated that beneficiation of limestone for steel-making will become a crucial metallurgical necessity, if not an absolute economic necessity. It has been argued that any industrial application of beneficiation techniques must be based on economic advantages thereby accruing. As such the beneficiation costs have to be adjudged in the ultimate analysis against the lowered consumption of the limestone flux, acceleration in steel-making following on increased reactivity of the up-graded limestone concentrate, reduced possibilities of off-grade steel heats and less damage to the furnace roof, etc. It will be difficult to straightaway evaluate the improved economics resulting from the use of beneficiated limestone at this stage even though there are clear indications thereto. It has been shown in these investigations that the up-graded limestones can be adequately pelletized without expensive binders and the pellets possess adequate strength for handling and providing necessary lime boil in open-hearth steel-making. An extremely well-equipped and fully integrated Mineral Beneficiation Pilot Plant is currently in full operation at the National Metallurgical Laboratory, with a capacity of treating upto 5 tons of a particular ore per hour depending upon its nature and concentrate needed, involving a capital outlay of Rs. 50 lakhs (about a million dollars) during the Third Five Year Plan.

28. The use of beneficiated limestone in iron-making in the blast furnace has not been taken up, even though increasingly high ash contents of Indian coke will require in turn additional quantities of the limestone flux. The limestone briquettes required for blast-furnace have to be exceedingly strong unless the upgraded limestone which is in the form of fines is directly used for making self-fluxing sinter. The reduction in silica content of the beneficiated limestone for use in iron production will have to be balanced against the high alumina contents of Indian blast-furnace slags requiring certain minimum silica values therein[3,4].

Small Foundry Iron Production Plants:

29. The importance of small Plants for iron production has been focussed by the National Metallurgical Laboratory through extensive Pilot Plant trials at its Low Shaft Furnace Pilot Plant; relevant technical results and recommendations were presented at the last International Symposium on "Iron and Steel-making with particular reference to Indian conditions" held at the National Metallurgical Laboratory[5,6,7]. The subject has also recently been aptly discussed and well presented by Dastur[3,4] and by Dowling and Whiting[8]. Sir Jehangir Ghandy in one of his Addresses[9] has also aptly presented the scope of small iron-making and steel Plants particularly under Indian conditions.

30. Several industrial licences have been granted for small foundry iron-making plants in the country based on regional utilization of raw-materials.

31. In most steel producing countries to-day, the flourishing of both big and small plants dispersed on the basis of raw-materials' regional distribution and transport facilities is often met with. Even in the United States, there are several small plants with an annual capacity of a few hundred thousand tons whilst integrated iron and steel complexes of over 6 million tons annual capacity do not exceed half a dozen. Likewise in Japan, new small foundry iron plants are currently being established, whilst there are a number of small plants successfully operating besides integrated iron and steel complexes embodying as if it were, the principle of "walking on both the legs". The small plants specifically cater to the regional requirements of premium quality iron production. The explanation that the small plants may be carry over from earlier days is only partly valid since new small plants are also being concurrently established. The parallel growth of integrated iron and steel complexes and small foundry iron plants is a step in the right direction both in advanced and under-developed countries. The total indigenous fabrication of such small plants in India to-day is a full-scale possibility and would encourage the growth in turn of related engineering industries. The growth of the small iron-making plants can be based on the use of surplus nut coke from integrated steel plants, or alternative fuels, such as low temperature carbonized coke or lignite coke made from Neyveli lignite in South India. The industrial scale production of low temperature coke (Kolsit) from Singareni non-coking coals has been well established by Regional Research Laboratory (Hyderabad) of the Council of Scientific and Industrial Research. In extended full-scale trials on iron smelting in the Low-Shaft Furnace Pilot Plant of the National Metallurgical Laboratory, Kolsit proved an ideal fuel for iron production - equally favourable results were achieved

with low temperature coke made from non-coking coals from the Bengal-Bihar basin. The low temperature coke is more reactive than the metallurgical nut coke which itself is an alternative sub-standard fuel for iron smelting. Foundry iron production through electric smelting is also feasible in India, as currently projected in Rajasthan and South India where optimum electric power rates are available. The above possibilities form the basis for the grant of industrial licences for foundry iron production in the Punjab, Andhra Pradesh, Rajasthan, Maharashtra (Western India), Goa and Orissa etc. whilst similar installations are being actively considered in Gujarat. Likewise, small foundry iron blast furnaces attached to the integrated Hindustan Steel Plants as "satellite" installations are also being currently considered. A small foundry blast furnace with the minimum of mechanisation of 100 tons daily output, with two-thirds of its cleansed gas bleeding and sand bed casting has been most successfully and economically operating in India at Barbil (Orissa) for the last several years, originally established with a capital outlay including housing and land, of about Rs. 250 per annual ton of iron. It would indeed be hard to put up a big blast furnace to-day for foundry iron production on identical capital outlay per annual ton of iron.

32. A modern high output giant blast furnace with all its latest ingenious and expensive auxiliaries, is intrinsically an highly capital intensive unit; more so, if its capacity is utilized merely to produce a relatively low cost, intermediate and crude product viz., foundry pig iron. Thus to utilize the giant blast furnace with its high initial capital investment and over-heads of heavy, integrated iron and steel complex for foundry iron-making may in most cases not be altogether acceptable on economic grounds; in the ultimate analysis, however, it would tantamount to producing a crude semi-finished product in a heavily capitalised integrated iron and steel complex, instead of giving the same crude semi-finished product its logical steel product-mix, which would thereby effectively ensure maximum capital returns and dividends on the heavy capital investment made. Thus, any foundry iron made in a heavy iron and steel complex would in most cases be at the expense of corresponding if not greater output of steel and its finished high premium product-mix, yielding thereby unfavourable capital returns. It is hardly necessary to indicate that integrated iron and steel bases are normally well balanced complexes. At the same time it is well-known to-day that blooming rolling-mill capacity is normally kept well in surplus in relation to iron and steel-making potential in a modern, integrated iron and steel plant; this flexibility would enable the operation of the blast

furnace plant exclusively on basic iron for steel-making. In this country, integrated steel plants have hitherto supplied the major foundry pig iron requirements of engineering industries. Prior to last World War II, however, the spread over of the demands of steel end-products did not follow any uniformly planned or steady patterns thereby making room for switching over of iron-making capacity from basic to foundry grades of pig iron. The situation has to-day undergone radical changes, amply justifying the stand that the responsibility for foundry iron-making should progressively and exclusively pass on to non-integrated blast furnaces.

33. World-wide trends in general favour the production of foundry iron in relatively smaller blast furnaces. In India, the reserves of metallurgical grade coking coals are extremely poor, estimated at about 1500 million tons[10]. The operations of big blast furnaces are dependent upon the use of optimum sized good grade metallurgical coke home made or imported. It is thus emphasized that big blast furnaces should be used for making only basic iron to be refined into steel and finally processed into specific product-mix, whilst the smelting of foundry iron ought to be undertaken in comparatively smaller blast furnaces which can operate on alternative Indian fuels referred to earlier. Such measures would be metallurgically feasible and economically acceptable and from the standpoint of highly scanty proved reserves of indigenous metallurgical fuels, perhaps offer the only solution both on short-term and long-range basis. The opportunity thus exists of bridging the present gap between the demand and supply of foundry grades of pig iron and of ensuring additional supplies for the future, independently of integrated iron and steel bases currently in operation or those planned.

34. India is a land of long distances involving heavy rail freight costs which can more than off-set any increase in the iron production costs in small regionally dispersed foundry iron-making units; the latter can well pattern the intandem growth of medium and light engineering industries region-wise, over a thousand miles away to the north and south of the major Indian integrated steel plants located to-day in the Bengal-Bihar-Madhya Pradesh belt. This then depicts the general Indian pattern of foundry iron-making in small plants in the broad spectrum covering the growth of iron and steel industry in India since the last World War. The subject has been critically discussed at different platforms in India and abroad by various authors[11,12] including the last International Symposium on "Iron and Steel-making with particular reference to Indian conditions" held at the National Metallurgical Laboratory in February 1963 and earlier in February 1959 on "Iron and Steel Industry in India".

Figure 3 shows the Low-Shaft Furnace Pilot Plant of the National Metallurgical Laboratory which has produced several thousand tons of foundry grades of pig iron from regional raw-materials from different parts of India since it went into operation in February 1959. The results obtained on the metallurgical feasibility and economic acceptability of iron smelting with regional raw-materials in the Low-Shaft Furnace Pilot Plant have been very valuable in determining the growth pattern of foundry iron production in small Plants.

Conclusions

35. Fast developing countries such as India have fully realized the importance of well-knit and integrated iron and steel bases to feed the chain-reaction growth of secondary and processing engineering industries that in turn form the backbone of consumer industries catering to the multitude needs of diverse products essential both in times of war and peace. Whilst the iron and steel industry is highly capital intensive, no country can afford to leave it to the vagaries of international trade. The rise of such an industrial developing economy in under-developed countries would however provide the basis subsequently of growth on "ones own legs" and not an alien superstructure based on the imports of iron and steel that is unlikely to withstand the stresses of peace and least of all the strains of war. The establishment of home iron and steel industry provides in the ultimate analysis a self sustaining economy to assist a fast developing country, such as India, to the stage of an economic "take-off".

36. Such growth pattern of iron and steel industry in India in her economic development Five Year Plans has not been without its inevitable tale of sweat and toil through which India is passing in its steady yet sure march in not only attaining self-sufficiency in iron and steel but also in her ultimate objective of becoming a leading iron and steel producing country in the world.

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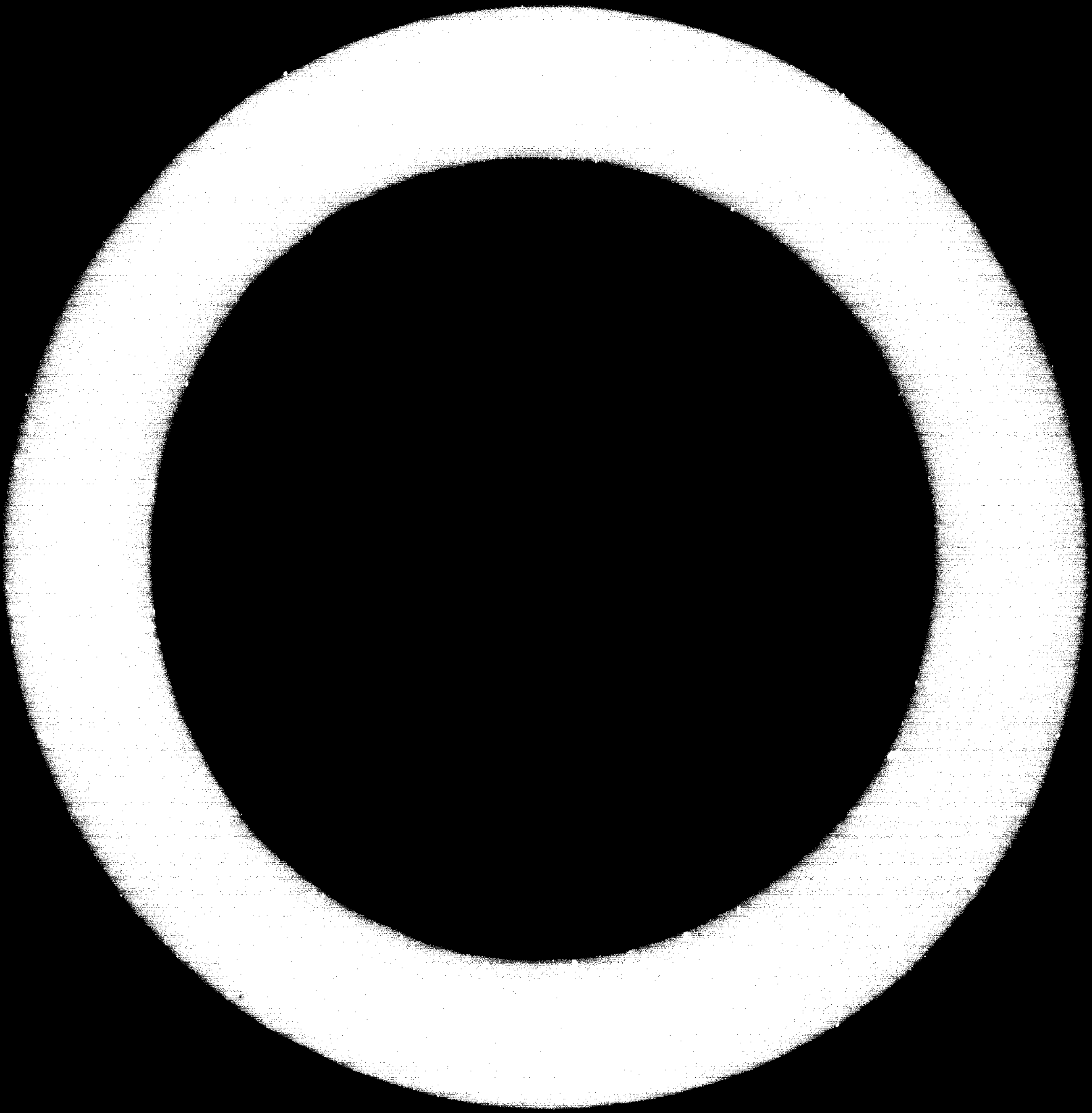
FIGURES



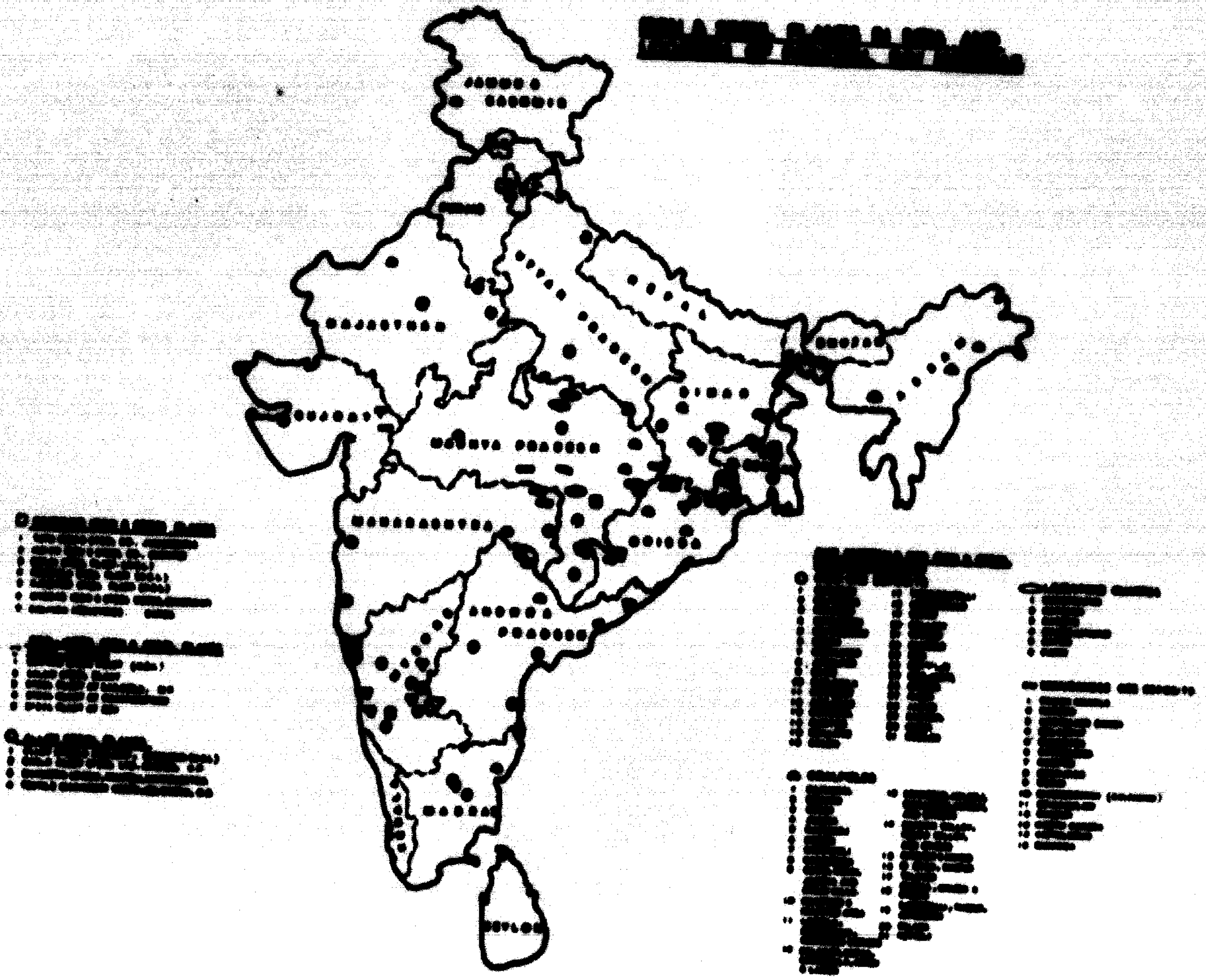
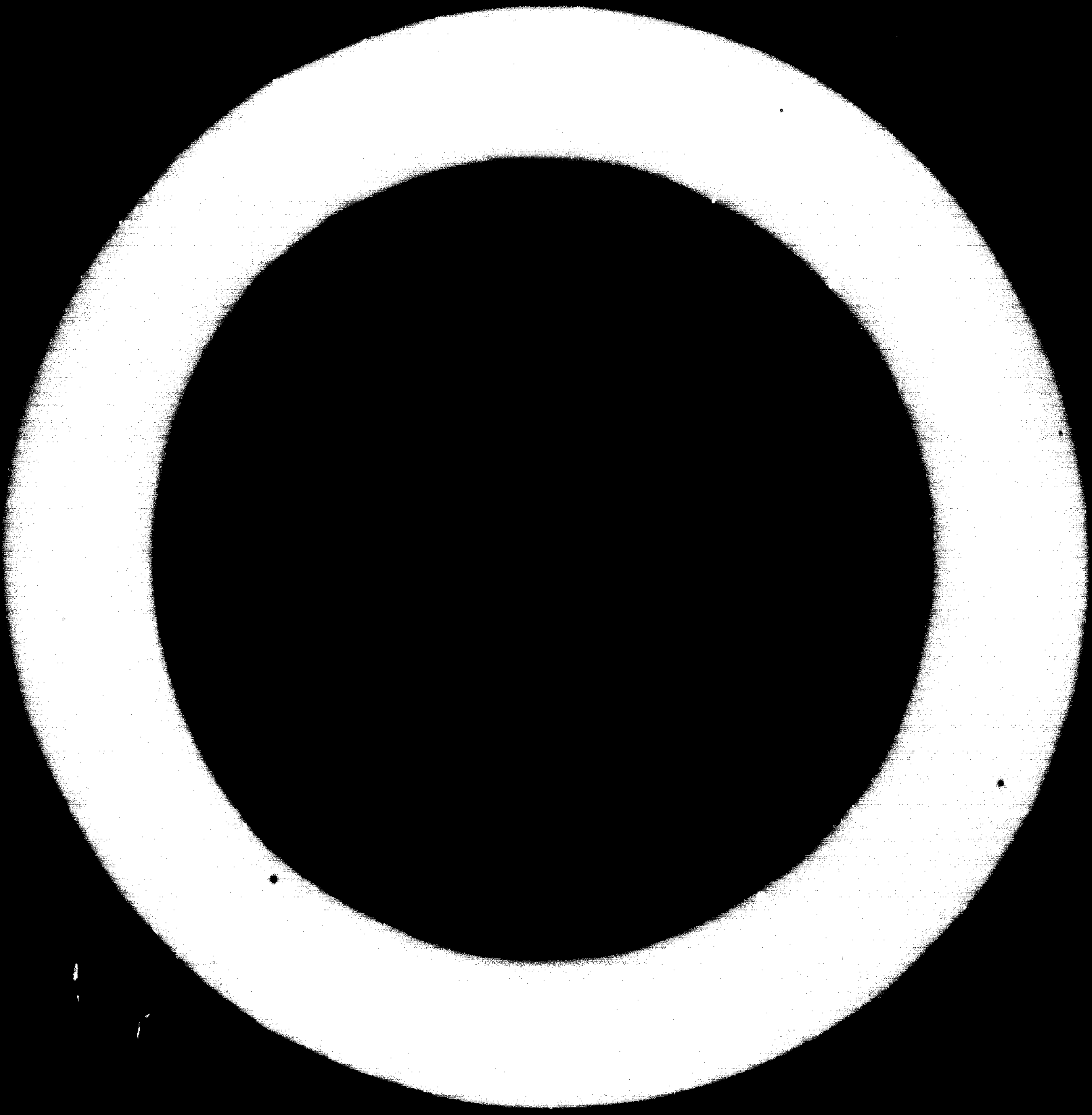
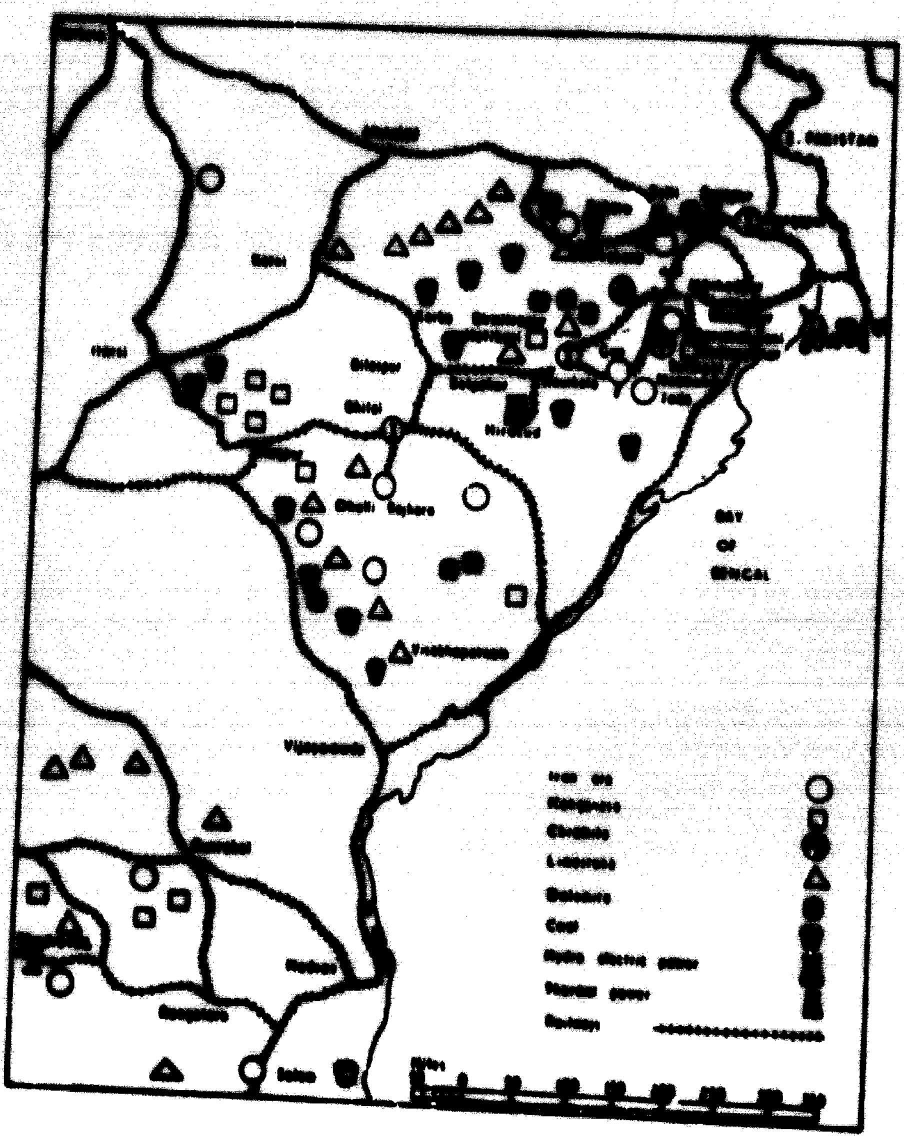


Fig.1

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BAY
OF
BENGAL
Vijayawada
Bangalore
Madras
Salem
Iron ore
Manganese
Chromite
Limestone
Dolomite
Coal
Hydro electric power
Thermal power
Railways
Miles

Fig.2

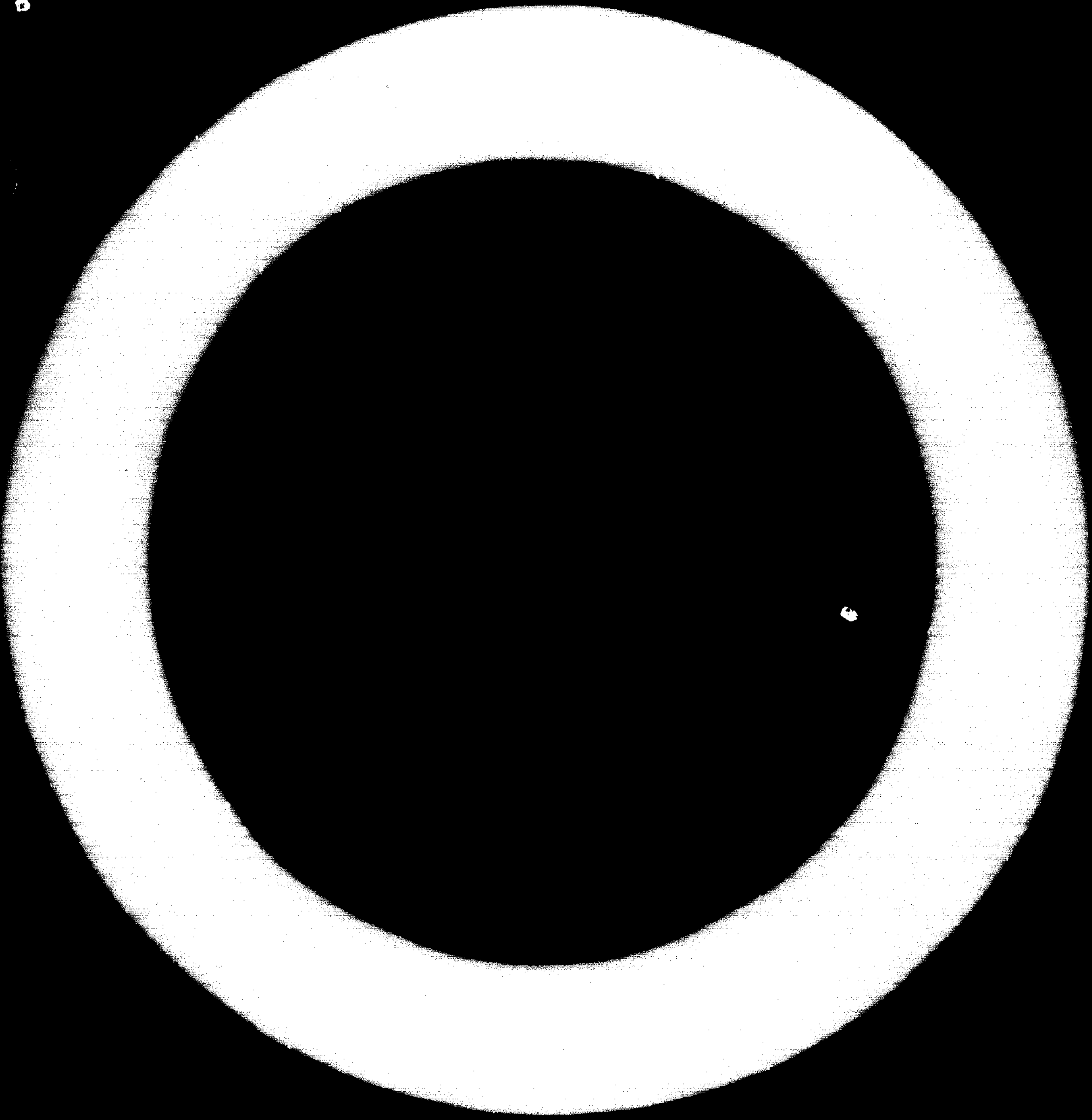
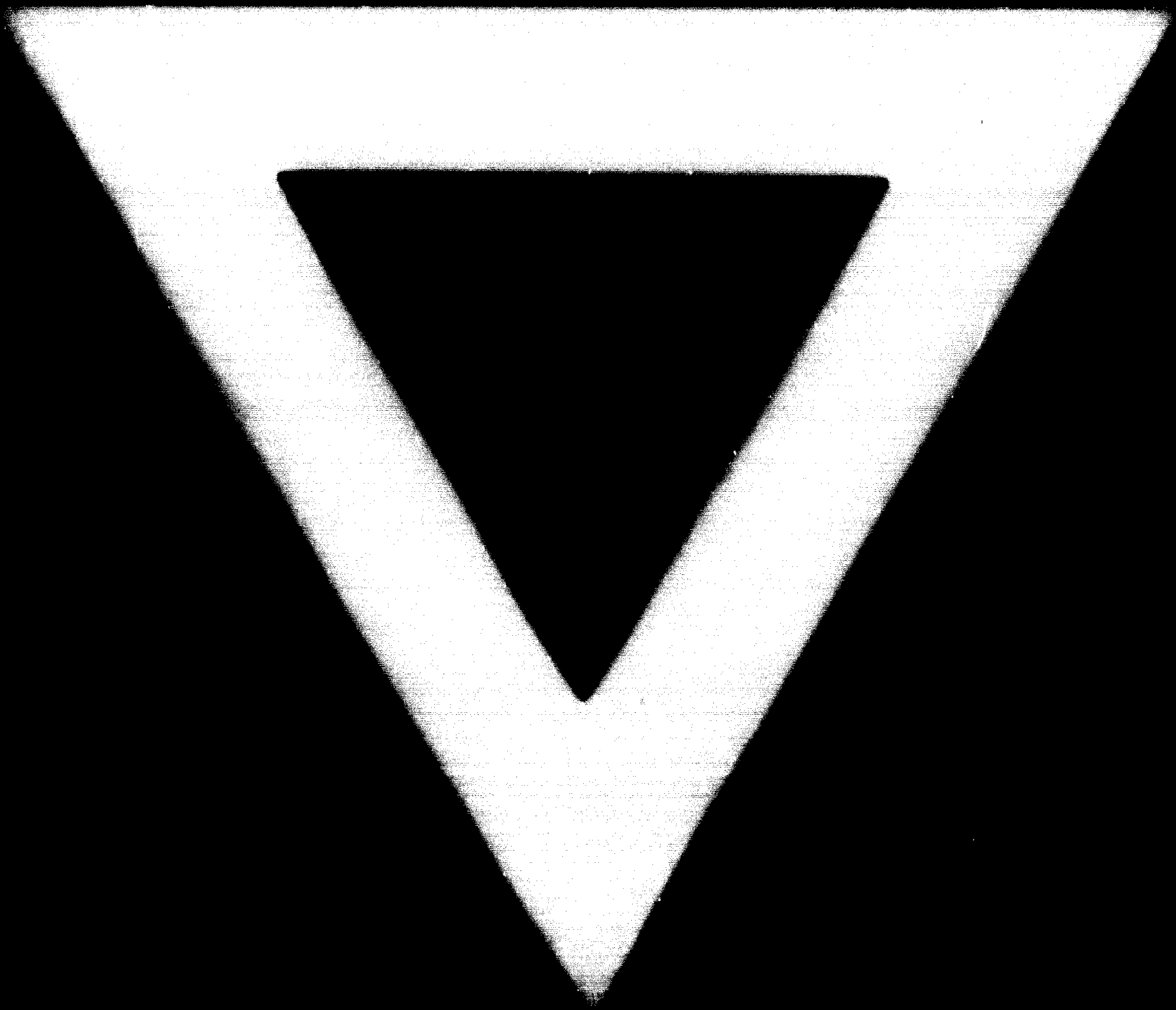


Fig.3: The Low-Shaft Furnace Pilot Plant of the National Metallurgical Laboratory.



8. 8. 74