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United Nations Industrial Development Organization

Distribution
LIMITED

ID/WG.14/62
2 August 1968

ORIGINAL: ENGLISH

Second Interregional Symposium
on the Iron and Steel Industry

Moscow, USSR, 19 September - 9 October 1968

D01338

THE IRON AND STEEL INDUSTRY AND INDUSTRIALIZATION OF THE DEVELOPING COUNTRIES 1/

by

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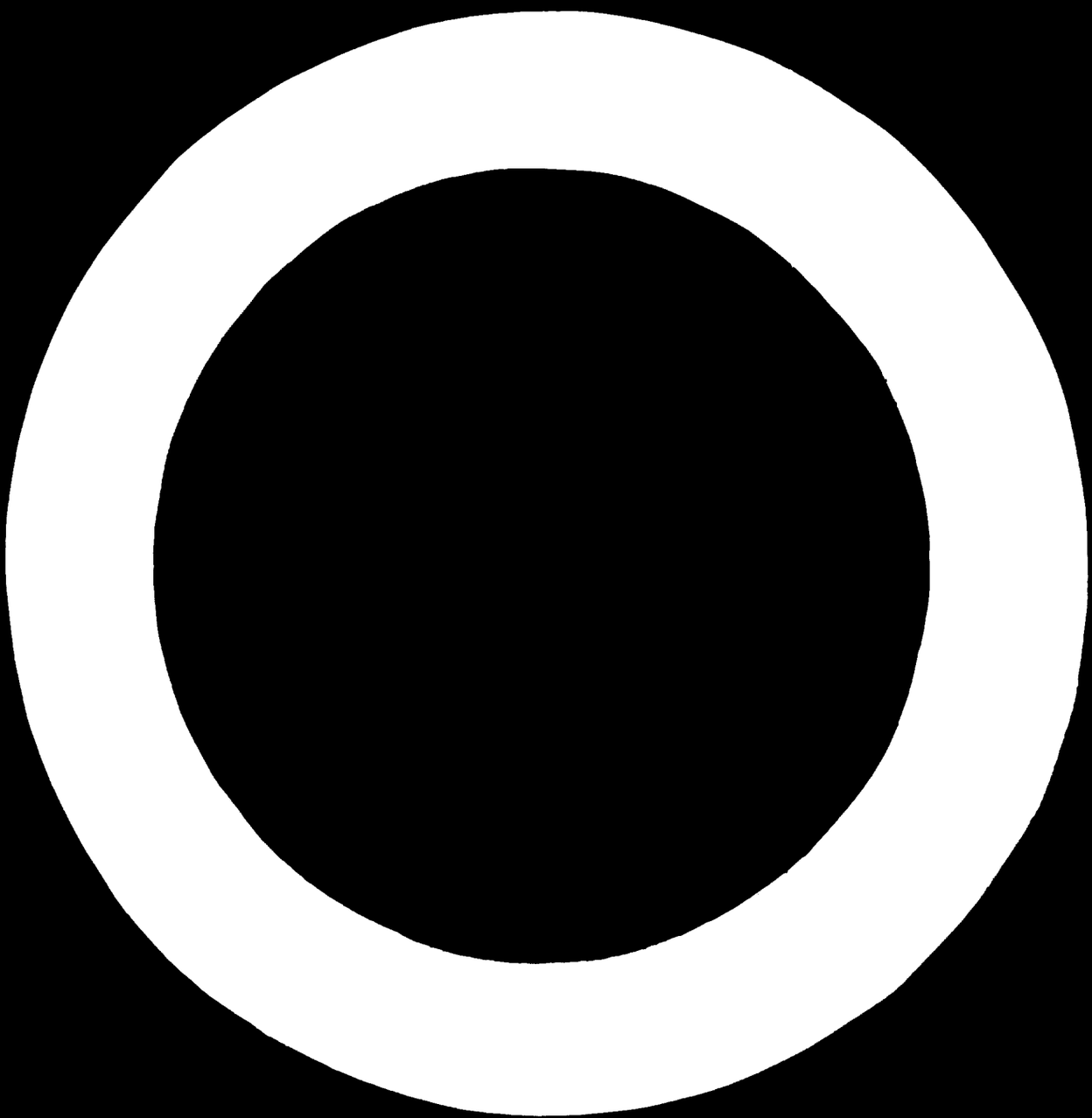
id. 68-2789



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SUMMARY

The role of an iron and steel industry in developing regions and countries in promoting economic growth in general and in catalysing the growth of iron and steel dependent light, medium and heavy engineering and consumer industries, has been referred to in this paper. The theme that establishment of an integrated iron and steel industry anywhere and more so in a developing country, requires specific parameters and prerequisites to be met, has been elaborated whilst the necessity of regional self-sufficiency in iron and steel end-products related to diversification of the steel industry, on non-integrated basis has equally been brought out. General statistical background data have been furnished on the subject.

References have been made to the role of raw-materials' processing including agglomeration, pelletising etc. of iron ores in general and their status in

* This is a summary of a paper issued under the same title as ID/WG.14/62.

developing countries in particular. Iron ores processing for home industry or export can be valuable foreign exchange saver and earner for developing countries and their establishment should be encouraged. Reference has been made to the cost of these operations vis-à-vis technological processes involved.

The important role of United Nations Industrial Development Organisation as an instrument for promoting the growth of iron and steel industry covering technical feasibility, pre-investment studies, economic appraisals and overall evaluations, has been discussed in this paper. Collaboration between UNIDO, Regional Commissions and related United Nations bodies, has been stressed for undertaking the above studies, as also for pursuing regional assessment of raw-materials' resources, market potentialities and optimum techno-economic integration required. The leverage effects of these projects levered through UNIDO assistance to developed countries, can go a long way in settling the thorny questions whether or not, a developing country or region should set up an integrated iron and steel industry or a net work of its constituent production facilities on reverse non-integration basis such as, the merchant and light section mill, cold mills for flat production etc. based on imported semis. Each case, however is important enough to be adjudged on its own techno-economic merits.

In some quarters, a view is tenaciously held and persistently advocated that the developing countries could import all their iron and steel market needs from advanced countries instead of endeavouring to be self-sufficient therein. The fallability of such a reasoning has been touched upon even apart from any emotional approach to the question of setting up of an iron and steel Plant in developing regions. The savings in foreign exchange resulting upon the home production of indigenous steel on integrated or non-integrated constituent basis, cannot be overlooked whilst the indigenous steel production costs should indeed lead to rational decisions. The process of such reasoning and of steel industry's growth in developing regions are of relatively recent origin by the chain reaction growth is very much in evidence today both in developing countries and those highly advanced. UNIDO's pivotal role in bringing the two together is important and has been fruitful since its recent formation whilst much more is hopefully projected in the years ahead.

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Introduction:

In the newly emerging nations and developing countries, the status of industrialization is measured apparently more by the magnitude of heavy industries growth rather than by the dispersal of medium and light engineering industries etc. catering to the needs of consumer industries. In the development of engineering heavy industries, the position of iron and steel industry is indeed unique since it measures up to the national and industrial prestige in owning a "basic" heavy industry and provides the essential semis to general engineering, structural and ancillary industries including in some cases ship building industry, automobile engineering and a host of related development projects.

Integrated Iron and Steel Industry is highly capital intensive - indigenous or imported, sustained by balanced application of the latest "technical know-how" in the background of continuous scientific and technological innovations taking place the world over, and maintained by thousands of workers, trained technicians and supervisors - technical and managerial - all devoted to the task of building the basic "Base" for engineering industrial complexes, essential in eras of peace and indispensable in times of war. Economic growth of advanced countries during the decades gone-by has followed the above dictum in the background of "produce or perish" - in a few cases irrespective of indigenous ore reserves and availability of requisite raw materials to feed the mighty Iron and Steel complexes, such as in the case of Japan which has built her steel industry from almost a scratch since the end of World War II to currently over 50 million tons of crude steel output a year, to be the third leading steel producing country of the world despite an almost total lack of indigenous raw-materials for iron and steel production; this achievement has been accomplished using raw materials almost wholly imported from countries far and wide thousands of miles away. In the case of advanced countries such as the USSR and the USA, the two giant steel producers of the world, indigenous raw materials reserves have more or less balanced the growth of their steel industry

supplemented in the case of the latter by imports of iron ores etc., raising the steel production curves to over 100 million tons a year mark; results of unceasing scientific researches into iron and steel production technology and applications of latest engineering technological innovations backed by ever increasing flow of capital financing, research ingenuity and human skill, have completed the picture of their gigantic economic growth and mighty industrial development. All countries have today realised the importance of well-knit heavy iron and steel bases to feed the chain reaction growth of secondary and processing engineering industries which have in tandem formed the sinews and framework for the consumer industries. Such integrated economic growth and development are the fruits that newly developing countries aspire to grow on home soils instead of importing them as "canned", and finished steel products and goods and of course, grow they must, if they have to meet the demands of reasonable living standards at home under the impact of increasing literacy and industrialization within and to survive the external international economic trade and competition without, whilst aiming at favourable trade balances in the overall economic growth.

The iron and steel industry anywhere cannot be left to the vagaries of international trade agreements and barter arrangements that tend to rise and fall in the background of world's political chess-board. This then forms the basis on which the growth of iron and steel industry in developing countries has been and rather should be planned with the objectives of achieving speedy self-sufficiency. It would be conceded that national growth of such dynamically planned industrial economy, despite acute shortages of trained specialists and capital funds, both indigenous and foreign, represents a growth "on one's own legs" and not necessarily on the crutches of imported merchandise and finished goods: this then forms the principle of the long range aims and short term objectives to attain self-sustaining growth leading to the economic "take off" stage. Various developing countries of the world are in different stages of the race towards speedy industrialization based on the establishment of home iron and steel industry. Such economic and industrial growth has not been without its tale of sweat and toil and yet there could be little doubt about the ultimate goal of self-sufficiency in iron and steel, provided the problems of establishment, growth and maintenance of the iron and steel industry at its peak operat-

ional efficiency are squarely faced and not lost sight of in the maze of vested interests and controversial endless discussions. The iron and steel industry of many developing countries presents a vast spectrum depicting various highlights of mundane difficulties and of national achievements which this paper seeks to analyse in order to illustrate the common problems, difficulties and objectives that confront the growth of their iron and steel industry and the development of ancillary engineering and consumer industries.

Iron and Steel Industry in Developing Countries

Whilst the basic factors interlinking the development of iron and steel industry relate in general to techno-economic evaluation and feasibility of the projects, the specific grounds and criteria for the promotion of steel industries in different developing countries varies over a wide context. In essence, for the establishment of iron and steel industry in developing countries and its continuous expansion in advanced countries, the following inherent factors are involved which need techno-economic appraisal -

a) The examination of the need for an iron and steel industry in a developing country - if it is justified considering the indigenous raw materials' resources and long range resources. For an iron and steel plant to be economically established and operated, the indigenous resources of raw materials should correspond to at least 20-25 years reserves and continuous supplies unless the industrial and economic development of the country is highly advanced which could warrant and support the Steel industry based wholly on imported raw materials such as in the case of Japan.

b) The study of market requirements for iron and steel products in a developing country and how such needs are currently met with (viz. through imports or home production). Survey of economics of market needs in relation to the fluctuations in demand within the developing regions. Studies on the development of home market in relation to possible exports and their continuous growth potential.

c) The status and standard of continuous geological and mineral exploration and proving of "economic mining" reserves in respect of their quality and metallurgical characteristics.

d) Study of specific parameters governing the location of a steel plant in a developing country and comparison of inland vis-à-vis coastal sites. Cost of transport of raw materials to the site and handling facilities at the two ends. The status of rail and road transport systems and their overall per ton-mile.

e) Choice of technology, alternative iron and steel-making processes and status of indigenous "technical know-how" available within a developing country for iron-making and steel production.

f) Size of an iron and steel plant. Feasibility and economics of integrated heavy steel industry vis-à-vis smaller steel plants. Study of governing factors in each case to determine the initial size of the plant in relation to its expansion possibilities and in-built growth potential over successive national developments plans.

g) Supply of capital plant and equipment both indigenous and import-based. A study of relevant capital cost structure of the Steel industry in relation to the availability of national capital finance and foreign exchange reserves supplemented by international bi-or multilateral aid, loans and/or critical analyses of these factors in relation to size of the plant will need to be done.

h) Study of turn-key and package deals vis-à-vis split-up contracts based on the maximum usage of home facilities. Erection and integrated operation of the iron and steel plants. Guarantees for the plant's in-built capacity for achieving rated production should be included.

i) Attainment of optimum conversion and comprehensive production costs for different product-mix bearing in mind the internal market and ruling export prices.

j) Steel plant's effective maintenance and supply of spares and extras should be ensured particularly for developing countries which would have to chiefly import them.

k) Manpower requirements for various units of the plant including supervisiory staff. Training of skilled labour, technicians and artisans for instrumentation and operational control should be provided for.

l) Survey of township, housing and auxiliary services, medical facilities and labour welfare units, etc.

m) The plant's main and utility services, such as water, gas, electric etc.; reclamation of water, each of these services will be integrated with a master plan for the plant's future expansion etc.

Following auxiliary factors will need to be studied for the iron and steel industry in developing countries:

i) Regional steel market surveys and their projections will need to be carried out well in advance.

ii) Apart from the creation of the home market and/or foreign export trade, how far does the growth of steel industry raise the G.N.P. and economic wealth of the country?

iii) How does the growth of the steel industry reduce the import bill of a developing country, promote import-substitution and affect its trade balances?

iv) The contribution of the steel industry to national programmes of economic and industrial development should be comprehensively studied.

It will need to be emphasized that in such techno-economic studies the last word would hardly have been said. The process of such appraisal of basic issues provides the base for industrialization plan of the developing country. Regional factors and needs of a particular developing country will differ from one area to the other. The importance and value of such inter-regional studies and surveys of basic themes cannot be over-emphasized. At the same time, the regional aspirations for iron and steel production cannot be altogether ignored, if not wholly accepted in terms of the developing country's resources of men, money and materials.

In examining these subjects, it is essential to study whether developing countries should meet their requirements of iron and steel products through an integrated heavy steel plant set up on an interregional basis for the inter-regional markets or should each region establish small steel production centres even if the latter do not meet the requisite techno-economic justifications. An illustration of this issue would be the need for an integrated steel plant for Maghreb in Africa vis-à-vis relatively smaller steel production units in each of the constituent African countries. An interregional steel industry would need the integration of regional market requirements and pooling of trade and capital resources - it would, however, be a step in the right direction.

Equally important it is to determine whether the steel industries of a

developing country should set up continuous highly automated and sophisticated mills or "jobbing" installations based on manual control and operations. Does the internal market of a developing country justify a most modern highly gadgeted remote control and high output mills or should a developing country install a less sophisticated and a rugged mill? The continuous mills are highly capital intensive but less labour intensive and hence judicious decisions will need to be taken whether the steel plant installations should be capital loaded or labour intensive depending upon the resources of capital finance, men and materials of a developing country.

National decisions would also need to be taken on the choice of technological processes such as for iron and steel production. Sometimes a developing country tends to gain the prestige lime-light by going in for a new process which has yet to establish its roots and acceptance in advanced countries, often with damaging results. It would thus be seen that the establishment of an iron and steel industry in a particular country is influenced by many factors and choice parameters. As such, no universal yardstick and overall rules can be formulated which can govern all eventualities. Business promotion factors can influence the choice of the plant equipment leading to heavy capital costs and making the plant operations uneconomic and loaded with heavy capital amortization and depreciation costs.

In the above background, the initial size and status of a steel plant's capacity would require careful examination. It is widely accepted that plants with a capacity of a million tons or more have advantages in capital investment cost per annual ton and comprehensive cost of production. Several countries subject to satisfactory raw materials' position so permitting, have therefore chosen to install plants of a million tons annual capacity or its multiples. In some cases, the initial steel output of a country is concentrated in one belt, encouraging further concentration of secondary and auxiliary industry in the same area and region. It may be necessary to examine the installation of somewhat smaller integrated iron and steel works, more evenly dispersed, if it could be established that the price of such decentralisation is not too heavy. This is not disputing the fact that the larger the scale of operations, the lower would be the cost per annual ton of steel output and less the production costs. However, there are plants operating in Tunisia, India and several other

countries where small yet integrated plants of 100,000 tons/year have now been successfully operating at a capital cost per annual ton identical to that associated with the large plant and sometimes even lower considering that the smaller plants have much lower overheads and do not have to establish and maintain heavy and expensive overheads including large townships, education, social welfare and medical hospital facilities etc. which have mostly to be set up by the steel plants themselves and operate them as well at considerable cost in diversification of efforts. It is obvious that a full range of end products cannot be rolled in a smaller plant as initially installed. It may, therefore, be necessary that in the first stages for example, the end-products should be limited to small diameter rods (10-16mm) and light section materials up to about 80 mm. At later stages of development, the plant can be equipped to produce medium sections range and all merchant sections for the internal market and regional countries. However, a small plant will not be in a position to roll heavy structural sections and flat products which necessarily have to be made in medium and heavy steel plants since the capital cost of heavy mills required to produce heavy sections and flat products, cannot be justified unless these mills get heavy tonnages throughout the year. The small plants may be considered for developing countries in their early industrial development plans to meet their internal market needs and additionally to provide the training ground of technicians, artisans and skilled workers and steel plant operators which can in the later stages of industrial development plans of the country, provide the operational basis for big or integrated steel plants. A network of such small plants would allow industrial and social developments over much wider areas, each area accumulating secondary industry and generally raising the living standards over larger regions in relation to the case where steel production is concentrated in one heavy plant and in a particular belt. These criteria are important are important for developing countries. Furthermore, such regional small plants, by virtue of their drawing on local raw materials and equally so feeding the regional markets would minimise the heavy demands on rail, road and communication systems and which in developing countries either do not measure up to the task or are acutely strained in the background of chain reaction shortage of capital investment for rail systems, rolling stock etc. The plans for an integrated plant having e.g. an output of 1 M.000 tons per year should include full provisions for doubling its capacity; such a unit plant can include

a blast furnace for iron-making followed by LD steel-making unit along with a merchant bar mill. An integrated plant of this type has been constructed at El Fouladh in Tunisia. The comparative cost of production has been estimated at 13/5 pounds per ton for a 100,000 ton plant and 15/5 pounds per ton for a million tons per annum integrated plant. During the three years, 1963, 1964, 1965, twelve medium sized Steel Plants have been exported from the UK (these cost between 0.1 million to two million pounds) to India, Spain, Bulgaria, Colombia, China, Yugoslavia, Venezuela, Turkey and Saudi Arabia - the total value of these exports was over 5 million pounds.

Some developing countries, despite an exceedingly poor internal market demand, aspire for an integrated steel plant of nothing less than a million tons annual capacity; the justification for the latter is furthermore greatly offset by the high steel production cost figures and the inability to compete in the international export markets thereby in the absence of an internal home market.

It would be of interest for them to note that in the USA, the following Steel Plants have less than 20,000 net tons annual capacity and this is the optimum size of a steel Plant which currently could be justified on techno-economic grounds for many of the developing countries.

Table 1

Steel plants in the United States with less than 200,000 net tons annual capacity

Company & Location	Hot Metal	Approx. Raw Steel Annual Capacity NT	Continuous Casting	Date Installed	Continuous Casting Capacity	Product Hot Rolled & Rebars
Allison Steel Mfg. Co. Tempe, Arizona	3-20 ton EF	150,000	No	—	—	Reinforcing bars
Armco Steel Corp. Sand Springs Works Tulsa, Okla.	1-70 ton EF	140,000	Yes- Demag	1965	140,000	Hot rolled & rebars
Border Steel Rolling Mills, El Paso, Texas	2-25 ton EF	140,000	No	—	—	Hot rolled & rebars
Calumet Steel Div. Borg-Warner Chicago Heights, Ill.	2-30 ton EF	180,000	Yes- Koppers	1967	180,000	Hot rolled bars structural and special shapes
Connors Steel Div., H. K. Porter Birmingham, Alabama	3-20 ton EF	200,000	Yes- Koppers	1964	200,000	Structurals & merchant bars
Huntington, W. Va.	2-30 ton EF	150,000	No	—	—	
Etiwanda Steel Producers Etiwanda, California	2-15 ton EF	90,000	Yes- United	1967	100,000	Hot rolled bars & rods and rebars
Florida Steel Corp. Tampa, Florida	1-75 ton EF 2-15 ton EF	200,000	Yes- Concast	1965	200,000	Hot rolled bars and structurals
Croft, N. C.	1-25 ton 1-15 ton	100,000	No	—	—	
Georgetown Steel Corp. Georgetown, S. C.	2-35 ton EF	200,000	Yes- Concast	1969	75,000	Wire rods and hot rolled
Harrisburg Steel Co. Harrisburg, Pa.	3-50 ton OH	80,000	No	—	—	Forging Blooms
Hawaiian Western Steel Ltd. Ewa, Hawaii	1-15 ton EF	50,000	No	—	—	Hot rolled & rebars
Intercoastal Steel Corp. Norfolk, Virginia	1-20 ton EF	90,000	No	—	—	Hot rolled and reinforcing bars
Judson Steel Corp. Emeryville, California	3-50 OH	80,000	No	—	—	Hot rolled & rebars
Kankakee Electric Steel Kankakee, Illinois	1-15 ton EF	70,000	No	—	—	Hot rolled & rebars
Kentucky Electric Steel Coulton, Kentucky	2-15 ton EF	140,000	No	—	—	Structurals and merchant bars
Knoxville Iron Co. Knoxville, Tennessee	2-10 ton EF 1-25 ton	100,000	No	—	—	Hot rolled & rebars

Table 1 (continued)

Company & Location	Hot Metal	Approx. Raw Steel Annual Capacity, NT	Continuous Casting	Date Installed	Continuous Casting Capacity	Product Hot Rolled & Rebars
LeTourneau, Inc. Longview, Texas	4-27 ton EF	250,000	No	—	—	Slabs and plate
Mississippi Steel Corp. Jackson, Mississippi	2-10 ton EF	50,000	No	—	—	Hot rolled & rebars
North Star Steel Co. St. Paul, Minnesota	1-50 ton EF	100,000	Yes - Concast Eng.	1967	100,000	Hot rolled & rebars
Northwest Steel Rolling Mills, Inc. Seattle, Washington	1-30 ton EF	100,000	No	—	—	Hot rolled & rebars
Oregon Steel Mills Portland, Oregon	3-20 ton EF	200,000	Pressure casting	1970	—	Hot rolled bars, plate
Owen Electric Steel Co. Owen, S. C.	NA	NA	No	—	—	Hot rolled & rebars
Pollak Steel Co. Marion, Ohio	1-30 ton EF	100,000	Yes - Olsson Western Gear	1958	100,000	Hot rolled & rebars
Roanoke Electric Steel Roanoke, Va.	1-12 ton EF 2-25 ton	100,000	Yes - Babcock & Wilcox	1962	100,000	Hot rolled & rebars
Republic Steel Corp. North Tonawanda, N.Y.	2-25 ton EF	140,000	Yes - Koppers	1964	140,000	Hot rolled & wire rods
Soule Steel Company San Francisco, Calif.	1-15 ton EF	60,000	Yes - Concast	1965	60,000	Hot rolled & rebars
Southern Electric Steel Birmingham, Alabama	2-14 ton EF	120,000	No	—	—	Hot rolled & rebars
Southwest Steel Rolling Mills, Inc. Los Angeles, California	2-15 ton EF 1-35 ton	150,000	No	—	—	Hot rolled & rebars
Structural Metals, Inc. Seguin, Texas	2-25 ton EF	50,000	No	—	—	Hot rolled & rebars
Tennessee Forging Steel Harriman, Tennessee	1-20 ton EF	70,000	Yes - Tenn. Forging Steel	1967	70,000	Hot rolled & rebars
Texas Steel Co. Fort Worth, Texas	1-25 ton EF 1-15, 1-4, 1-3	100,000	No	—	—	Hot rolled, rebars & alloy steels
Washburn Wire Co. Phillipsdale, R. I.	2-35 ton EF	120,000	No	—	—	Hot rolled bars & rods & strip & wire
Total Capacity		3,670,000	15 plus 1 pressure casting	—	1,255,000	% conticasting-35%

Current World Trends in Iron and Steel Production and Trade

The world wide steel production during 1966 totalled approximately 518,000,000 tons representing an increase of about 17,000,000 tons over the 1965 figure. Leading producers over 10 million net tons are as follows:-

TABLE 2

	1966 (approximate) (tons)	1965
USA	134,000,000	131,400,000
USSR	106,000,000	103,300,000
Japan	51,000,000	46,000,000
West Germany	40,000,000	40,000,000
UK	27,500,000	30,200,000
France	21,200,000	21,600,000
Italy	14,800,000	13,900,000
Poland	10,400,000	10,000,000
Canada	10,400,000	10,000,000
Czechoslovakia	10,000,000	9,480,000
Belgium-Luxembourg	-	15,200,000

The European coal and steel community, despite drops in steel production by West Germany and France, matched the 1965 production of 94,000,000 tons; the drop was made up by increase in Italian steel production. US share of the export market showed a decline in 1966, falling by 20% below the 1965 figure of 2.5 million tons and compared to the record of 7.9 million tons in 1940. On the other hand, imports into the USA of steel products provided for the second consecutive years more than 10% of the steel consumed in USA. Imports into the USA in 1966 totalled about 10.5 million tons, i.e., up by 0.1 million tons over the 1965 figure. Most of the imported tonnage, chiefly from Japan, was made up of hot and cold rolled sheets and wire rods. The imports into the USA were obtained from Japan (47%), Belgium-Luxembourg 15%, West Germany 10% etc. Two-thirds of the imported hot rolled sheets came from Japan.

The shifting pattern of world steel trade offers scope for deep thought and scientific study. The developing countries are becoming less dependent on imports and the traditional producers are exceeding their home demand pattern. The list of steel producing countries continues to grow despite problems inherent in the establishment of a highly capital-intensive steel industry. During the last decade and a half, the number has increased from about 30 to over 60. Amongst the new entries into the field of steel production, who have either begun production or have facilities under construction, are various developing countries such as Tunisia, Algeria, Pakistan, the Philippines, New Zealand and Indonesia. Others seriously considering setting up facilities for steel production are Liberia, Afghanistan and Albania, along with several of the newly emerging African countries in the background of urge to industrialize despite economic and capital deficiencies. World steel production in the past half a dozen years has increased by 150,000,000 tons. By 1970, the world total of steel production will exceed 600 million tons and by 1975, the figure will topple the 700 million tons mark. Considering that the world's steel total production in 1950 was 210 million tons and 346 million tons in 1960, the current rate of overall growth is not only phenomenal, but will also maintain its upwards curve and classification trends. France is busy making plans to be competitive on a worldwide international scale. The French Fifth Economic Plan aims at an annual output of 26 million tons by 1970. In a determined effort to centralize facilities and reduce production costs, the French Government is encouraging firms to merge and reduce high energy and transport costs. Soviet steel output in 1966 totalled about 106 million tons i.e., representing an increase of 6 million tons over 1965 and matching the growth curves of the preceding years. The current Soviet five-year plan aims at a figure of 140 million tons by 1970; pig iron at 103 million tons, rolled steel 107 million tons and steel tubes in which Soviet Union has been a world leader at 15 million tons also by 1970. L.D.oxygen steel-making is to increase 5 folds and electric steel-making by 150% in the USSR. In order to project these aims, the plan providing for the addition of 13 new blast furnaces, 30 L.D. converters, 10 electric steel-making plants and 30 rolling and tube mills. Oxygen converter steel-making production by 1970 will be about 15%, i.e., over 30 million tons compared to 4%, i.e., 4 million tons in 1965.

Spain, which produced 4 million tons in 1956, is expanding its facilities to target 14 million tons within the next five years. Italy is, for the first time, a net steel exporter in 1965 and is maintaining increased plant investment. The plans call for an increase in capacity to exceed 20 million tons by 19[illegible] with home requirements estimated at 18 million tons a year in 1967, would be a substantial exporter of steel products. India, whose steel capacity was less than a million tons a year a decade ago, is touching a figure of 7 million tons in 1966. Additional heavy expansion is currently underway including the setting up of Bokaro steel plant with Soviet assistance with an initial and ultimate capacity of 1.5 and 5.5 million tons annual output respectively. The Indian plans call for eliminating lines instead of providing lines in view of the chronic shortage of zinc supplies - in this field, considerable research and development work have been done in India at the National Metallurgical Laboratory, Jamshedpur.

Production in Latin America has doubled in the last six years and could double itself again by 1[illegible]. The expansion plans have slowed down owing to shortage of capital, but the long term investment potential is promising. Mexico attained a rise of over 1[illegible] production i[illegible] over the 1965 figures.

In Japan, the giant Nippon Steel steel works at Kimitsu Yokan began operation in September 1966 and has been designed to have the lowest production cost per ingot ton in the world - its ultimate aiming production capacity will exceed [illegible] million tons compared to the present capacity of 1.5 million tons - this plant makes extensive use of computer production controls. Japanese production during 1966 exceeded 90 million tons, i.e., rose by 6 million tons over the 1965 figure and the projected targets exceed 70 million tons by 1970. The expansion plans call for 4 plate mills, 2 cold strip mills, a seamless tube mill, a hot strip mill and a large section mill, all to be completed within the next couple of years. Concerning steel-making process in Japan, basic oxygen steel-making furnaces exceed 45 in operation - Japan has more basic oxygen L.D. converters in operation than any other steel-making country in the world. The US has 47 L.D. oxygen furnaces whilst in annual tonnage, the US has a slight edge over Japan, with 99.3 million tons output in relation to Japan's 89.3 million tons. Between them the two countries account for 33% of the world

Table 3

Crude Steel Production by main Countries

1,000 metric tons

	Japan	U. S. A.	U.K.	E. C. S. C.							U.S.S.R.
				West Germany	France	Italy	Belgium	Luxemburg	Nether-lands	Total	
1955	9,403	106,173	[illegible]	21,502	12,631	5,548	[illegible]	3,226	979	52,[illegible]7	45,271
1960	22,138	[illegible]	24,683	34,100	17,[illegible]	8,462	7,181	4,0[illegible]4	1,950	7[illegible]6	65,292
1961	28,268	88,899	22,440	33,458	17,577	9,133	7,[illegible]	4,113	1,975	73,[illegible]	70,751
1962	27,546	89,181	20,535	32,[illegible]	17,[illegible]	9,757	7,351	4,010	2,090	7[illegible]	76,306
1963	31,50[illegible]	99,1[illegible]	22,941	31,597	17,55[illegible]	10,157	7,52[illegible]	4,0[illegible]	2,354	7[illegible]	80,226
1964	39,799	11[illegible]	26,2[illegible]	37,33[illegible]	19,781	9,793	8,[illegible]	4,559	2,659	82,956	85,03[illegible]
1965	41,161	119,[illegible]	27,43[illegible]	36,821	19,[illegible]	12,68[illegible]	9,[illegible]	4,545	3,143	8[illegible]7	91,000

Source : Japan Iron and Steel Exporters' Association

Table 4

Iron and Steel Export by main Countries

1,000 metric tons

	Japan	U. S. A	U.K.	E. C. S. C.					
				West Germany	France	Italy	Bel-gium	Nether-lands	Total
1955	1,851	[illegible]	2,772	2,324	4,[illegible]	234	5,257	712	[illegible],354
1960	2,507	2,701	3,346	9,07[illegible]	3,0[illegible]	9[illegible]	7,1[illegible]	1,[illegible]	21,243
1961	2,513	1,50[illegible]	3,455	7,58[illegible]	5,[illegible]	650	6,545	[illegible]	21,281
1962	4,132	1,826	3,3[illegible]	7,389	4,8[illegible]	582	6,9[illegible]	1,1[illegible]	20,876
1963	5,033	1,[illegible]77	3,574	7,6[illegible]6	4,[illegible]	501	7,[illegible]	1,5[illegible]	21,334
1964	6,921	2,976	3,486	[illegible]	5,703	1,009	5,193	1,582	2[illegible]173
1965	9,909	2,[illegible]4	4,134	8,[illegible]60	6,137	1,8[illegible]7	9,013	1,803	[illegible]355

Source : Japan Iron and Steel Exporters' Association

total L.D.oxygen converter steel-making. The E.C.S.C. nations are rapidly pushing ahead with L.D. oxygen steel-making capacity. The present total of 35 L.D. oxygen steel-making converters with an annual capacity of 22.35 million tons, is less than the corresponding annual capacity of either Japan or the US. There are over 226 L.D. oxygen steel-making converters in use throughout the world today with a total annual output of 122 million tons of steel and these are on the increase. 55% of Japan's total in 1965 of 44.7 million tons steel output was produced by the L.D. oxygen steel-making process compared to 44.2% in 1964. By comparison, this figure was only 17.4% in 1965 and 14% in 1964; in the UK, the figure was 14.6% in 1965 and 9.6% in 1964, and in France, the figure was 13.1% in 1965 and 11.2% in 1964. In 1956, N.K.K. became the first Japanese steel-maker to employ L.D. oxygen steel-making technique by concluding an agreement with the B.O.T. Company of Austria - the holder of the patent of the L.D.oxygen steel-making process. These developments have enabled the Japanese today to hold over 25% of the total volume of the iron and steel trade in exceeding over 10 million tons export figure in 1965. By destination, Japanese exports have mainly shifted to highly advanced countries such as the USA and European countries unlike the past when shipments were made chiefly to South-East Asian countries. Particularly, the US have become the largest market for Japanese exports, importing over 44% of the total Japanese exports. In technological spheres, the coke ratio declined from the average 664 kg in 1955 to average 506 kg in 1964 and an average of 503 kg in 1965 whilst the all time lowest touched 456 kg. This means a remarkable rationalization attained in Japan ahead of the US and European countries where more than 600 kg coke rate is still the average. Tables 3 and 4 provide the general steel production trends.

Of other steel-producing countries, the overall trends may be seen as follows in relation to 1965 production figures: -

Australia	5.5 million tons
Sweden	5.2 " "
India	6.5 " "
Canada	9.3 " "

TABLE 5

1952 Price = 100 - Steel Prices Indices

	1955	1960	1964
USA	113	147	150
India	137	152	161
Belgium	114	127	123
West Germany	102	114	120
UK	96	83	91
Japan	99	87	79

The above figures are illustrative of the disproportionate rise in steel prices in some countries.

Table 6 gives the world production of crude steel and castings for different years.

TABLE 6

WORLD PRODUCTION OF CRUDE STEEL AND CASTINGS

thousand net tons

Countries	196-	1964	1963	1962	1961
North America	141,486	136,297	127,451	109,101	101,080
United States*	131,462	127,076	119,261	98,328	92,012
Canada	10,024	9,131	8,190	7,173	6,466
Latin America	8,992	8,252	7,731	6,471	5,683
Argentina	1,485	1,394	986	715	487
Brazil	3,239	3,413	3,131	2,826	2,693
Chile	470	644	575	382	431
Colombia	268	263	245	173	212
Cuba	50	50	50	20	20
Mexico	2,685	2,566	2,223	1,837	1,954
Peru	102	90	84	79	83
Venezuela	653	486	395	157	78
Others	55	56	42	54	25
Europe	273,869	260,914	236,619	228,354	222,805
Western Europe	142,667	137,228	120,381	117,[illegible]	119,143
ECSC	94,715	91,334	80,698	80,465	80,739
Belgium-Luxembg.	15,153	14,643	12,740	12,519	12,252
France	21,609	21,806	19,350	18,997	19,375
West Germany	40,586	41,160	31,830	35,894	36,381
Italy	13,930	10,795	11,196	10,736	10,059
Netherlands	3,437	2,930	2,582	2,299	2,172
Other Western Europe	47,952	45,894	39,686	36,637	38,404
Austria	3,552	3,521	3,251	3,273	3,420
Denmark	452	437	396	405	356
Finland	381	392	359	365	328
Greece	235	231	220	78	72
Ireland	22	22	44	45	45
Norway	756	679	599	539	536
Portugal	303	276	245	192	75
Spain	3,810	3,333	2,556	2,424	2,565
Sweden	5,208	4,947	4,278	3,979	3,920
Switzerland	395	380	355	351	327
Turkey	651	446	400	284	335
United Kingdom	30,247	29,378	25,823	22,990	24,736
Yugoslavia	1,940	1,852	1,750	1,758	1,689

*Includes steel casting production which is reported directly to Bureau of Census as follows: (thousand net tons) 1965-n.a.; 1964-1,380; 1963-1,332; 1962-1,314; 1961-675.

Sources: From various national and international statistical publications.

Cont'd overleaf

Table 6 (continued)

Countries	1965	1964	1963	1962	1961
Eastern Europe	131,202	123,636	116,235	111,252	103,062
Bulgaria	634	593	494	466	364
Czechoslovakia	9,480	9,239	[illegible]	[illegible]	7,761
East Germany	4,233	4,341	[illegible]	4,511	4,314
Hungary	2,712	2,606	2,617	2,572	2,315
Poland	10,013	9,445	8,[illegible]	8,469	7,973
Rumania	3,778	3,347	[illegible]	2,708	2,345
USSR	100,305	93,691	[illegible]	84,112	77,990
Africa	3,640	[illegible]	[illegible]	3,256	2,833
Rhodesia	113	250	[illegible]	90	90
Republic of South Africa	3,450	3,426	3,122	[illegible]	2,725
Others	77	67	38	33	18
Middle East	292	292	[illegible]	265	250
Egypt	200	200	[illegible]	165	165
Israel	72	72	72	100	85
Lebanon	20	20	20	...	...
Far East (excl. centrally planned economies)	52,364	51,103	[illegible]	36,295	35,042
India	6,899	6,653	[illegible]	[illegible]	4,517
Japan	45,383	43,370	34,724	30,364	31,160
Pakistan	13	13	13	15	15
South Korea	143	143	176	81	50
China (Taiwan)	275	275	229	150	150
Others	151	157	109	50	50
Far East (centrally planned economies)	14,378	12,150	9,832	9,157	14,055
China (Peoples Rep.of)	13,228	11,000	9,000	8,000	13,200
North Korea	1,150	1,150	832	1,157	855
Oceania	5,386	5,772	5,219	[illegible]	4,414
Australia	5,736	5,622	5,119	[illegible]	4,339
New Zealand	50	50	...	...	...
Philippines	100	100	100	100	75
Total centrally planned economies	145,580	135,836	126,117	[illegible]	117,117
Total other	355,327	343,139	296,122	273,647	272,945
Total World	501,407	479,025	422,239	394,056	390,062

The following Table No.7 outlines the world's crude steel output in 1967 showing a spectacular rise in Japanese steel production from 93.5 million tons in 1967 to 68.[illegible] million tons in 1967, representing an astounding rise of over [illegible]. Steel production in USSR rose from 107.6 million tons in 1966 to 112.0 million tons in 1967, whilst in the United States, about 5.4% drop in steel production took place during 1967 (126.9 million tons) over the 1966 steel production figures (134.1 million tons).

TABLE 7

Crude Steel Production Trends

(million of net tons)

	1964	1965	1966	1967 (Preliminary Estimates)
USA	127.1	131.5	134.1	126.9
Japan	43.9	45.4	53.5	68.6
W.Germany	41.2	40.6	38.9	40.5
UK	27.4	28.2	27.2	26.8
France	21.3	21.6	21.6	21.7
Belgium-Luxembourg	14.6	15.2	14.6	15.7
Italy	10.8	13.9	15.0	17.5
Netherlands	2.9	3.4	3.6	3.7
USSR	93.7	100.3	107.6	112.0
Other Nations	93.6	101.6	103.7	107.6
Total World Steel Production	479.9	503.1	519.-	541.0

In USA, one of the notable developments in steel-making production techniques is the drop in open hearth steel output (which has held its ground over more than half a century) and the rapid growth in the L.D. oxygen steel making capacity and of the electric arc furnace steel making potential - this can be seen from the following Table:-

TABLE [illegible]

Raw Steel Production in US (Types of Processes used)

(Percent of total output)

	Open Hearth Process	L.D. Oxygen Process	Electric Arc Steel-making	Bessemer Process
1960	7[illegible]	3.3[illegible]	[illegible].4[illegible]	1.20
1961	[illegible]	[illegible]	.[illegible]	0.[illegible]
1962	[illegible]4.[illegible]	5.[illegible]	[illegible].15	0.[illegible]1
1963	[illegible].24	[illegible].77	[illegible]	0.3[illegible]
1964	[illegible].1	1[illegible].11	.[illegible]	0.[illegible]7
1965	7[illegible]	17.[illegible]1	1[illegible].4[illegible]	0.44
1966	[illegible]	[illegible].27	1[illegible].11	0.20
1967	[illegible]3	32.7[illegible]	11.[illegible]6	0.[illegible]7

These general trends are illustrative of the choice of technological processes for steel production in other countries of the world. It is expected that in a few years time, open hearth steel-making in the US will account for no more than [illegible] of the total steel production. The concurrent growth of electric arc furnace steel-making in the US and in some other countries has been substantial, though not so widely advertised - it is expected that it will outpace the open hearth steel capacity in US in less than a decade. Many developing countries including India, have set up several [illegible] to [illegible] tons capacity electric arc furnaces, (including those used for special steels), whilst in the US, [illegible] tons electric furnaces have been installed in many of their integrated steel plants.

In recent years, steel scrap based electric arc furnaces coupled with continuous casting and flexible rolling mills schedules have rendered possible the operations of steel plants on a integrated basis with minimum of capital investment costs - the capital costs have been of the order of [illegible].5 million dollars for an annual finished steel output of [illegible] net tons. These developments are of significant interest to some of the developing countries where electric power costs are low by virtue of massive developments in hydro-

electric power generation and those who have hitherto been habitual exporters of steel scrap to countries like Japan. The future role of these small yet integrated steel Plants is important in countries where conditions are optimum in relation to the market needs, power costs, scrap availability etc. Such Plants have been in successful operations in developing countries such as India, Ceylon, Singapore, etc.etc.

Re-Organisation of the Steel Industry

The established iron and steel industry the world over is passing through a period of re-organisation following the impact of new technological innovations all over and in the wake of developing countries setting up their own steel production units and reversal of the earlier trends of balance of trade such as in the case of Japan, USA, etc. The iron and steel industry of the United States has designed radical improvements in the constitution and started modernisation investments at a high pitch since 1964. Investments made in 1965 amounted to about $ 1.900 million, exceeding the earlier peak year capital investment during 1955. These investments spread over all manufacturing process geared to the adoption of new processes and equipment such as, heavy oxygen L.D. converters, continuous casting facilities, fast and highly automatic hot and cold continuous strip mills etc. The leading works such as Gary Steel Works of the US, Steel and Sparrows Point Works of Bethlehem Steel Corporation will assume such big scale producers as to exceed 8 million tons output annually in each case during 1967.

In Europe, mergers of the large enterprises have successively taken place. There have been amalgamations of Thyssen-Rheinroh (with capacity of 8 million tons per annum of ingot steel), Roesch-DHH - Hoogovens (10 million tons), Rheinhausen-Bechmen-Verein (4 million tons) of West Germany, Arbed Hadin of Luxembourg (5 million tons), Usinor Louvrain-Escant of France (6 million tons) etc. These mergers are promoting gigantic scale operations of multiple end products.

Quite recently in France, an iron and steel 5-year plan aimed at the centralisation has been announced to form a concerted co-operation system amongst steel producers. In West Germany, there is a move towards formation of a syndicate to sell rolled items, i.e., a central organ of the cartel with a

function of joint selling. In India, such re-organization is being initiated right from the start, such as the move for setting up an integrated 5.5 million tons per annum steel complex at Bokaro and on the sales side, the establishment of a Joint Plant Committee representing the steel industries in private and public sectors for price fixation of the multiple product mix and promotion of sales within the country and for stepping up of the exports.

Current developments in the world steel markets indicate a progressive increase in steel trade and increasing competition amongst the world's steel exporting countries. There is an increasing tendency for the steel industries of the advanced countries to continue building up their competitive power on the international market through modernisation of plant equipment and by re-organisation and management of their steel industry. There has also been substantial progress towards the goal of steel importing countries to achieve self-sufficiency in home steel production. There has also been fair progress in the Kennedy Round negotiations aimed at across-the-board tariff reductions. These three factors point to increasing intensity of competition amongst steel producers and exporters who are continuing their efforts to reinforce their competitive power by expansion of capital equipment and relying on greater emphasis on researches and development work on steel-making. The spray steel-making process successfully developed by British Iron and Steel Research Association is an indicator of the tempo of research in production technology of steel. Likewise, the pneumatic basic air side-blown process successfully developed at the National Metallurgical Laboratory in India indicates the progress made in research and development work on steel-making which may find potential applications in developing countries for small scale steel production.

According to Japanese circles, their steel exports to US - a key export market, should be in appropriate amounts commensurate with US demands and at appropriate stable prices so that such exports can contribute to US economy. Likewise, exports to developing countries should also be made on a basis that will assist in their overall economic development. And apart from the export of basic steel product mix, it is desirable to export finished end products such as plant, equipment and machinery for railways, road building and port facilities. Very often, the foreign exchange needed for these imports by developing countries represents a major obstacle to the export trade. And in

such cases, Japanese offer extended credit facilities, deferred payment basis and barter exchange payments. About 70% of the Japanese steel exports have been in the form of basic steel products whilst 30% is made up of steel fabricated goods.

Concerning world steel market, the Organization for Economic Co-operation and Development has pointed out that there is a need for some form of international co-operation and planning to establish a programme for adjusting supplies based on reasonably accurate evaluation of demands.

The above trade pattern can also be examined in relation to import and export of raw materials for the steel industry including iron ore pellets etc. An illustration thereof is provided by the Japanese Ministry of International Trade and Industry which has indicated that during the 1967 financial year, Japan will have imported over 42 million tons of iron ore and 4.2 million tons of pellets valued at 598 million dollars as analysed below:-

TABLE 9

Iron Ore Imports by Japan

Regions	Financial Year 1966	Financial Year 1967
Southeast Asia	7,465.000	6,600.000
India	10,131.000	10,000.000
North America	3,450.000	3,400.000
South America	14,710.000	15,500.000
Africa	4,072.000	4,000.000
Australia	7,143.000	7,100.000
North Korea incl. USSR and China	9,666.000	400.000
TOTAL	43,955.000	47,000.000

TABLE 10

Pellets Imports

Sections	Financial Year 1966	Financial Year 1967
USA	1,053.000	1,250.000
Peru	1,054.000	1,000.000
India (Goa)	-	550.000
Philippines	300.000	400.000
	3,306.000	4,600.000

*Concerning the most recent period, low cost foreign steel products have been exported to United States markets during 1967; imports totaled a record 11.5 million tons and accounted for 12.2 per cent of domestic steel consumption. Such imports, in fact, have almost doubled every three years since 1955.

The Staff Study of the Committee on Finance of the United States Senate points out that imports ultimately could "reach such high percentages of the markets for certain steel products to render them unprofitable for the domestic industry to make." The study also says "It means courting a possible future national ordeal if such a highly strategic industry as steel should be permitted to drift into even partial decay." Why is all this foreign steel imported by USA? World production figures give part of the reason -545 million tons during 1967, a two-and-one-half-fold increase since 1950. Right now more than 65 nations are producing steel and many make more than they can use. Last year, 49 of them sent steel to the United States with Japan being the dominant exporter. Furthermore, by 1973, that country's planners expect to be able to produce 40 percent more raw steel, a total of 100 million tons. They estimate that they will need about 70 million tons of that in Japan, leaving an excess of 30 million tons for export. Unless conditions change radically, there is every reason to expect much of the excess (then, as now) to find its way to the United States. Many other foreign steelmaking nations are expanding their iron and steel industries with export markets,

*Steelways - March/April 1968

particularly the United States, in mind. The main reasons can be analysed thus.

First, US has the world's largest markets for steel mill products. Second, these markets are largely unprotected by the import surcharges, border taxes, import licensing controls and numerous other barriers with which other countries protect their own steel industries. And third, foreign steel producers can sell steel products in this country cheaper than domestic producers mostly because their labour costs are very much lower than those in the United States.

The valuation of steel imports in 1967 into USA exceeded the valuation of steel exports by more than $ .77 million. This does not include adjustments for freight charges, insurance and allowance for government-financed exports. With such adjustments estimated, the deficit in this country's steel trade amounted to nearly $ 1.1 billion. This has had a negative impact on US balance of payments. The analysis of these imports is given as follows: -

TABLE 11

36% came to border and Inland Ports from:

West Germany	1,027,000
Japan	9[illegible].000
Canada	660,000
Belgium-Luxembourg	3[illegible]3.000
United Kingdom	3[illegible].000
All other	427,000
Total (Net Tons)	3, [illegible]7,000

TABLE 12

27% came to Atlantic Coast Ports from:

Japan	1,665,000
Belgium-Luxembourg	773.000
West Germany	453.000
France	2[illegible].000
United Kingdom	256.000
All other	871,000
Total (Net Tons)	3,[illegible]6.000

TABLE 13

16% came to Pacific Coast Ports from:

Japan	1,480.000
Belgium-Luxembourg	98.000
Australia	58.000
West Germany	55.000
United Kingdom	40.000
All other	92,000
TOTAL (Net Tons)	1,823.000

TABLE 14

20% came to Gulf Coast Ports from:

Japan	855.000
Belgium-Luxembourg	380.000
West Germany	366.000
France	245.000
United Kingdom	134.000
All other	329,000
TOTAL (Net Tons)	2,309.000

UNIDO's role in providing assistance to the Growth of Iron and Steel Industry in Developing Countries

UNIDO's basic role in the development of Iron and Steel Industry is more of a promotional character rather than of capital investment. The following areas are broadly concerned in which UNIDO has been and is in a position to provide technical assistance to developing countries:

1. Technical feasibility pre-investment and techno-economic studies.

2. Appraisals of capital costs, negotiation of Contracts for iron and steel plants in developing countries.

3. Projection and Project evaluations including expansion and modernization of existing facilities;

4. Promotion (developing, implementing, evaluating) of iron and steel industry projects;

5. Development planning on a national, regional and interregional levels.

6. Technical appraisal of raw-materials including beneficiation, agglomeration of iron ores etc.

7. Iron and steel production technology, selection of technological processes and equipment; new methods; quality of products; techno-economic evaluation of competitive processes and latest innovations and their implementation/adaption with suitable measures in developing countries.

8. Production of ferro-alloys and related technological processes.

9. Making, shaping, rolling and treating of steel. Choice of steel rolling mill equipment.

10. Provision of technical training.

11. Market surveys and projections for developing countries and regions.

12. Provision of facilities for metallurgical testing, development and research including Pilot Plant installations.

13. Formulation of Special Fund Projects related to the development of iron and steel industry for developing countries and regions.

14. Technical assistance to developing countries through Special Industrial Services and UN Technical Assistance and regular Programmes to developing countries.

In promoting and undertaking above technical assistance projects, the background supporting studies are given equal importance such as on the following aspects of Iron and Steel Industry's growth in developing countries and regions.

(a) One main basic issue for the establishment of iron and steel industry revolves round the resources and reserves of raw materials in different countries and regions and very often basic data on the depth and quantum of deposits of raw materials resources are very scanty and unproved. It is therefore, necessary to undertake national surveys of raw materials for the establishment of iron and steel industry in developping countries in which the UNIDO can promote and the advanced countries can co-operate on a planned basis.

(b) Does the internal and/or neighbouring market pattern justify the

installation of integrated iron and steel complex in a developing country or should it be chiefly based on export potential of multiple product mix. This issue is interlinked with the market surveys of the multiple product-mix of steel industry which have not so far been conducted on any well-planned basis. The importance of such surveys of internal market pattern on regional bases can hardly be overestimated. UNIDO promotes such regional surveys of market pattern through working groups meetings or otherwise aiming at the projection of the demand pattern of the markets over the next decade or so.

(c) Perhaps the most important consideration to be debated would be whether a developing country should have a small iron and steel plant or an integrated iron and steel industry of a million tons output annually or its multiple. In discussing this issue, it would be necessary to study various parameters governing the location of a steel plant in a developing country and comparison of inland locations vis-à-vis coastal sites. Related to this issue would be the status of the cost of transport of raw-materials to the site and handling facilities at the two ends including the status of rail and road transport systems and their overall cost per ton per mile. In the examination of this basic issue of the size of the steel industry, a study of different parameters will determine the initial size of the plant in relation to its expansion possibilities and in-built growth potential over successive five-year plan schedules. UNIDO will undertake such surveys through specific working groups for different regions in co-operation with other United Nations Agencies including the Regional Economic Commissions.

(d) Another important factor relates to the choice of technological processes for iron and steel-making which a developing country should adopt for the industry's techno-economic success; should the choice be the conventional process of iron-smelting in a blast furnace or direct reduction processes, or the new spray steel-refining process or the L.D.steel-making, LD-AC steel-making or the pneumatic basic lined converter steel-making process more suited for small iron and steel industry. UNIDO can promote the surveys for judicious choice of technological processes through working groups on a regional basis based on the availability of lignites, coals, i.e. fossil fuels or gaseous fuels or oil resources and related to the nature of iron ores and fluxes available. In a very tangible way, advanced countries can assist the developing

countries in undertaking these surveys through UNIDO for the choice and detailed formulation of technological processes ideally suited for different developing regions and countries.

(e) Reference has already been made to an essential criterion whether a developing country should go in for turn-key package installations or split up the plant into constituent units and then go in for their in-tandem installations utilising maximum indigenous design and fabricating capacity. The experiences of Indian and Brazilian steel industries would provide illustrations thereof and in undertaking these studies, UNIDO can in collaboration with advanced countries play a major role.

(f) An important decision to be often taken is whether the steel industries of a developing country should install continuous mills or "jobbing" non-continuous mill installations which could need more manual control and operations. Does the internal demand pattern in a developing country or its export potential justify the most modern highly instrumental and remote control mills or should a developing country install a less sophisticated but more rugged and manually operated hand mill such as for sheet rolling of steel. Apart from the fact that the modern continuous hot and cold rolling strip mills and ancillary installations represent status symbols of a steel industry, the main issue is whether it is justified in relation to a developing country's resources of maintenance facilities and continuous spare servicing so important for such automated mill operations. The continuous rolling mills are highly capital intensive but less labour intensive and hence judicious decisions are needed, whether the steel plants in different regions should be capital intensive or labour intensive depending upon the resources of capital finance, men and materials in a developing country. It would be necessary in the same context to institute "efficiency surveys" on a broad-based measure of the technological efficiency in terms of economic productivity of the steel industry in different regions which UNIDO should promote through the formation of working groups and holding seminars on the subject.

(g) The status of iron and steel industry inevitably covers the role of auxiliary plants to determine its success such as iron and steel foundry plants which vary in status in accordance with the laws of demand and supply. These basic parameters could be well examined by UNIDO in collaboration with advanced countries preferably through forming working groups on the subject.

The process of examination of these essential and all pervading criteria is self-generating giving rise to fresh issues connected in a chain reaction growth of industrial technology and techno-economic development. An open eye will need to be kept at the same time, to bear in mind the individual factors and needs of a particular developing country which will differ from one region to another. The importance and value of such interregional studies and surveys of basic issues cannot, therefore, be over-emphasised.

In many of these fields, UNIDO has already been very active and instrumental in promoting the establishment of iron and steel industries in developing countries such as in South Korea, Indonesia, Philippines, Colombia, etc.etc. It is equally hoped that in the years ahead, U.N.O. role in providing technical and practical assistance to the iron and steel industry of developing countries will be mutually rewarding on an increasing scale. In this connection, it is gratifying that UNIDO's assistance in the above fields has been duly appreciated and there is no doubt that equally so will be the case on an ever increasing measure in the years ahead.

Some Current Iron and Steel Developments in Relation to Developing Countries

It will hardly be possible to cover bulk of the references to important current developments in iron and steel industry particularly in relation to developing countries but an attempt will be made to highlight a few of the important ones in these fields in the overall context of the steel industry's global growth in general.

World steel production based on the present trends of its growth, is estimated in some quarters at 500 million tons in 1970. The estimates for 1975 and 1980 are 710 million tons and 930 million tons respectively. The regional breakdown estimates are shown overleaf:

TABLE 15

Crude Steel Production by Region
1964 and forecasts for 1970, 1975 and 1980
(Million Tons)

Region	1964	1970	1975	1980
Western Europe	124.5	154.5	168.7	180.1
Eastern Europe	112.3	164/169.0	210.3	248.6
North America	123.4	140.4	163.2	185.4
Latin America	8.0	16.8	30.2	48.9
Africa, Middle East and China (mainland)	3.7	6.5/8.5	15.6	26.0
Far East and Oceania	62.1	95.1	121.5	140.8
Total	434.1	577.2/584.4	710.0	830.0

The world production of iron ore, concentrates and agglomerates has been regionally estimated to be the following for the decade ahead.

TABLE 16

Million of Gross Tons

	1950	1964	1965	1975
US	98	81.3	87.7	92
Centrally planned economy countries	44.5	205.8	198.3	236
Asia, Africa Oceania	14.4	60.9	77.6	151
Western Europe	76.9	137.1	138.1	105
South America	5.3	42.1	53.6	80
Canada	3.2	31.5	34.2	58
Total	242.3	558.7	589.5	722

Likewise, the world iron ore pellet capacity continues to expand as follows:

TABLE 17

Pellet Plant Operating

US	-	37,300,000	
Canada	-	15,525,000	Annual Capacity (gross tons)
Other Countries	-	11,590,000	
Total		64,215,000	

Pellet Plants under Construction

US	-	12,700,000	
Canada	-	3,950,000	
Other Countries	-	11,370,000	
Total world, under erection	=	32,020,000	tons
Total world, operating and under construction	=	96,235,000	

World wide growth of iron ore, its beneficiation and agglomeration facilities have proceeded at record rates during the last few years and will continue to thus expand. The cost of an iron ore pelletizing project ranges from $ 25 to $ 50 per annual ton capacity depending upon whether or not the project requires railway transport, township, port and dock facilities etc.

The developing countries in general are rich in the resources of raw-materials for the iron and steel industry including iron ore which present an hitherto untapped potential for ore pelletizing projects for experts of pellets to advanced steel producing countries of the world. New iron ore pelletizing plants in developing countries such as in India, Philippines, Brazil etc. illustrate these upwards dynamic trends in the economic and industrial growth of the developing countries. The following Table 18 provides the list of the pelletizing plants established in different parts of the world as it stood during 1966-67.

Table 18

Iron ore pellet processing plants throughout the world

Operation	Location	Annual capacity thousand Gross Tons: Present Capacity	Planned additional Capacity	Total
	UNITED STATES			
Bethlehem Steel Co.	Cornwall, Pa	700		700
	Grace, Pa	1,500		1,500
Cleveland Cliffs Iron Co.	Eagle Mills, Mich.	800		600
	Empire Mich.	1,400	1,000	2,400
	Humpolt, Mich.	800		800
	Republic Mich.	2,000		2,000
	Pioneer, Mich (Mather)		1,400	1,400
Erie Mining Co.	Hoyt Lakes, Minn.	3,000	1,600	[illegible],600
Hanna Mining Co.	Groveland, Mich.	1,250		1,250
Itasca County, Minn.	Itasca County, Minn.		2,000	2,000
	Pilot Knob, Mo.		750	750
	Keewatin, Minn.		2,400	2,400
Meremec Mining Co.	Pea Ridge, Mo.	2,000		2,000
Reserve Mining Co.	Silver Bay, Minn.	7,250		7,250
United States Steel Cor.	Atlantic City, Wyo.	1,500		1,500
	Mountain Iron, Minn.		4,500	4,500
Kaiser Steel Corp.	Eagle Mt., Cal.		2,200	2,200
Eveleth Taconite Co.	Virginia, Minn.		1,600	1,500
Utah Construction and Mining			1,000	1,000
Jones and Laughlin	Biwabik, Minn.		1,500	1,500
Total	United States	27,200	19,950	47,150

Table 19 (continued)

Operation	Location	Annual capacity thousand Gross Tons: Present Capacity	Planned additional Capacity	Total
	CANADA			
Bethlehem Steel Co.	Marmora, Ont.	450		450
Carol Pellet Co.	Carol Lake, Lab.	5,500		5,500
Hilton Mines, Ltd.	Ont.	875		875
International Nickel Co.	Ont.	950		950
Jonas and Laughlin Steel Corp.	Kirkland Lake, Ont.	1,250		1,250
Lowphos Ore Ltd.	Ont.	625		625
Inland Steel Co.	Atikokan, Ont.		1,000	1,000
Mabana Mines	Pt. Noire, Que.		4,900	4,900
Caland Ore, Otd.	Ont.		1,000	1,000
Consolidated Mining and Smelting	Kimberly, BC	300		300
Anaconda Iron Ore Co.	Labine, Ont.		2,000	2,000
Kaikatush Mining	Sudbury, Ont.		500	500
Mt. Wright Iron Mines	Mt.Wright Area, Que.		4,000	4,000
Quebec Cartier	Lac Jeannine, Que		4,000	4,000
Wentfrob Mines	Mt.Charlotte Is., BC		1,000	1,000
Total	Canada	9,950	18,400	28,350
	Pellet Plants, Other Countries			
Otanmaki Og	Finland	200		200
Mines de Perds Score	France	50		50
Montecatini	Italy	330		330
Kawasaki Steel Corp.	Japan	1,000		1,000

Table 18 (continued)

Operation	Location	Annual capacity thousand Gross Tons: Present Capacity	Planned additional Capacity	Total
Saltqitter	Germany	250		250
Norsk Jernverk A/S	Norway	600		600
Marcona Mining Co.	Peru	1,300	2,000	3,300
Hallefors Bruk	Hallefors, Sweden	40		40
Svenska Kullager Gabriken	Sweden	60		60
LKAB	Sweden	500	1,000	1,500
Addeholms AB	Persberg, Sweden	60		60
Svora Kopperberqs	Soderfors, Sweden	30		30
The Granesbero Co.	Strassa Sweden	200		200
Total	Other Countries	4,620	3,000	7,620
	Proposed or Under Construction			
MISIPA	Argentina		1,000	1,000
Basic Materials Ptq,Ld.	Australia		3,000	3,000
Broken Hill Ptq.Ld	Australia		3,000	3,000
Minerals Mining and Export Ptq.Ld.	-"-		500	500
Pickens Mather	Tasmania, Aust.		2,000	2,000
Hamersly Iron Ptq.Ltd,	Australia		1,000	1,000
C.Valedo Rio Doce	Brazil		2,000	2,000
Yamone Steel Cos.	Germany		5,000	5,000
Madhya Pradesh	India		500	500
Chowgula Mining Co.	India	500	1,500	2,000
Yoce Steel	Japan		1,000	1,000
Mitsui-San-Juan	Japan		1,500	1,500
Philippines Iron Mines	Philippines		750	750
Cotomagner	Spain		1,000	1,000
Total	Proposed or Under Construction	500	24,750	25,250
Total	World	42,270	66,100	108,370

The physical form of iron ore consumed in major areas in 1964 and projected for 1970 and 1975 (million of metric ton) is tabulated in the following Table 19.

Table 19

PHYSICAL FORM OF IRON ORE CONSUMED IN MAJOR ARE AS IN 1964 AND PROJECTED FOR 1970 AND 1975 (MILLIONS OF METRIC TONS)

	Screened Run of Mine and Direct-Charge Ore			Fines for Sinter			Pellets			Total		
	1964	1970	1975	1964	1970	1975	1964	1970	1975	1964	1970	197
United States	52.2	31.0	36.0	41.0	40.0	38.0	31.0	58.0	66.0	124.2	129.0	140.0
EEC + UK	66.5	67.0	83.0	86.4	90.0	80.0	2.5	11.0	20.0	155.4	168.0	183.0
Other Western-Europe	10.5	12.5	17.0	4.0	6.0	6.0	0.5	2.5	5.0	15.0	21.0	28.0
USSR	20.5	23.0	26.0	100.0	124.0	140.0	1.5	5.0	9.0	122.0	152.0	175.0
Other Eastern Europe	14.4	16.0	20.0	25.0	35.0	42.0	0.6	1.0	1.0	40.0	52.0	63.0
Japan	12.3	30.0	37.0	16.9	18.0	18.0	1.5	12.0	15.0	30.7	60.0	70.0
Other	43.5	72.5	103.0	9.2	10.5	13.0	4.0	10.0	15.0	57.0	93.0	131.0
	219.9	252.0	322.0	282.5	323.5	337.0	41.6	99.5	131.0	544.3	675.0	790.0

The following is a Summary of the estimated operating costs per gross ton of pellets made by the established processes viz:

a. Horizontal Grate
b. Grate Kiln
c. Shaft Furnace

TABLE 20

Operating Costs per Gross Ton of Pellets

	Horizontal Grate (1)	Horizontal Grate (2)	Horizontal Grate (3)	Grate kiln	Shaft Furnace
Supervision and Clerical.	$ 0.066	$ 0.066	$ 0.066	$ 0.066	$ 0.066
Direct Labour	.140	.158	.158	.180	.180
Labour in Maintenance and Repair	.190	.201	.201	.190	.190
Materials in Maintenance and Repair.	.270	.310	.290	.270	.270
Bentonite	.225	.225	.225	.225	.225
Fuel	.300	.310	.300	.300	.225
Power	.250	.280	.290	.200	.260
Other expenses	.000	.060	.000	.080	.080
	$ 1.529	$ 1.630	$ 1.630	$ 1.511	$ 1.496

(1) Without hearth and side layer
(2) With hearth and side layer

The following Table 21 presents the production data and estimated costs for iron ore pellets from selected areas and plants. -

Table 21

Production data and estimated costs for iron ore pellets from selected areas

Company	Erie Mining	Reserve Mining	Empire C.C.I.	Cleveland Cliffs Hanna	Republic C.C.I.	Canada Carol I.O.C.	Canada Quebec Cartier
Capacity-million tpy	10.3	10.7	3.6	1.3	2.4	5.5	9.0
Investment-$-million	433.0	367.0	100.0	37.0	75.0	255.0	450.0
Product %Fe	62.0	61.0	63.0	60.0	63.0	65.0	65.0
% SiO_2	8.0	8.0	7.0	8.0	7.0	5.0	5.0
Ore grade % Fe	30.0	30.0	34.0	33.0	39.0	37.0	31.0
Ratio of concentration	3.11	3.01	2.61	2.11	2.01	2.21	2.51
Mining	Cost $/ton	Cost $/ton	Cost $/ton	Cost $/ton	Cost $/ton	Cost $/ton	Cost $/ton
Stripping	0.20	0.10	0.05	0.10	0.20	0.02	0.24
Drilling	0.09	0.09	0.05	0.08	0.10	0.06	0.08
Blasting	0.03	0.30	0.07	0.09	0.11	0.11	0.08
Loading	0.07	0.06	0.07	0.08	0.07	0.07	0.07
Haulage	0.14	0.14	0.06	0.08	0.15	0.13	0.17
Miscellaneous	0.06	0.05	0.07	0.07	0.07	0.05	0.07
Total $/ton ore	0.64	0.54	0.37	0.50	0.70	0.49	0.69
$/ton pellet	1.98	1.62	0.96	1.05	1.40	1.07	1.73
¢/unit Fe nat.	3.20	2.70	1.50	1.70	2.20	1.70	2.70
Beneficiation							
Coarse crushing	0.10	0.11	0.07	0.08	0.08	0.08	0.12
Fine crushing	0.16	0.17	-	0.20	0.20	-	-
Concentration	0.58	0.55	0.38	1.03	0.89	0.33	0.28
Total $/ton ore	0.84	0.83	0.95	1.31	1.17	0.41	0.40
$/ton pellet	2.60	2.49	2.47	2.75	2.34	0.90	1.00
¢/unit Fe nat.	4.20	4.10	3.90	4.60	3.70	1.40	1.50
Agglomeration	Pellet	Pellet	Pellet	Pellet	Pellet	Pellet	Pellet
Regrinding	-	-	-	0.65	0.96	0.65	0.70
Palletizing	1.15	1.15	1.25	1.30	1.40	1.59	1.70
Total $/ton pellet	1.15	1.15	1.25	1.95	2.36	2.24	2.40
¢/unit Fe nat.	1.80	1.90	2.00	3.30	3.70	3.40	3.70
General costs							
Overhead	0.45	0.40	0.45	0.45	0.45	0.50	0.50
Loading and stockpiling	0.15	0.15	0.05	0.05	0.05	0.15	0.15
Rail transportation (Privat)	0.22	0.39	-	-	-	-	0.57
Total $/ton pellet	0.82	0.94	0.50	0.50	0.50	0.65	1.22
¢/unit Fe nat.	1.30	1.50	0.80	0.80	0.80	1.00	1.90
Franchise payments							
Royalty	0.30	1.25	0.40	0.40	0.40	0.99	-
State and local taxes	0.39	0.44	0.20	0.20	0.20	0.31	*0.95
Federal income tax	0.65	0.61	1.63	0.91	0.97	**0.61	**0.94
Total $/ton pellet	1.34	2.30	2.23	1.51	1.57	1.91	1.89
¢/unit Fe nat.	2.20	3.30	3.50	2.50	2.50	2.90	2.50

Table 21 (Cont'd)

Amortization							
$/ton pellet	3.33	2.46	2.17	2.19	2.44	3.06	4.25
¢/unit Fe nat.	5.40	4.00	3.50	3.70	3.90	4.70	6.50
Total f.o.b.plant							
$/ton pellet	11.22	10.96	9.58	9.95	10.61	9.83	12.45
¢/unit Fe nat.	18.10	18.00	15.20	16.60	16.80	15.10	19.20
Transportation							
Chicago $/ton pellet	2.43	2.43	2.81	2.81	3.06	5.73	3.73
Pittsburgh $/ton pellet	4.93	4.93	5.56	5.60	5.56	7.23	5.23
Total cost delivered							
Chicago $/ton pellet	13.65	13.39	12.39	12.76	13.67	15.56	16.22
Chicago ¢/unit Fe nat.	22.00	22.00	19.70	21.30	21.70	23.90	25.00
Pittsburgh $/ton pellet	16.15	15.89	15.14	15.55	16.17	17.06	17.72
Pittsburgh ¢/unit Fe nat.	26.00	26.00	24.00	25.50	25.70	26.20	27.30

Note
* Exclusive of Canadian provincial corporate income tax
** Includes provincial income tax either collected by the Federal or Provincial Government.

In some of the highly developed countries, such as the Soviet Union, the USA, etc., phenomenal advances have been recorded in recent years in diverse fields of iron and steel-making. Whilst it may not be possible to introduce these advances on any empirical or ad-hoc basis in developing countries, nevertheless, one should study such technical developments very closely. For example, in Krivoi Rog at the Lenin Memorial Metallurgical Plant, the No.8 blast furnace, with a useful volume of 2700 cubic meters is rated to produce 1.7 million tons of iron per year. The combination of a large useful volume, high degree of automation and mechanization will enable this furnace to produce the cheapest iron in USSR at the highest labour productivity rate.

The No.I blast furnace of NKK's Fukuyama Iron Works produced an overall of 4303 metric tons in June 1967. The ore ratio of the blast furnace burden is 69% sintered ore and 31% lumpy ore. The furnace is operated with a top pressure of 0.4 kg (5 lbs per sq.foot). The coke ratio is as low as 430 kg per metric ton and the crude oil consumption as 35 litres/mt (10 gallons/net ton). This furnace established a Japanese production record of 2.15 metric tons/cu.m of working volume (5.36 net tons per sqn.foot up hearth area). This blast furnace has a working volume of 2004 cu.meters.

The No.1 blast furnace at Oaka Steel Works is operating at the pig ratio of 2.3 - 2.4 tons/Nm^3/day whilst most of the large sized blast furnaces in Japan are operating at more than 1.5 tons/Nm^3/day. The hot blast temperatures are in the range of 950°C - 1000°C and possible increases to 1300°C have been shown to be possible. The use of high top pressure of more than 500 g/cusm coupled with new and improved types of valve seals have led to high productivity rates. The heavy oil injection rate has been over 50 kg/ton of pig iron. The use of sintered ore accounts for 65% of the total charges whilst the use of pelletized ore is fast gaining ground.

Current technological developments in the processing of iron ores contain considerable emphasis on pre-reduced and metallized lumpy ore and pellets. Significant developments on industrial scale in these respects have taken place very recently in Yugoslavia, at the Iron and Steel Plant at Skoplje which started production in 1967 based on prereduced metallic burden in rotary kilns and its smelting in electric smelting furnaces of 26,000 KW (5 in number -

Electro Kemisk A/S). This plant has a capacity of 500.000 tons iron capacity per annum estimated to have cost about three million pounds.

In the same direction, the new plant of High Veld Steel and Vanadium Corporation Ltd. (South Africa) went into production at the end of February 1968. The operations of this Plant are also based on pre-reduction of the metallic burden and its smelting in electric smelting furnaces. There are 4 pre-reduction rotary kilns of 13 feet diameter and 200 ft-long with a rotary speed of 0.40 and 1.25 revolutions per minute. The pre-reduced ore (reduced 45%) is taken in refractory lined vessels to the charging platform of the electric smelting furnaces - 4 of them of 30 MVA rating, 46 feet diameter each, operating on a tap to tap time of 4 hours to yield 60 tons per tap i.e. 120.000 tons/year of the output. The iron will be refined in LD oxygen steel-making shop followed by continuous casting of blooms and slabs (5½ and 8 inches square blooms and two 2 strands 20" x 10" and 16" x 9" slabs).

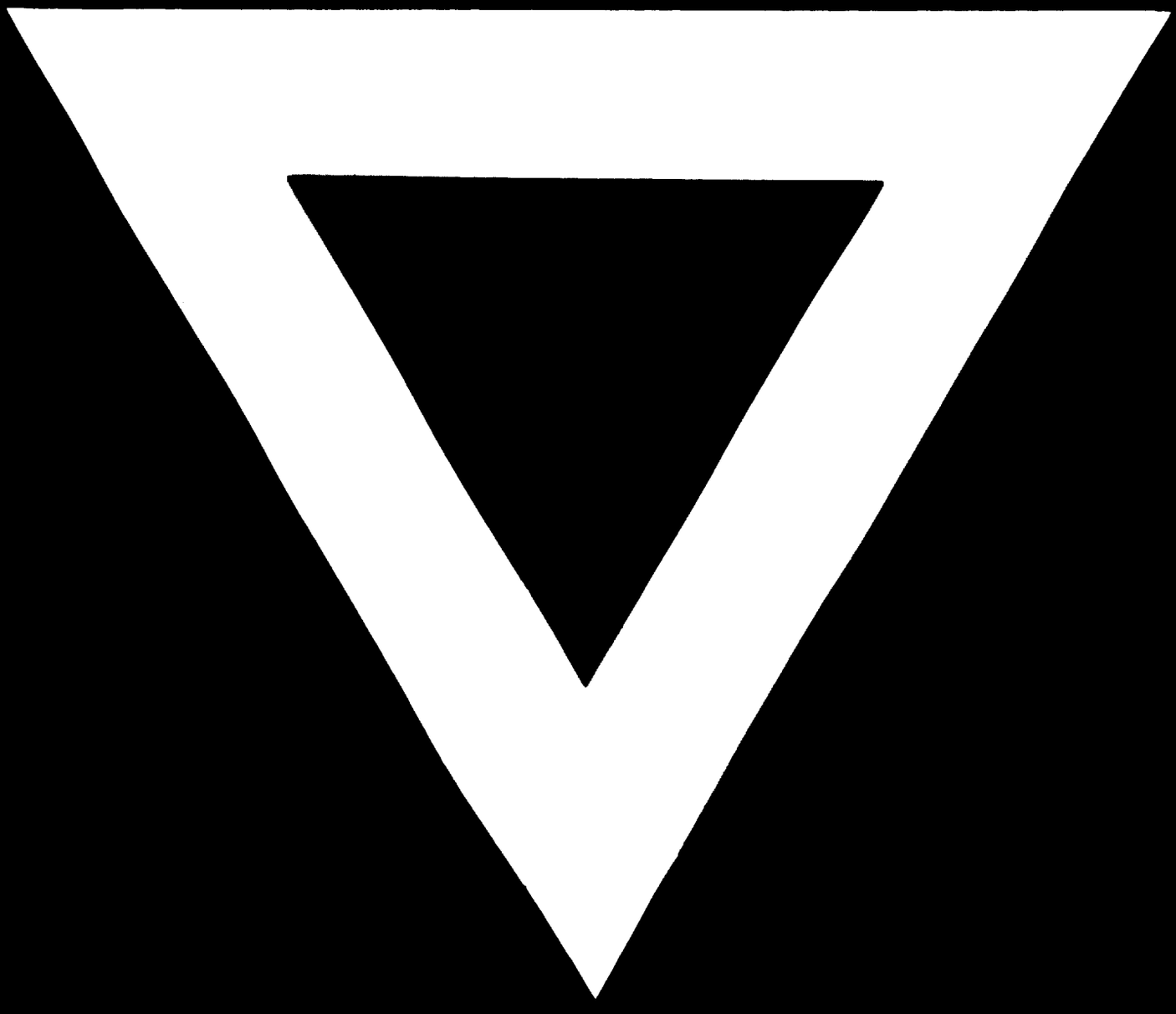
The above typical developments are illustrative of the current trends which could find considerable favour and applications in developing countries. Recently, Seminars and technical Symposia have centred round the role and development of pre-reduction of the metallic ore or pellet burden and electric smelting of pig iron. One 0.2 million tons output/per annum Project has been under active study in India in recent years based on pre-reduced burden for electric smelting of iron. An SL-RN Direct Reduction Plant of identical size including electric smelting of directly reduced sponge is nearing completion in South Korea whilst another unit is reported to be under installation in New Zealand.

The developing countries would be well advised to take into account these technological innovations in the production metallurgy of iron and steel.

There is little doubt that the growth of iron and steel industry in developing countries activates and comprehensively promotes the overall economic growth and general industrialization of the developing regions. It is necessary to encourage and step up these trends within the framework of optimum and acceptable techno-economic parameters. The argument that a developing country could always buy steel from advanced countries is no longer tenable or holds ground, involves as it does heavy drain of foreign exchange from the meagre and chronically short resources of the developing countries. What is therefore

needed is a balanced techno-economic appraisals and market evaluation of iron and steel industry's establishment and rational growth in developing regions of the world. It would be in the interest of and to the mutual good of the developed and developing countries alike, if the growth of iron and steel industry in developing countries follows such sustained and balanced trends in promoting which, the catalytic and promotional role of UNIDO would undoubtedly play an active part in the years ahead as it has been very much so in its early past.

Certain quarters always look askance and are deeply allergic to any scheme of medium or heavy industry including iron and steel projects in developing areas and countries and tend off-hand to reject any such venture as being beyond the domains of regional market potential and far beyond the national resources of capital funds required. This is not an appropriate or the right approach. Many developing countries have outstanding records of developments in the fields of iron and steel industry in the recent past, which is indeed a healthy sign. The United Nations Industrial Development Organization will strive hard to meet the aspirations of the developing countries in their drive towards iron and steel industrial self-sufficiency based on sound techno-economic rationale.



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