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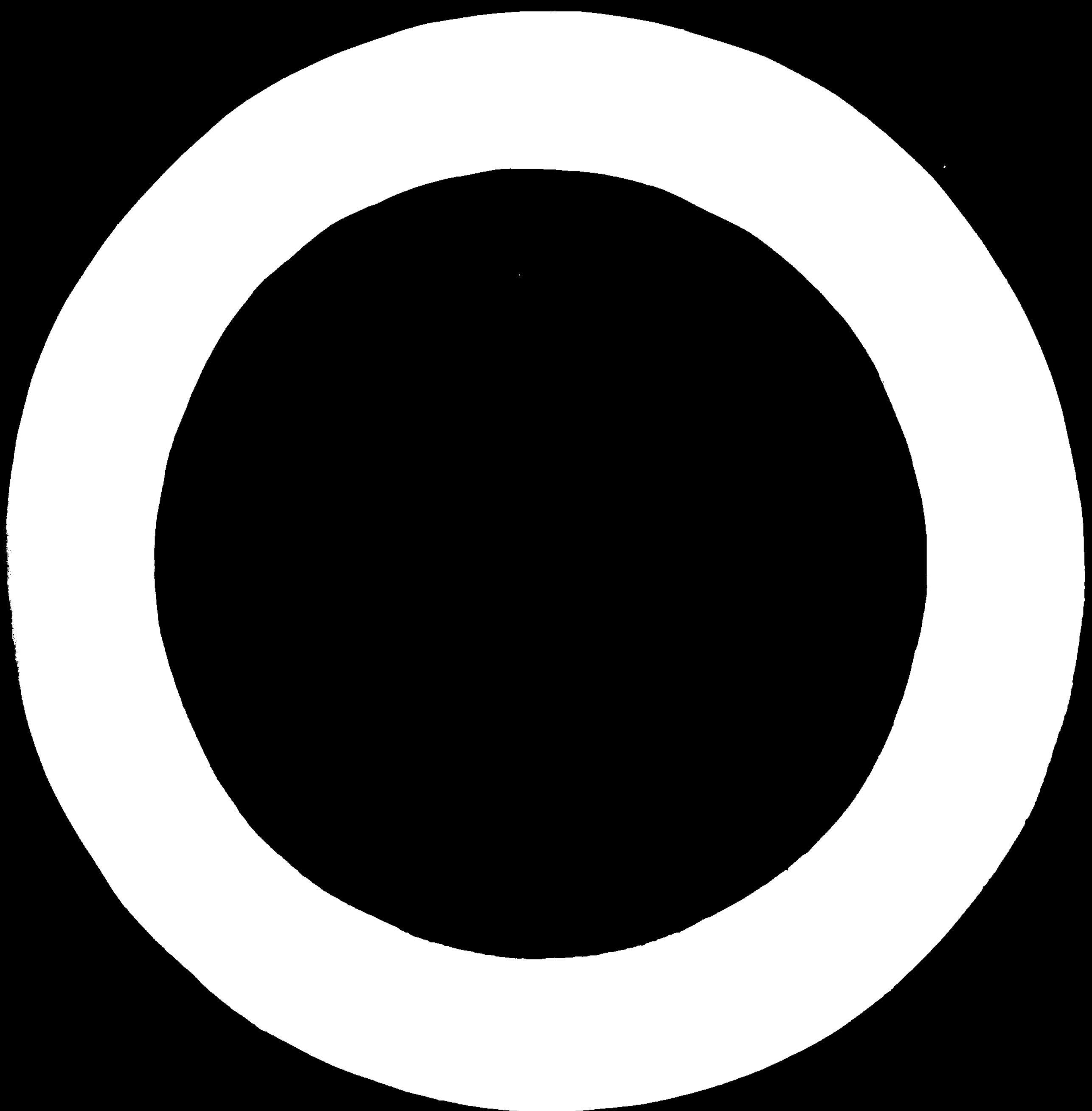
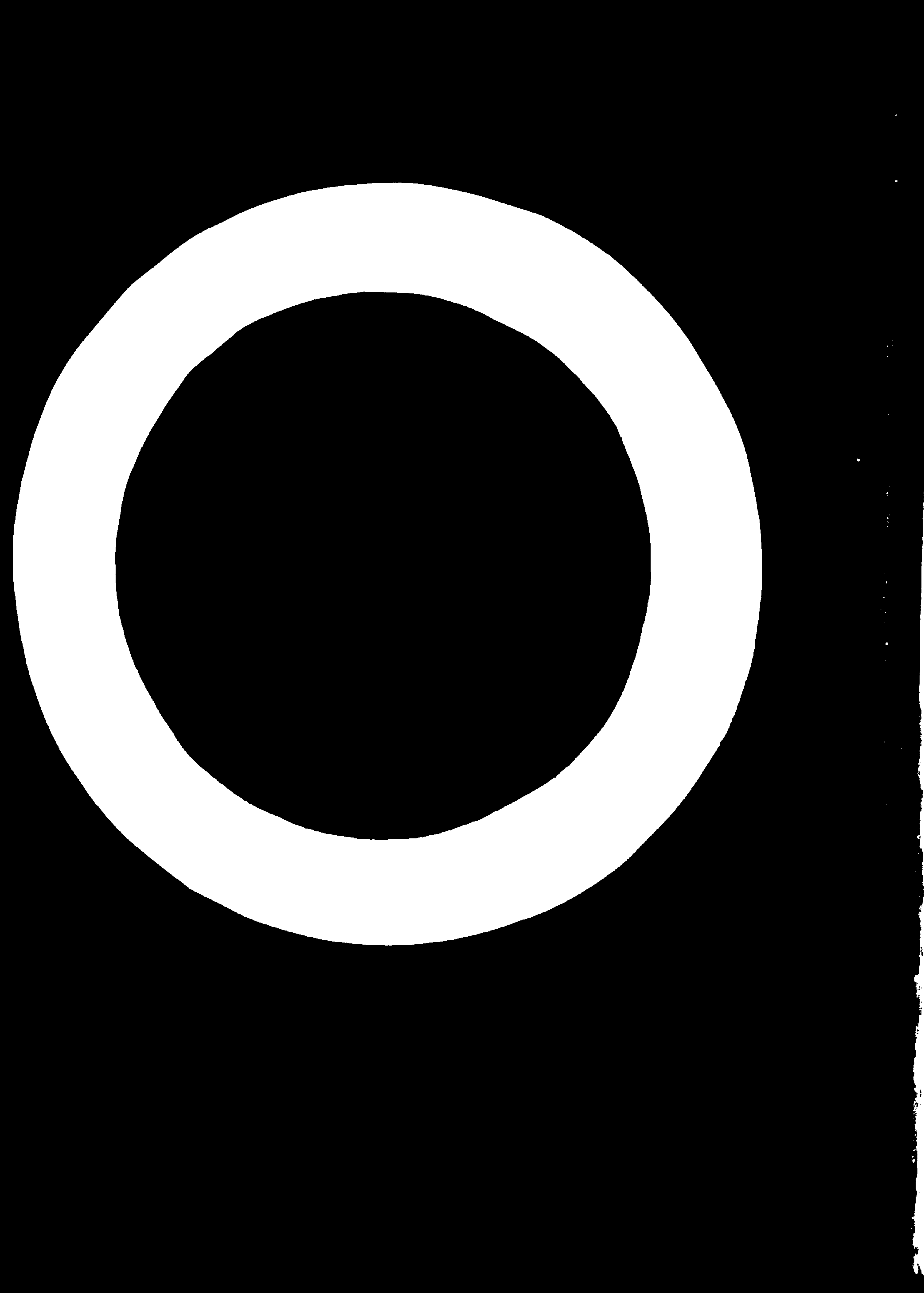
PROCEEDINGS

United Nations Interregional Symposium on the Application of Modern Technical Practices in the Iron and Steel Industry to Developing Countries

Prague-Geneva / November 1963

UNITED NATIONS





Department of Economic and Social Affairs

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UNITED NATIONS
New York, 1964

NOTE

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ST/CID/1

UNITED NATIONS PUBLICATION

Sales No.: 64. II.B. 7

Price : U.S. $ 2.00
(or equivalent in other currencies)

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INTRODUCTION

GENERAL

The United Nations Interregional Symposium on the Application of Modern Technical Practices in the Iron and Steel Industry to Developing Countries was held from 11 to 26 November 1963 with the following objectives:

(*a*) To establish closer contacts among the several nations represented at the Symposium, one with the other and each with the Centre for Industrial Development, on the basis of common interests in iron and steel industry developments;

(*b*) To make available to a large number of developing countries, and also to some more advanced nations, a body of information relating to ferrous metallurgy in order to help them to advance towards industrialization;

(*c*) To foster a broad awareness of the Centre for Industrial Development and its activities; and

(*d*) To develop bases for new meetings, seminars and symposia that might be incorporated into future programmes of the Centre around specific subjects relating to steel industry development and technology.

The Symposium represents the effective implementation of one of the tasks established in the work programme of the secretariat at the third session of the Committee for Industrial Development. It was sponsored by the Centre for Industrial Development in the Department of Economic and Social Affairs, the Bureau of Technical Assistance Operations (BTAO), the Economic Commission for Africa (ECA), the Economic Commission for Asia and the Far East (ECAFE), the Economic Commission for Europe (ECE) and the Economic Commission for Latin America (ECLA). The meetings, which were held first in Prague and then in Geneva, were attended by 126 experts in iron and steel research, development, plant operations and facility design, from fifty countries. Twenty-nine of these, or 58 per cent, may be considered "developing areas", and provided 36 per cent of the individual attendance at the meetings.[1]

The first six days, 11 to 16 November, were devoted to the presentation and review of technical documents in Prague. The Symposium members then formed six groups, each of which visited a separate European country — Czechoslovakia, the Federal Republic of Germany, France, Italy, Poland and the United Kingdom — to take part in an extensive inspection tour of steel plant operations and related facilities and establishments of the country visited. The Symposium then reassembled in Geneva on 25 and 26 November for summary discussions.

[1] A break-down of countries represented at the Symposium is given in annex I. A list of participants appears in annex II.

The Prague-Geneva meetings were, in effect, a specific extension of the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas in March 1963. The theme of the Symposium developed in great detail a single subject — the iron and steel production process — to which only one brief session could be devoted during the UNCSAT discussions. Even so, the technological advances made by the steel industry during the past decade have been so extensive that any comprehensive examination would have required more time than the fifteen days allotted to the Symposium. The scope of the meetings covered two main subjects: (*a*) the two initial phases of the steel industry operation — the preparation of iron and steel-making raw materials, and the conversion of those materials into the steel ingot; and (*b*) problems arising from the establishment and development of iron and steel operations in developing countries. In connexion with the first of those subjects, it was decided to defer consideration of the two "final" aspects of the steel production process — rolling and finishing — to a later meeting, if warranted by the results of this present Symposium.

The problems of preparation and conversion of iron and steel-making materials were considered in a world-wide context. The needs of the developing areas were emphasized primarily, but comparable situations in industrial countries were also reviewed in detail. This coverage of all levels of steel activity provided a preview of new tasks that may be self-engendered within a steel industry development programme and also insured a subjective interest in the meetings by both developing and developed countries.

PRAGUE DISCUSSIONS: 11 TO 16 NOVEMBER 1963

Sixty-two papers were presented at fifteen technical sessions in Prague.[2] Eleven of then were Secretariat papers, the main working paper, two introductory papers and eight regional reports, two by each of the Economic Commissions, dealing with the iron and steel-making raw materials position in their respective area and the current status of steel industry operations and planning within the regional boundaries of their responsibility. The remaining fifty-one papers, presented by a group of widely-esteemed authorities in the field of iron and steel metallurgy, covered the following subjects: iron ore, exploration and extraction (four papers); iron ore preparation (three); sinter practice (five); improvement

[2] A list of the papers presented at the Symposium appears in annex III. Some of these papers are available and requests for them should be addressed to the Centre for Industrial Development, United Nations Headquarters, New York.

or substitution of non-coking coals (three); blast furnace operation (two); special iron ore reduction processes (seven); modern steel-making practices (four); steel quality (one); continuous casting (three); electricity in steel plant operations (five); steel standards and standardization (two); technical and economic aspects of steel project planning and development (ten); personnel training and staff formation (one); and regional integration problems (one). Nine of the secretariat papers are reproduced here, together with summaries of the discussions on all the papers.

Inspection tours: 18 to 23 November 1963

One hundred members of the Symposium took part in the six plant inspection tours; 16 in Czechoslovakia; 11 in the Federal Republic of Germany; 15 in France; 19 in Italy; 18 in Poland; and 21 in the United Kingdom. Each tour group prepared a detailed report of observation and commentary on the steel industries facilities which were visited.

Each tour included visits to at least one major integrated steel works, three or more smaller non-integrated and/or semi-integrated plants; a research or testing institution devoted to iron and steel development; an engineering and design office; a training school for steel plant personnel; and an engineering works specializing in the production of steel industry facilities and equipment.

The six steel plant inspection tours benefited greatly from the valuable co-operation extended by steel industry organizations of each of the countries visited. The arrangements were handled with great effectiveness by the Ministry of the Metallurgy and Ore Mining Industries in Czechoslovakia; by the Chambre Syndicale de la Sidérurgie Française in France and Luxembourg; by the Wirtschaftsvereinigung Eisen- und Stahl-Industries in the Federal Republic of Germany; by the Associazione Industrie Siderurgiche Italiana in Italy; by the National Central Iron and Steel Board in Poland; and the British Iron and Steel Federation in the United Kingdom.

The following excerpt from the French tour report gives a typical picture of the inspection tours, and the reaction of those who took part in them.

"This report cannot do justice to the rich variety of the facilities seen, inspected and discussed. Each participant came with an awareness of some special problem of his country. On many occasions he could explore these problems in detail with the technical personnel at the plants visited . . . The inspection programme was designed to provide a maximum of information in each area of interest related to the scope of our meeting. In the field of ore extraction, we saw a typical mine, illustrative of the most recent developments of mechanization and high productivity operations. In the area of iron ore enrichment, we saw the first attempts at magnetic separation for certain ores of the region. With regard to ore agglomeration practice, we were shown how a quantity of mixed fines was processed to ultimately become part of a 100 per cent sinter charge to a blast furnace. We saw two of the processes described in Prague, for the utilization of poor-coking coals in the iron-making operation. We were able to see old-style blast furnaces whose performances were being improved by prepared ore in the burden, and also very modern blast furnaces working on crushed ore. In steel-melting areas, we were shown, or given full explanations, of the different procedures for applying oxygen techniques to the Minette phosphorous ores of Lorraine. Thanks to these visits, a number of points which were not conclusively settled during the discussion in Prague could be rounded out fully on the basis of information drawn from practical experience."

Geneva summary discussions: 25 to 26 November

One hundred and twenty-three of the original Symposium participants reassembled in Geneva on 25 November for two days of summary discussions. On the first day, representatives of each tour party presented reports of their inspection visits. The final day of the Symposium, 26 November, was devoted to a thorough examination of a tentative final report on the meetings, which was afterwards sent to all the Symposium members for comments. The report notes that the main problems facing the developing countries (with regard to the establishment of steel industry operations) are "insufficient or inadequate reserves of raw materials, especially coking coals; lack of capital necessary for steel project investments; limited transportation facilities; varying and occasionally unstable economic conditions; lack of trained manpower in sufficient number; need for a broad product-mix in plants of relatively small capacity; difficulty in establishing initial capacity levels consistent with probable early expansion needs". The manner in which modern technical steel industry practices may be used in the solution of many of these problems constituted the underlying content of most of the papers presented at the meetings, the relevant discussions and the conclusions reached.

I. OPENING OF THE SYMPOSIUM

The opening session on 11 November 1964 was called to order by Mr. Robert Muller, Director of the Symposium.

Mr. Josef Krejci, Minister of Metallurgical Industries and Ore Mining, welcomed the Symposium to Czechoslovakia. He observed that his country was well qualified to act as host to an international Symposium on the development and application of modern methods of iron and steel making by virtue of its long and established tradition in metallurgy. In 1879, the first heat of steel produced in a Thomas converter on the European continent was poured at Kladno, and in the same year the first application of the duplex process anywhere in the world occurred at the Witkowitz Iron Works. Today, Czechoslovakia's metallurgical tradition might be measured by a steel ingot production of 7.6 million tons, or 551 kilogrammes per person in 1962. Although the country's steel output fell below that of the first 10 steel producing nations, its high *per capita* production record placed it among the foremost industrially advanced states of the world. Czechoslovakia was determined to maintain this leading position by increasing its steel production and improving its metallurgical industry. The Minister was convinced that this Symposium would contribute to the initiation and improvement of mutual contacts among the many metallurgists present. Specialists from advanced countries and from developing nations would exchange technical, economic and social experiences. Such a broad interchange of views and experiences could contribute greatly to the solution of many metallurgical problems in the developing countries. For these reasons, the Minister was happy to greet the members of the Symposium and to bring them wishes for complete success on behalf of the Government of Czechoslovakia.

Responses to the opening statement and to the following welcoming address by Mr. Adolf Svoboda, Lord Mayor of the City of Prague, were read from Mr. William R. Leonard of the Bureau of Technical Assistance Operations and Mr. Arthur Ewing of the Economic Commission for Africa. Replies were also made by Mr. V. M. Subramanian for the Economic Commission for Asia and the Far East; by Mr. I. A. Iliuschenko for the Economic Commission for Europe, and Mr. Bruno Leuschner for the Economic Commission for Latin America.

A message from the Commissioner for Industrial Development, Mr. I. H. Abdel-Rahman, was then read to the meeting (see page 4), followed by an address by the Symposium Chairman Mr. Frantisek Houdek (see page 6) and a paper on "The modern iron and steel industry" prepared by the Technological Division of the Centre for Industrial Development (see page 7).

MESSAGE FROM Mr. I. H. ABDEL-RAHMAN, UNITED NATIONS COMMISSIONER FOR INDUSTRIAL DEVELOPMENT

The idea of holding the Iron and Steel Symposium was a natural outcome of two trends that have in recent years marked the efforts of the United Nations in the economic field. The first of these trends is the drive to promote and accelerate, by every means at our disposal, the industrial development of the poorer nations. This drive has found its most recent expression in the action programme of the United Nations Development Decade, in which industrial development has been singled out as one of the areas of highest priority. Also among the fruits of these preoccupations was the creation, two years ago, of the United Nations Centre for Industrial Development.

The second trend is the increased concern of the United Nations with the need for making available to the developing countries the fruits of scientific and technological advances as a basic tool in the struggle for development. This concern was reflected foremost in the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas held earlier this year in Geneva. In large measure, your Symposium may be viewed as a sequel and amplification of the section of that Conference which was devoted to iron and steel technology.

Scientific and technological research is still, by and large, a privilege of a small number of countries. Until recently, influenced by local conditions and environment, scientific and technological research has been primarily oriented to the resources endowment and to the requirements of the already advanced countries. This has certainly been true of iron and steel technology which has been conditioned for a considerable time by the availability in the Northern Hemisphere of cheap and plentiful coal as a source of energy.

Today, as is well illustrated by the documentation before you, increasing efforts are being devoted to the investigation of processes better suited or more adaptable to the conditions prevailing in the less developed regions. Direct reduction of iron ore and electric steel making can be cited as examples. Although some of these technological innovations can be traced back, in all objectivity, to preoccupations prevailing in the more advanced countries, it cannot be denied that part of the progress can be ascribed to a growing sense of solidarity among scientists and technicians the world over towards a better mastery of our physical environment. The furtherance of this solidarity and the stimulation of the concern for early and practical benefits for all fellow men from the results of scientific and technological research are obviously a task which must rank high among our preoccupations and which calls for measures towards a speedier international diffusion of newly acquired knowledge.

For one who has had occasion to experience at first hand the difficulties that a country in the process of industrialization may find when dealing with the problem of choosing the technology which is best suited for its particular conditions, this Symposium appears as one of the most important undertakings of an eminently practical character. The knowledge that the United Nations is organizing meetings such as this and that so many distinguished technicians have responded generously, by their writings and by their presence, to the call of the United Nations, will be a source of great satisfaction for all those concerned in the less developed countries with the task of industrial development.

From the papers which are before you, it is obvious that very profound technological changes are taking place in several phases of iron and steel production, with a combined effect that can almost be characterized as revolutionary. I am referring in particular to major improvements in the preparation of raw materials, to fuel injection and oxygen-enriched blast for blast furnaces, to the new oxygen processes of steel making, to oxygen injection in open-hearth furnaces; to vacuum melting and pouring, to continuous casting and to automatic control and partial automation of a wide variety of processes. Your Symposium has selected the most relevant of these technological innovations for scrutiny as to their applicability to iron and steel making in the less developed countries.

It is gratifying to note that your meeting is not limited to purely technical aspects. It reveals, on the contrary, a high awareness of the economic and cost aspects of the establishment of steel industries in the less developed countries. Most of the innovations just mentioned are conducive to greater productivity, to greater savings in raw materials which may be scarce in the less developed countries, and to the making of better and more economical products. These are considerations of paramount importance to countries in the process of development. It is often said that industrial development may nowadays be telescoped by applying to the less developed countries all the technological knowledge already acquired. But it cannot be denied that the less developed countries are often confronted with the economic impossibility of acquiring from abroad the elaborate and expensive equipment required in order to reap the full benefits of this situation. The solution of this problem may not be within the purview of your meeting, but it would have been difficult to conceive that it should not have retained your attention.

That the Government of Czechoslovakia should have so graciously invited the United Nations to hold this interregional Symposium on its soil can only be regarded as an expression of that country's concern with rapid industrial development, as exemplified by its own achievements, in attaining the highest industrial standards within a small geographic area. May the Czechoslovak authorities accept my gratitude for having, in so many respects, facilitated the organization of this Symposium.

Our gratitude also goes to the Governments and steel federations of France, the Federal Republic of Germany, Italy, Poland and the United Kingdom which have so kindly arranged for a number of steel plant visits to take place within the framework of the Symposium.

To all participants, may I extend my best wishes for the fullest success of your work.

STATEMENT OF THE CHAIRMAN, Mr. FRANTISEK HOUDEK

This interregional Symposium, organized by the United Nations Centre for Industrial Development, the Bureau of Technical Assistance Operations, and the regional economic commissions for Africa, Asia and the Far East, Europe, and Latin America, will concern itself with the "Application of Modern Technical Practices in the Iron and Steel Industry to Developing Countries".

"Modern technical practices" is a relative term. When small charcoal blast furnaces were being blown with cold air the use of a hot blast of 200° to 400°C was a "new" development. Similarly, the replacement of charcoal by coke and the scrubbing of blast furnace gases were once modern techniques. What was called "progressive and modern" yesterday is designated "normal" today; in a little while it will be considered "old", "traditional" and even "out-of-date", subject to replacement by "new" methods. Thus, technical progress continues to move forward, always directed towards the same goal: increased output and productivity, lower production costs and the best possible product quality.

It follows from the title of our Symposium that we will concern ourselves mainly with the problems of the developing countries. But in my opinion, the programme which we have before us will deal with problems that apply not only to developing countries, but to all countries. Even those which have a producing iron and steel industry will find much that is of interest to them.

Each country represented here has had its individual experiences. Some of these countries have decided to establish their own iron and steel plants, some are just looking into the matter, and others have already taken advantage of the rapid advances in modern technology to improve existing installations. The experience of each particular country depends on the objective conditions applying to its steel industry, its age, size and related background. Countries with established traditions in iron and steel operations will have experiences that have to do primarily with facilities based on the so-called classical methods. Countries which erected their metallurgical plants some 20 years ago, as in the cases of India, some of the Latin American nations and Australia, have already applied many of the modern techniques while expanding their iron and steel installations. Thus, some of these countries have a greater proportion of electric furnace steel plants compared with the developed nations. Even now, many of these countries have had some experience with the new practices, and they have been especially active in introducing continuous casting, oxygen steel-making, vacuum melting and other contemporary developments into their steel plants. As a result, most of the modern steel industry procedures which we shall discuss have already been studied to some degree in commercial applications by a number of nations represented here. Among these, the countries with the largest and oldest steel industries are not necessarily the most numerous.

Developing countries which are now planning to build steel plants and those which have just begun to erect such facilities face problems that are quite different from those confronting countries which already have established metallurgical installations. The former are more interested in today's new techniques since they must frequently select practices which are feasible with inferior raw materials with which they must nevertheless maintain reasonable production costs on facilities that involve minimal investments. Furthermore, they must solve problems dealing with such matters as plant location, transportation, materials handling, electrical distribution and the training of personnel from economic directors to foremen and technicians for complicated metallurgical operations. This Symposium will deal with most of these problems; there will be something of interest for everyone, be he from a developing country or from one with an established metallurgical background.

The Symposium will therefore be an excellent means to establish and intensify close personal ties among all of us — metallurgists, specialists and directors of iron and steel establishments from all five continents. Furthermore, it will facilitate the fullest exchange of technical and economic experience. The inspection tours of the steel industries of six countries — Czechoslovakia, Federal Republic of Germany, France, Italy, Poland and United Kingdom — will enhance and broaden the areas of interest of the numbers of the Symposium. Our success will provide for an ultimate success of other international conferences and metallurgical meetings which will surely follow soon as a continuation of this meeting which we open tonight. This Symposium is only a beginning.

In closing, I want to thank the United Nations organizations, and especially the Centre for Industrial Development and the Bureau of Technical Assistance Operations, that conceived and brought to fruition this Symposium which marks the start of a mutually useful co-operation among metallurgists from all the United Nations.

D03912

THE MODERN IRON AND STEEL INDUSTRY

(DOCUMENT SEC. 1)[1]

This meeting begins as the second year of the United Nations Development Decade draws to a close. The purpose is to examine an essential growth element in such a decade, the iron and steel production process which has contributed immeasurably to yesterday's industrialization and which will surely make an equal contribution to today's developments and tomorrow's further expansion.

The field for our inquiry is world-wide, including the largest as well as the smallest steel producing areas, even those — indeed, especially those — whose steel activities are still in the planning stage. For within the area of our interest in industrial development, the primary emphasis properly belongs on the needs of the less developed countries.

Attention will be focused upon only two of the four fundamental phases of iron and steel making, and it will be for us to decide at the end of these sessions whether, and when, we shall concern ourselves similarly with finished product rolling and treatment.

Our judgements will be based on consideration of the technical and economic merits of long-established procedures compared with those of new techniques of challenging potential. Ingenious preparation treatments of raw materials have altered concepts of quantities and qualities needed to support a steel project. Special burden compositions at the top, and multiple blowing of air, oxygen and hydrocarbon combinations at the bottom of blast furnaces have greatly increased daily outputs from a given shaft. Direct reduction with hydrogen or other gases offers tantalizing promises. The effectiveness of steel making with oxygen has already been proved conclusively by a fivefold increase in the rate of hourly production of high quality ingots. Ingot teaming, as known for a century, faces elimination today by the challenge of continuous casting.

All these considerations are embodied in the title of this Symposium, "The Application of Modern Technical Practices in the Iron and Steel Industry to Developing Countries". The comments which follow refer briefly to some of the important features of today's technology and their place in the modern iron and steel industry.

To evaluate the effect of today's steel technology on industrial development, it is necessary to examine their past mutual relationship. We can go back no further than 1769, when the basis for our industrial society was founded on a steam engine invented by James Watt. Slowly but steadily thereafter, the resulting impact on economic trends and national growth rates made itself felt. By 1827, the term "industrial revolution" was used for the first time to describe what was taking place.

What was taking place was a great and continuous rise in the quantity and the rate of production of material goods. For 50 years new machines of every description were turning out increased amounts of products to be distributed on new-laid steel rail lines to domestic consumers and over lengthening sea routes in steel ships to foreign markets. To support these novel applications of steam power the iron masters of the period were called upon to supply cast and wrought iron in unprecedented tonnages. In 1870, one hundred years after Watt had patented his steam engine, world pig iron production stood at 12 million tons. The United Kingdom provided 50.3 per cent of the total: its competitors were Germany with 11.6 per cent; United States, 14.1 per cent; France, 9.8 per cent; and Belgium, Austria, Hungary, Russia and Sweden, which together accounted for 13.6 per cent.[2] These eight countries represented the "developed" areas of 1870.

But 1870 was also 15 years after the introduction of Henry Bessemer's method for converting pig iron into steel, and William and Frederick Siemens' invention of the regenerative principle for the open hearth process to accomplish the same result. By that time the serious difficulties encountered by Bessemer's unit of 1855 had been resolved by modifications developed by Thomas and Gilchrist, and improvements by Martin gave to the original Siemens furnace an unequalled flexibility, enabling it to operate with almost any combination of scrap and molten pig iron. Thus modified, the two new steel-making processes were being used in an increasing number of successful commercial operations. Within a few years, they exerted a profound influence on the prevailing demands for pig iron and steel.

For both methods greatly simplified the materials and labour required for the cementation and crucible steel processes which they ultimately replaced, and both could be applied to larger tonnage scales of production. The result was a significant reduction in the cost of steel. As a consequence, steel began to replace cast iron (which was too brittle for wide application) and wrought iron (which could be produced only in relatively small quantities and was therefore both costly and of limited availability) as the primary structural material for an

[1] Paper prepared by the Technological Division of the Centre for Industrial Development.

[2] Belgium, 4.7 per cent; Austria, Hungary, 3.4 per cent; Russia, 3.1 per cent; and Sweden, 2.4 per cent. The figure for Germany includes Luxembourg (1.1 per cent).

expanding era of industrialization. The effective application, during the 1860-1870 decade, of the inventions of Bessemer and Siemens marked the birth of today's "modern" steel industry. It comes as a mild shock to find that industry to be only 100 years old.

For nearly 50 years, until the start of the First World War, the facilities of the steel industry were located almost exclusively on opposite sides of the Atlantic Ocean; in Europe (primarily the United Kingdom, Germany and France) and in the United States. The following twenty-year period, from 1920 to 1939,[3] saw the addition to that select circle of a small number of new steel enterprises in Asia and the Far East. The years following 1945[3] have been marked by the establishment and early expansion of steel plants in Latin America, and by the planning for new enterprises in Africa and Asia. The figures of the table illustrate the growth and development within the iron and steel industry since its inception a century age.

[3] The omission of the war years 1914/1919 and 1940/1944 needs no explanation.

World production of iron and steel (1870 to 1913; 1920 to 1939; 1945 to 1962)

(In millions of ingots in metric tons)

	1870-1913			
	1870		*1913*	
	Pig-iron	*Steel*	*Pig-iron*	*Steel*
Europe	10.34	0.47	46.10	43.74
North America	1.70	0.04	32.49	32.86
South America	...	—	—	
Africa	—	—	—	
Asia and Far East	—	—	0.50	0.30
WORLD TOTAL	12.04	0.51	79.09	76.90

	1920-1939			
	1920		*1939*	
	Pig-iron	*Steel*	*Pig-iron*	*Steel*
Europe				
West	21.50	25.14	41.91	54.23
East	1.28	2.21	18.51	24.17
North America	38.55	43.93	33.21	49.31
South America	0.01	0.03	0.28	0.21
Africa	—	...	0.30	0.37
Asia and Far East	1.30	1.27	7.75	9.51
WORLD TOTAL	62.64	72.58	101.96	137.80

	1945-1962			
	1945		*1962*	
	Pig-iron	*Steel*	*Pig-iron*	*Steel*
Europe				
West	12.37	18.91	77.88	110.85
East	9.66	14.15	67.73	96.20
North America	51.60	75.02	64.95	95.73
South America	0.48	0.39	4.24	5.74
Africa	0.56	0.54	2.26	2.58
Asia and Far East	3.66	5.66	57.17	55.94
WORLD TOTAL	78.33	114.67	274.23	367.04

DEVELOPMENT OF THE CLASSICAL PROCESSES — 1870 TO 1913

Pig iron and steel ingot production both increased steadily during the 1870-1913 period, but at unequal rates. Where pig iron tonnage was more than twenty times greater than steel ingots in 1870, production of both materials was approximately equal, 79 million tons to 77 millions, in 1913. Since that year, world output of crude steel has surpassed pig iron production consistently and by increasing amounts.

Since the average steel ingot is produced from a metallic charge containing a substantial amount of pig iron, the rise in steel output was largely responsible for a parallel advance in pig iron demand and, in turn, the growth in steel-making operations was dependent upon a corresponding expansion in blast furnace installations. Achievement of the latter did not need any fundamentally new methods for making iron comparable to the revolutionary changes that had been brought to the steel meltshop. For the iron producing units of 1870 were already effective technical instruments; they were small-scale forerunners of today's classical blast furnace, fuelled with coke and blown with a heated air blast. Coke, as a reducing agent, was used widely, but a fair number of furnaces were still run on charcoal.

The demand for ever-increasing tonnages of iron and steel established two main objectives for the industry in those years: first, to raise productive capacity by adding larger facilities and by expanding existing installations; and secondly, to meet competitive pressures which made minimum product costs essential. These ends were achieved mainly by adapting known processes to equipment and facilities of increased sizes and improved design. Within the area of our immediate interest, accepted methods were elaborated for large-scale raw materials exploration and recovery, and established transfer systems were extended for the more effective handling of large quantities of materials. At the mines, at the blast furnaces and in steel meltshops, major emphasis was placed on attaining greater outputs and lower production costs, and few fundamental technical concepts were introduced. In the main, 1870 to 1913 saw the perfection of the "classical" practices of the steel industry. Many of those practices, with minor modifications, are still in use today. Some of them will be described during our discussions; for example, Methods of Iron Ore Beneficiation and Concentration in paper A.4; the Charcoal Blast Furnace in B.3, and Standard Methods of Steel-making in B.10. Such papers will not only review the essential features of their subjects; they will also set a basis against which some of the more recently developed practices may be compared.

Although 1870-1913 saw relatively few fundamentally new processes introduced, there were many noteworthy innovations. Open pit mining on a maximum scale was developed at the Mesabi Range in the United States; some of the problems involved in the exploitation of this great iron resource, which for more than sixty years was the principal United States iron ore source, is described in paper A.3.

As the geology of the Mesabi Range was being delineated in 1891, the first electric drills were introduced at iron ore mines in England, with a resulting increase in output per man and a new accessibility to deeper seams that previously could not be worked economically. Such greater penetration made more thorough separation of ore and rock necessary. By 1900, mechanical ore cleaning was in use, and magnetic concentration of fines was also known. At that time, sintering of magnetic concentrates was introduced in Sweden. The first plant to produce iron ore sinter from accumulations of flue dust, ore fines and coke breeze was designed by John E. Greenawalt and built in Harrisburg, Pennsylvania. This was an intermittent type operation, soon to be matched by a continuous type sintering process designed and developed by Dwight and Lloyd. Among the five papers we shall hear on sintering is A.8, written by Mr. Greenawalt, who may be called the inventor of the iron ore sintering process and who, at the age of 96, is still active in the field.

Developments at the blast furnace were concerned mainly with pig iron output. The generalities of classical furnace practice were quite well known by 1870 and there were even furnace stacks 80 to 100 feet high, developed in England by Lowthian Bell. Bell had been responsible, since 1850, for much intensive research concerning the chemical reactions inside the furnace and the effects of changes in furnace lines, temperature and burdan composition. But even the best furnaces in England were in 1875 averaging only about 100 tons a day, and the typical unit about half that amount. Furnace outputs in America at that time were about the same and rather less on the Continent. In 1913, the blast furnace in the United States produced 350 to 400 tons of iron daily, approximately twice the output of the average European furnace. Among the American furnaces, however, were a number of units that were exceeding their designed daily capacity of 1,000 tons.

With larger blast furnaces came important reductions in coke rate. The 1880 furnace with a 2.6-metre hearth produced 65 tons of iron daily with a coke rate of 1.2. Ten years later a 3.4-metre hearth made 290 tons of iron daily with a 0.86 coke rate. Paper B.27 presents corresponding data for three furnaces with hearths of 9', 10' and 17', currently in operation at a single plant in Rhodesia. Daily production is 140, 190 and 670 tons with coke rates of 0.75, 0.75 and 0.70 respectively.

Coke was produced mainly in beehive ovens. By-product plants were installed between 1890 and 1900 in Britain, Germany and France, but the acceptance of by-product coke came slowly. It was not until well after 1880 that a generally accepted view that "by-product recovery spoiled the coke" [4] was overcome in Britain. In the United States the first by-product ovens were built in 1893, but by 1913 only a few of the larger integrated plants used by-product coke.

Bessemer and open-hearth furnaces soon established a firm monopoly in the steel meltshop. Twelve per cent of the 1880 production came from open hearth furnaces and 86 per cent from pneumatic converters. By 1913, the greater flexibility of the open hearth had made itself felt decisively and that process accounted for 61 per cent of all steel production, while 38 per cent was poured from converters. Another 230,000 tons of the 1913 steel ingot production were manufactured in electric furnaces.

In the steel shops, as elsewhere in the steel plant, the primary interest was in developing production units of the largest possible size. The standard Bessemer converter increased from 5 tons in 1870 to 35 tons by 1913. Side-blown converters, introduced around 1900, were slightly smaller. Open hearth furnaces, which were soon to

[4] Quoted from *History of the British Steel Industry* by Carr and Taplin. This excellent work has been drawn upon extensively in the preparation of this paper.

dominate the American steel industry, were being built for heat sizes averaging 100 tons in 1913. In Britain, interest in the Talbot process led to the installation of several 200-ton tilting furnaces in 1910. On the Continent, where high phosphorus ores had motivated a dominant pattern of basic Bessemer steel-making, open hearth furnaces, stationary or tilting, were somewhat less in evidence.

The demand for special purpose steels was reflected in the development of alloy steels in all steel-producing countries. Cutlery steels in England and Germany; iron-chrome alloys in the United States and France; manganese steels at Sheffield; silicon steels for the developing electrical industry; nickel steels for armour plate; tungsten-chrome alloys for high-speed tools; corrosion-resistant stainless steels; self-hardening alloys with varying amounts of vanadium, cobalt, molybdenum: all these had been developed before the outbreak of the First World War. The high temperatures required for the production of these specialties soon led to experimentation with electric furnaces, beginning around 1895. Among the first to recognize the possibilities of electric steel melting was William Siemens who, in 1881, demonstrated its feasibility by melting 5 lb of steel scrap in twenty minutes. By 1908, German electric steel output was nearly 20,000 tons, rising to almost 75,000 tons in 1913. Small electric furnace shops were also in operation in Austria, France, Italy, Sweden, Switzerland, the United States, Britain, Luxemburg and Spain.

Electricity was first used in the steel industry around 1890, mostly for driving rolling mills and other plant machinery. In 1894, it was proposed in England to use waste blast-furnace gases for the generation of electricity at the steelworks itself, and by 1900 this was a widely accepted practice. Electric power has since been an increasingly important element in all phases of the steel plant operation. The over-all electric power requirements in the steel industry are examined in paper A.20.

We shall end this review of the 1870-1913 period of the steel industry by citing two of its early development projects. In 1869, William Siemens produced steel by reducing a mixture of crushed ore and fuel in a rotating cylindrical furnace that discharged into a steel-melting furnace. After four years of small-scale trials Siemens expressed the belief that "the direct process . . . may be carried into effect with great practical advantage as to the economy of fuel, saving of labour and quality of material produced"; after which he built a commercial plant in 1877. Unfortunately, the operation was abandoned after two years because production costs were too high. At that time, Lowthian Bell wrote to Siemens, "I have a kind of instinctive opinion that the blast furnace will be difficult to eliminate."

Also, early in the 1850s, patents were obtained by Henry Bessemer on a method for the continuous casting of steel.

The inter-war period — 1920 to 1939

1920 was the beginning of an increase in crude steel production which, in the twenty years' space between the two world wars, saw nearly a doubling in world steel output from 73 million tons to 138 millions, in 1939. Early in the period, steel industry operations were disrupted by the sharp economic crisis of 1921. Recovery came relatively soon and 1922 marked the start of activities which, in eight years, brought world ingot production totals from 73 millions to 121 millions in 1929 when the surge forward was halted dramatically. Three years later, world steel output had dropped to a low point of 50 million tons. However, production began to increase again in 1933, and by 1939 it had reached a new peak of 138 million ingot tons.

Europe and the United States still dominated the field; together they accounted for approximately 97 per cent of total world production in 1922. One development is of particular interest: the United Kingdom, which in 1913 supplied 40 per cent of the world's steel, contributed only 9 per cent of the total ten years later.

By 1939, there were new members in the steel-making community. The Union of South Africa was producing 350,000 tons of ingot steel. In South America, small operations in Chile, Brazil, and Mexico provided a total of 200,000 tons. But the significant changes had taken place in the USSR and the Far East. The former had increased its steel ingot output from 300,000 tons in 1922 to over 17 million tons, almost 18 per cent of the world total. In the Orient, Japan's steel production had surged ahead to nearly six million tons of ingots. By 1939 two new major industrial areas had been established: Japan and the USSR. Together they accounted for 17 per cent of the world's steel production.

Just as the 1870-1913 period was mainly concerned with the perfection and improvement of the classical iron and steel-making processes, so too was the industry impelled primarily by a need for product-cost reduction and increased output between 1920 and 1939. In the United States, the million-ton plant was no longer considered "big", and the Sparrow's Point Works foreshadowed single integrated tide-water operations with annual capacities of over 5 million tons. In the USSR the Magnitogorsk Works was built between 1929 and 1933, and work was started in Germany on a huge complex, projected to ultimately include 32 large blast furnaces on a single site. The "modern" steel plant of the period was being planned with blast furnaces of over 1,300 tons per day capacity and with 150-ton and larger open hearths in the steel-making department.

In addition, imaginative innovations to the metallurgical process were being studied. A number of significant conditions had emerged after the war: raw materials' limitations, higher prices for equipment and supplies, and rising labour costs. These new factors stimulated critical economic and technical examination of all phases of the steel industry and its operating procedures.

The raw material problem stemmed from a simple basic cause: the original steel-making operations, based almost in all cases upon domestic iron ores and coal, were being confronted with dwindling high grade reserves of both. The United Kingdom, Germany and Belgium-Luxembourg found themselves forced to augment their own iron ore output with imports from Sweden, Spain and North Africa. In 1929, Belgium-Luxembourg imported 5 million tons of ore, almost twice the region's own production. Germany's ore imports of 10 million tons equalled five times the tonnage mined locally. The United Kingdom added 3 million tons of foreign ore to 4 million tons of home production. Japan's imports of nearly one million tons of ore represented more than 90 per cent of its requirements for that year. In the United States, concern was being expressed about domestic supplies of high grade ore, and steel producers were beginning to look about for foreign sources in Canada and South America. At the same time, steps were being taken to use lean ores. The situation was somewhat similar with regard to good coking coal, except that the shortages were generally more aggravated. Most countries with steel producing capacity had started their operations with a reasonable backing of domestic iron ore reserves; this was not usually the case for metallurgical fuel.

At the plant sites, large stockpiles of ore fines, flue dust and coke breeze stimulated the development of sintering. With iron ores being extracted from greater depths, utilization studies of pellets and nodules were being carried out widely. Procedures for concentrating lean ores by grinding, separation and magnetic roasting were introduced, especially but not at all exclusively, in the United Kingdom, Germany and France. The difficulties raised by growing scarcities of suitable coking coals were less easy to resolve; coal washing (to reduce excessive ash content) and blending (to "stretch" the available "good" grades of coal) techniques were already in use but they offered only a limited solution. Attention was therefore focused on the possibilities of new metallurgical processes that would reduce specific coke requirements for the production of pig iron. One such development was the electric smelting furnace in areas where electric power costs were favourable. With electricity providing the energy needed for heating and melting, metallurgical carbon was needed only to maintain the chemical reactions. This reduced the quantity of coke needed by approximately one-half, under conditions where much of the coke could be of a relatively inferior grade. We shall review the inherent characteristics of electric pig iron smelting in papers A.21 and A.25.

Following a more fundamental line, the possibilities of direct reduction were being examined. This, it was hoped, might eliminate the need for coke entirely by using hydrogen as a reducing agent rather than carbon. During the 1930s, gaseous and other direct means for removing O_2 from iron ore were being investigated widely. Except for a few applications, such as the Wiberg process in Sweden and the Krupp-Renn kiln in Germany, this work had not moved beyond the pilot plant stage by the beginning of the Second World War.

In the steel-melting departments, emphasis was placed upon better control of existing processes and higher furnace productivity. Electric steel furnaces which accounted for 230,000 tons in 1913 (0.3 per cent of world output) had risen, as a result of decreased electric power costs and improved furnace design, to 6 million tons (4.2 per cent of the world steel ingot total) by 1937. Nevertheless, the electric process for steel making was still a high-cost operation, carried out in small furnaces. Its use was restricted to alloy steel production from 100 per cent scrap charges.

By 1939, the open hearth process accounted for more than three-quarters of the total world steel ingot production, and furnace heats of 150 tons were being poured. To reduce heat time, increasing amounts of molten iron ("hot metal") were being used. Oil, coke oven gas and by-product tar had replaced producer-gas firing in the larger meltshops. Improved material handling was being developed to make the large multi-furnace open-hearth shop practical. These efforts were all aimed at reducing the average labour requirement per ton of steel ingot but the over-all result was only one of minor improvement in open-hearth productivity. Unit outputs from the best operations did not much exceed 12 to 15 tons per hour.

Aside from open hearth steel making, only the basic Bessemer process was used to any appreciable extent. In 1937, approximately 15 per cent of the world ingot output was being made by this method in bottom blown vessels. By that time, the principles of today's oxygen practice had already been studied and were known in considerable detail.

The interest in the use of oxygen in steel making was motivated not only by an attempt to raise production rates through an increased speed of metallurgical reaction, but also by the need to resolve a rolling mill problem that arose from nitrogen absorption which could be traced to the standard pneumatic steel process and, to a lesser extent, the open hearth. Nitrogen, even when present in minimal quantities, adversely affects the drawing properties of sheet steel. This was an increasingly troublesome matter since the early mid-1930s, as flat products came to represent larger proportions of the total steel mill product list. By 1937, details of a reasonable oxygen steel process had been worked out which largely eliminated the nitrogen absorption difficulty and, incidentally, appeared to offer interesting possibilities for higher rates of steel production. The immediate application of the process on a commercial level was delayed for two reasons: first, high purity O_2 needed for the new practice was expensive; and second, the pressures for maximum product output arising from growing preparations for the Second World War discouraged the construction of any new plants based on fundamentally new concepts.

In actual fact, the 1920-1939 period witnessed only one truly new development in the industry's technology. This was the multi-stand wide hot strip mill, operated on a continuous basis, in the rolling mill. Because of the limited scope of our inquiry, this interesting area of development must be left for some later meeting dealing with rolling and finishing the steel product. The continuity concept was actively explored in all phases of the steel industry operation. These studies revealed great opportunities for all departments, but any new practices to exploit such possibilities had to wait until after 1945.

THE "NEW" IRON AND STEEL INDUSTRY — AFTER 1945

At the close of the Second World War, the iron and steel industry was confronted with several sharp challenges. A post-war demand, destined to raise steel production from 115 million tons in 1945 to 367 million tons by 1962, was clearly indicated. To meet requirements for outputs of such magnitude it was necessary to undertake huge programmes of reconstruction where existing facilities had been destroyed, or where long years of operation had rendered them obsolete. Furthermore, it soon became obvious that the steel industry would have to give far more attention than ever before to the development or expansion of steel-producing potentials in many areas where local needs had been inadequately filled in the past.

Europe's recovery from the effects of the war was most spectacular, and the re-establishment of its steel industry was one of its more noteworthy accomplishments. Together, steel production of Europe and the United States provided 153 million tons or 95 per cent of a world total of 160 million in 1949. By 1960 this evident imbalance had changed dramatically. The European and U.S. combined output had gone up to 204 million tons by 1960, an increase of 52 million tons or 34 per cent. On the other hand, the 7 million tons produced in the "other" areas of the world had grown to 65 million, or 18 per cent of the total world production. The rise of 58 million tons occurred mainly in Japan (23.5 million tons) and in China (18 million tons). Many new nations were in the steel-producing fraternity in 1962, among them the following: in Latin America: Colombia, Chile, Peru, Uruguay, Venezuela, and also Cuba and Puerto Rico; in Africa: Algeria, Rhodesia and Tunisia; in the Far East: Burma, Pakistan, the Philippines and Australia; in the Middle East: United Arab Republic and Israel. Steel projects were also under consideration in Nepal, Honduras, Guatemala, Ceylon, Cambodia, Singapore, Indonesia, Formosa, as well as Senegal, Ghana, Nigeria and New Zealand. New steel plant projects are still being announced and the above lists are incomplete. The papers to be read at our technical sessions will refer to some of the problems involved in interesting phases of such projects in Peru (A.23), Australia (B.2), New Zealand (B.19), Chile (B.20), Rhodesia (B.27) and Venezuela (B.21).

The urge for new steel plants comes from many factors, not the least of which is the picture of improving living standards in almost all the industrialized countries as their steel outputs grew between 1950 and 1960. The European nations averaged a 130 per cent advance in ingot production: France, 100 per cent; Federal Republic of Germany, 140 per cent; Italy, 285 per cent; Belgium-Netherlands-Luxembourg, 94 per cent; the United Kingdom, 36 per cent and the USSR, 155 per cent. In the Orient, Japan's steel output increased 490 per cent; India, 180 per cent; Australia, 235 per cent; and Latin America as a whole, 240 per cent. One notable exception in this generally rising trend was the United States, where the 1961 steel tonnage was virtually unchanged from that of 1950. It must, of course, be remembered that percentage increases do not tell a wholly complete story. Japan's 490 per cent rise started from a 4.8 million base in 1950 to 23.3 million tons of ingots in 1961; in the United States, approximately 90 million tons of ingots were poured during both those years.

From all these figures one significant fact stands out: namely, an increase of 176 million ingot tons in 13 years, from 191 million tons in 1950 to 367 tons in 1962. This growth in steel production is expected to continue. The Economic Commission for Europe, in its *Long-Term Trends and Problems of the European Steel Industry* estimates world ingot production to reach 630 million tons by 1972-1975. Some forecasters judge this figure optimistic. If, for the sake of argument, the ECE anticipation be cut in half, a 1972 steel production of over 500 million ingot tons may still be expected. No one will deny that this is a very respectable annual output of steel ingots.

At this moment we are concerned with the production of the past decade. For the 10 years 1951 to 1960, the total world ingot production averaged 265 million tons a year. Steel outputs at such a level brought into sharp focus problems of raw material quantity and quality, process productivity, equipment and plant efficiency, capital investment requirements, product costs. Such matters had concerned steelmakers before the war and had motivated their inquiries into the possibilities of non-classical practice. Many of the researches of the 1930s — iron ore concentration and agglomeration, electric pig iron smelting, direct reduction, oxygen steel making, continuous casting — had been brought to the point of practical application when the war intervened. In the 1950s there was no such deterrent, and the need for improved techniques was even greater than a generation earlier. In terms of technological development, the stage was set for a "new" iron and steel industry.

The explorations for raw materials initiated in the 1930s were intensified. New iron ore sources were investigated in Canada, Norway, Pakistan, the Congo, Venezuela, Uruguay and New Zealand. The list may be continued almost indefinitely to include such places as the primary forests of Thailand and the Western Sahara Desert area of Algeria. Papers A.1 and A.2 will discuss the search for iron ore, the evaluation of newly found deposits and the problems of ore extraction on small and intermediate scales. An iron ore mining operation of major proportions in Liberia is described in paper A.24.

New methods for preparing iron ores, the utilization of which has hitherto been uneconomic, were elaborated in great detail. Sinter burdens, used for many years to absorb waste materials from the storage yard, were found to reduce coke rates and to increase the output of a given blast furnace. Sintered ore charges are therefore being used, in proportions up to 100 per cent, at an increasing number of blast furnaces. High sinter burden practice will be of direct interest to almost all iron and steel producers, since the technique may be useful in lowering both operating and capital costs for a particular iron-making department. For this reason, five papers (A.7 to A.11) have been devoted to this subject in our programme.

Two methods of ore preparation, designed specifically for utilizing the iron values of low grade ores, will be discussed: pelletizing, in paper A.5, and the Krupp-Renn kiln for high silica ores, in paper A.6.

The search for good coking coals has not led to the discovery of any unusual new sources. This stimulated many studies to find methods for using low-grade non-coking coals in the iron-making operation (A.17 and

A.19); to establish effective substitutes for coking coals (A.18, B.2 and B.28); or, both these alternatives being unfavourable for a given application, to develop new processes for iron ore reduction, involving minimal quantities of reducing carbon.

Intensive work on "direct reduction" has therefore been carried on throughout the industry. The results cannot yet be considered adequate to warrant any definite judgement, favourable or otherwise, except in specific cases. In Mexico, the HyL process has successfully been producing sponge iron by gaseous reduction in a 200-ton per day installation which has, in recent years, been supplemented by a 500-ton plant (paper B.6). Similar applications of minor size are the basis for operations that may be considered successful for special local conditions. Such applications include some practices with many years' background as, for example, the Wiberg and Hoganus process in Sweden (paper B.3); and other plants based on newer direct reduction systems such as Echeverria, in Spain (paper B.7) and the Strategic-Udy process that has, during the past year, been coupled with one of the large electric smelting furnaces in Venezuela (paper B.8). This by no means exhausts the long list of direct reduction processes that have been, and are, of interest in the steel industry. Some of these are described in papers that will be made available during the meeting (papers B.4, B.5 and B.25).

The widespread search for a successful direct reduction process may be traced back, as we have seen, for more than 100 years. This great interest stems from the need, in many areas including the industrialized countries, for a viable metallurgical practice that may be used where initial capacities may be small, iron ore resources limited as to quantity and quality, and coking coals scarce. A technically feasible direct reduction process might make a reasonable steel producing operation possible even with such restrictions. This has engendered high hopes for a direct process which must still be tempered by the fact that the great breakthrough in direct reduction has not yet been achieved, except in special cases.

At the blast furnace, the use of 100 per cent self-fluxing sinter burdens and other prepared charge materials has been supplemented by high top-pressure and the addition of oxygen and/or steam to the blast. To reduce coke requirements, hydrocarbons in gaseous, liquid or solid form are being injected through the tuyères. The technique has been adopted at many plants and should be of interest wherever natural gas or fuel oil are available and coking coals are scarce, conditions which are to be found in many of the newly emerging countries. The details and implications of these new practices at the blast furnace are reviewed in paper B.1.

The developments just referred to concern operations of large blast furnaces, including shafts rated at 2,500 to 3,000 tons of iron per day, but which are actually expected to produce 4,000 tons. On the other end of the scale, we may be attracted by Mr. Constantine's thesis in paper B.2, based on his experience in Western Australia, that a charcoal blast furnace producing up to 500,000 tons of iron annually may, under certain conditions common to some developing countries, be competitive with the standard coke blast furnace.

Electric pig iron smelting is considered in papers A.21 and A.25. Such units have been greatly improved and a large number are in operation. They include "big" 200-ton per day installations, burden with 100 per cent self-fluxing sinter that is belt charged, and operated from 33,000 kVA transformers, as in Mo-i-Rana, Norway, and in Venezuela where 9 similar furnaces are installed in the largest electric smelting plant in the world designed to produce some 700,000 tons of pig iron a year. Smaller electric furnaces for iron production are also in operation in Peru, India, Japan and elsewhere.

In the steel meltshop, the top blown oxygen converter has been definitely proved for more than five years, and vacuum melting has received increasing attention. Numerous modifications of the original oxygen practice have been developed, such as rotation of the vessel in the Kaldo (paper B.26) and Rotor processes; injection of lime directly or with the oxygen stream, for use with high phosphorus irons as in the OLP, LD-AC and similar processes (paper B.12); and in the extension of the use of oxygen to the open hearth furnace (paper B.11).

The use of oxygen in steel making has been recognized throughout the industry as a revolutionary development. Its acceptance by steelmakers everywhere in a relatively short period of time attests to the ability of the process to produce first-quality steels at high production rates and with favourable operating costs. The oxygen process in its many new forms has been studied exhaustively by the Economic Commission for Europe. The findings of its widely read report, *Comparisons of Steel-making Processes*, will be discussed in paper B.10.

The breakthrough achieved by oxygen steel making is now being duplicated in the development of continuous casting. Construction of more than 50 such installations has been started within the last five years and many of these are already in operation. Billets in sections upwards of 2″ square, and slabs over 60″ wide are being poured successively in nearly all grades and types of steel, and with high yields, in plants throughout the world. A recently-perfected change in the shape of the mould of the machine makes it possible to forecast even wider use of continuous casting, since the earlier high (or deep) installations may now be greatly reduced. Experiences with continuous casting during the past, and future possibilities of the process are outlined in papers B.16, B.17 and B.18.

While oxygen has been the great "stimulant" of the steel industry during the last few years, it nevertheless does not approach the broad influence exerted by electric energy as the main supporting service of the iron- and steel-making operation. The over-all requirements for electric power by the steel industry are described in paper A.20. In view of the flexibility of the electric steel-melting furnace and its adaptability to small plant installations that may be of interest in developing countries, special attention has been given to the use of electricity for steel ingot production in papers A.22 and A.23.

We have now completed an over-all review of the more important developments in metallurgical practice that mark today's modern iron and steel industry. Generally speaking, these new procedures must be considered supplementary, rather than alternative, to the classical practices that still account for the greater part of today's steel production. The blast furnace is very likely to remain, in Lowthian Bell's words of 100 years ago, "the optimum means of producing pig iron even after direct reduction methods are effected", and the great success of the oxygen converter does not necessarily mean the demise of the open hearth or the electric steel-melting furnace.

Nevertheless, for the specific conditions to which they have been applied, the new developments are undoubtedly of the greatest importance. Inadequate sources and resources of good raw materials, restricted market requirements and financial limitations which, two decades ago, would have impeded the development of a given steel plant project, no longer apply because of the new technical practices that are now available. This fact is of paramount importance to many emerging countries for whom prompt industrialization is essential for continued economic existence. The soil in which the roots of full economic development will flourish may, in some of those countries, be provided by an iron and steel industry whose feasibility stems largely from the new practices.

THE MODERN STEEL INDUSTRY IN THE DEVELOPING COUNTRY

We may, at this point, ask how all this very interesting information about the modern steel industry may be applied to a given country, and particularly to one with limited or no metallurgical background or experience. Given the raw material resources and the programmes for metallurgical development which will be presented by the various Economic Commissions (paper ECLA.1, ECA.2, ECAFE.2, ECE.1, etc.), what steps can be taken to reach proper decisions concerning any steel-industry project? Clearly, there will be no single formula to answer all the possible questions that may arise. But we may be able to benefit from recent experiences at steel-plant installation, expansion and rehabilitation projects. We shall turn to such examples to find replies to inquiries that are essentially of a non-technical nature; questions which seek to determine whether or not a given project should be undertaken even if the objective technical conditions seem to be adequate. We shall, for example, examine the basis of judgement for selecting where to locate a plant on a given site and how to choose that plant site in the first place. We shall try to define the alternatives for decision-making in matters of plant size, product-mix, operating costs, labour force and the many technical and other elements that determine economic feasibility for a metallurgical project.

Paper B.22 presents a step-by-step enumeration of the problems which must be solved in planning for a steel plant. A special point is made regarding the training of native operating and supervisory personnel in the emergent countries. Paper B.24 deals with this matter of staff formation. The experience of the past 25 years in a highly successful training programme, developed at the University of Pittsburgh for many Latin American steel-producing countries, is outlined with considerable detail.

The influence of small steel plants on the economic and industrial growth of developing countries is evaluated in paper A.12, which makes the interesting point that the initial size of a new plant is less important than proper provision for future expansion. The patterns for such expansion are discussed in papers A.13 and A.14, based on the experiences of Canada and India.

The factors that are involved in planning a project and the problems of the construction period will be reviewed in reports on four interesting integrated plants. Paper B.21 refers to an installation of major size, completed only last year in Venezuela. Pig-iron is produced in electric smelting furnaces, and steel refined in open-hearth units. As already noted, pre-reduction of the iron ore is being tested; studies are still being made to permit the use of low grade domestic coals instead of imported coke; and oxygen is lanced through the roofs of the open hearth furnaces. Paper B.20 describes the experiences with a plant in Chile, which was conceived initially as an intermediate-size operation for 250,000 tons of ingots yearly. After 10 years, the plant had doubled its output and its present capacity is being increased again to 600,000 tons through the application of more modern techniques and some additional facilities.

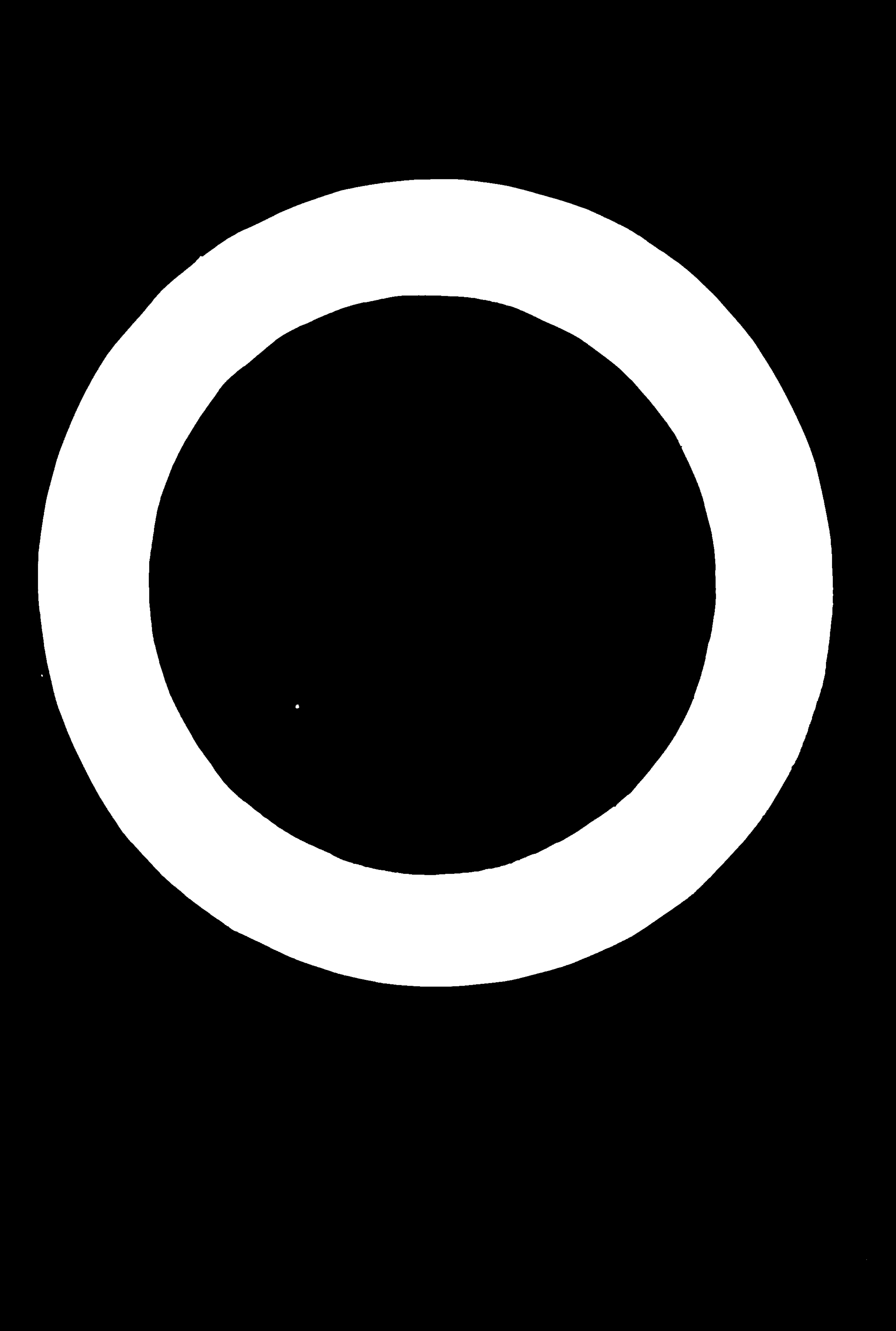
Paper B.19 reviews the problems that have had to be resolved at a new project now under way in New Zealand. A detailed exposition is made of the reasoning underlying the determination of the technical and economic feasibility of a new 150,000-ton a year plant. The project is to be based wholly on non-classical practices that will probably include concentration of low-grade iron sands, direct reduction, electric steel-melting and continuous casting. On a somewhat larger scale, paper A.15 discusses the parameters of a semi-integrated plant in Poland and highlights the problems encountered in an expansion programme that converted the facilities to a fully integrated operation.

Perhaps no single characteristic marks the over-all success of a steel operation so much as its ability to maintain a high level of quality at all times. Quality is sufficiently important to justify a seminar or symposium devoted wholly to that subject. Our programme could not provide time for a full discussion, but a very valuable introduction to the problem of quality in steel production is given in paper B.13.

Adequate steel standards, which are part of a rational over-all standardization programme, will always contribute to the maintenance of high quality. The experience with a standards programme in a single country, India, is presented in paper B.14; the results of a similar programme to establish unified steel standards for the entire Latin American region are reviewed in paper B.15. A second paper from Latin America, B.23, deals with the successful co-operative activities by the steel industries of eight neighbouring countries during the past four years, and reports on more recent efforts for regional integration in the area.

Most of the papers that are included in our programme contain economic data relating to the specific subjects that are being discussed. A general examination of the economic considerations for steel plants in developing countries is presented in paper A.16. This discussion deserves close attention, since it may well be that for some developing countries, whose financial resources may be limited, economic factors may outweigh technical considerations. Certainly, correct decisions relating to a steel plant project cannot be reached without examining related economic implications. There are some who believe that the developing countries would be well advised to devote their limited financial resources to projects outside the metallurgical field. In all good faith, the contention is put forward that the new countries could import their steel requirements at much lower costs than they could themselves manufacture the same products. On the other hand, there are others who hold, with equally good faith, that all newly developing countries must have domestic steel producing facilities if they are to grow in national and economic stature, and if their peoples are to attain decent standards of living. It is probable that there is some truth and some error in each of these positions.

The United Nations Centre for Industrial Development, to the extent that it may assist any country, newly developed or otherwise, to move forward economically and industrially, is willing and anxious to help to the full limit of its resources. Such help can include support and advice that may lead to an increase in steel consumption from domestic sources, if feasible; from foreign suppliers, if necessary; or by a combination of both, if desirable. By making such assistance available as widely as possible, all countries may be helped to move towards fuller economic development. This Symposium is dedicated to establishing an accessible direct path to the attainment of that goal.



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II. DISCUSSION PAPERS

RAW MATERIALS IN AFRICA FOR IRON AND STEEL MANUFACTURE

(DOCUMENT ECA.1)[1]

Introduction

The primary raw material for the manufacture of all iron and steel products is pig iron, which is produced from iron ore, coke and limestone flux. Iron ore may be partly replaced by scrap iron which in turn is ultimately derived from iron ore. It may be stated in rough figures that every ton of iron requires one ton of coal and half a ton of limestone. More than half the coal can be eliminated by electric smelting methods which use approximately 2,000-2,500 kWh per ton of pig-iron produced. Coal can occasionally be replaced by other forms of carbon e.g., natural gas or charcoal. Pig-iron for steel production requires varying quantities of manganese and the corresponding amount of ore is added to the furnace charge. Refractories are needed for the construction or lining of furnaces. Silica linings may be employed with an acid steel-making process whilst magnetic or dolomite refractories are used with the more common basic process.

This study intentionally omits two important constituents of iron and steel manufacture: water and electricity.

Water is admittedly a vital raw material since it takes 5-10 cu. m. of added water to produce one ton of steel. This represents 2½-3 per cent of the total circulating load. Any of the other raw materials can be transported over long distances from foreign sources to a viable steel industry as is the case in Italy, but water has to be in plentiful supply at the site. Inventories of surface and underground water resources were considered to be outside the scope of this study.

[1] Paper prepared by the secretariat of the Economic Commission for Africa. See page 121 for discussion.

Electricity is not usually named a natural resource unless it derives from water power. While an iron and steel industry would benefit from cheap hydroelectric power, this is not an essential condition. Some of the leading steel industries in the world, e.g., the United States, Great Britain and Germany, were developed without hydroelectric power. It was therefore decided to exclude actual and potential supplies of electric water power from the present study.

This report represents an up-to-date inventory for Africa of the mineral substances mentioned above. Each material has been treated under a separate heading. For purposes of presentation the countries have been listed under the following sub-regional groupings:

NORTH AFRICA

Morocco, Rio de Oro, Algeria, Tunisia, Libya, UAR (Egypt).

EAST AFRICA

Sudan, Ethiopia, Somalia, Kenya, Uganda, Rwanda, Burundi, Tanganyika, Nyasaland, Northern Rhodesia, Southern Rhodesia.

CENTRAL AFRICA

Cameroon, Chad, Central African Republic, Congo (Brazzaville), Gabon, Congo (Leopoldville).

WEST AFRICA

Niger, Nigeria, Dahomey, Togo, Ghana, Ivory Coast, Liberia, Sierra Leone, Guinea, Senegal, Mauritania, Mali, Upper Volta.

SOUTHERN AFRICA

Madagascar, Mozambique, Bechuanaland, Basutoland, Swaziland, South Africa, South West Africa, Angola.

Summary of iron-ore production and reserves in Africa
(Million tons)

The mineral deposits have been divided into three groups:

(*a*) Recognized and in production;

(*b*) Recognized deposits for which production plans have been or are being drawn up;

(*c*) Deposits where no extraction is envisaged at present and which are not necessarily of economic interest.

	1962 production	Reserve tonnages (*a*)	(*b*)	(*c*)
SUB-REGION:				
North	4.43	237	220	2.374
East	0.64	102	100	653
Central	0.01	—	860	370
West	6.73	1,539	1,404	1,283
Southern	4.83	253	400	6,843
	16.61	2,131	2,984	11,523

Summary of iron-ore production and reserves in Africa *(continued)*

	1962 production	Reserve tonnages (a)	(b)	(c)
By sub-regions				
North Africa				
Morocco	1.15	50	20	149
Rio de Oro	—	—	—	20
Algeria	2.06	140	—	995
Tunisia	0.76	27	—	30
Libya	—	—	—	1,100
UAR (Egypt)	0.46	20	200	80
Total, North Africa	4.43	237	220	2,374
East Africa				
Sudan	0.02	12	—	39
Ethiopia	—	—	—	8
Somalia	—	—	—	100
Kenya	—	—	—	27
Uganda	—	—	—	10
Tanganyika	—	—	—	121
Northern Rhodesia	—	—	—	300
Southern Rhodesia	0.62	90	100	47
Total, East Africa	0.64	102	100	653
Central Africa				
Cameroon	—	—	—	120
Central African Republic	—	—	—	—
Congo (Brazzaville)	—	—	—	—
Gabon	—	—	860	150
Congo (Leopoldville)	0.01	n. a.	n. a.	100?
Total, Central Africa	0.01	—	860	370
West Africa				
Niger	—	—	—	96
Nigeria	—	—	30	60
Dahomey	—	—	—	250
Togo	—	—	—	42
Ghana	—	—	—	1
Ivory Coast	—	—	—	344
Liberia	3.60	289	424	—
Sierra Leone	1.90*	100	—	100
Guinea	0.45	1,000	950	20
Senegal	—	—	—	125
Mauritania	0.78	150	—	185
Mali	—	—	—	10
Upper Volta	—	—	—	50
Total, West Africa	6.73	1,539	1,404	1,283
Southern Africa				
Madagascar	—	—	—	250
Mozambique	—	—	—	53
Swaziland	—	43	—	240
South Africa	4.33	200	400	6,000
South West Africa	—	—	—	300
Angola	0.50	10	n. a.	n. a.
Total, Southern Africa	4.83	253	400	6,843

Iron ore

North Africa

Morocco

This country produced 1.15 million tons of iron ore in 1962.

The most important known deposit is Uixan in northern Morocco, which accounts for two-thirds of the current output. The ore is hematite averaging 62 per cent iron with a low content of phosphorus and silica. The Setolazar deposit is in the immediate vicinity of Uixan; the ore is pyritic hematite and magnetite of 51 per cent Fe, and is mined by underground methods. The ore reserves of the Uixan-Setolazar deposit are 50 million tons.

The Ait Amar mine is Morocco's third producer. The deposit is 150 km west of C ..blanca and contains siliceous low grade ore with a fairly high phosphorus content. The remaining reserves of 30 million tons will have to be extracted by underground workings.

Several known deposits have been studied with a view to future exploitation. The most promising is Khenifra between Meknès and Marrakech: proved underground reserves are 27 million tons and an additional 32 million may be considered as potential. The ore is goethite averaging 43 per cent Fe with 10 per cent SiO_2 and a high barytes content. Attempts to upgrade the ore have met with partial success.

The following other deposits are also under study:

Tachilla-Ouarzemine	10-20 million tons,	40-45% Fe
Imi-N-Tourza	40 million tons,	50-52% Fe
Keradid	25 million tons,	40% Fe
Ait-Ahmane	10 million tons,	46% Fe

Rio de Oro (Spanish Sahara)

A titaniferous iron ore occurrence has recently been discovered at Agracha. The orebody has been drilled and sampled, and the tonnage is estimated at 20 million with a 54 per cent iron content.

Algeria

Algeria has been a substantial iron ore producer for many years.

The 1962 production was just over 2 million tons, all of which was exported. The various mines have an annual capacity of 4 million tons but the actual output is governed by sales outlets. The most important deposits are those of Quenza-Boukhadra with a proven reserve of 130 million tons of hematite ore, assaying 54 per cent Fe and 3 per cent SiO_2. Five other deposits have a total of about 10 million tons of ore reserves.

A substantial deposit of oolitic iron ore has been studied at Gara Djebilet near Tindouf in south-west Algeria. The probed tonnage established in 1961 represents 765 million of 57.5-58.3 per cent Fe. The probable and possible reserves total an additional 230 million tons with on avarage Fe content of 57+ per cent. The ore is principally magnetite which lends itself to dry magnetic concentration; the first trials have indicated a possible shipping product of 60+ per cent Fe.

The phosphorus and titanium contents are fairly high: 0.8 per cent P and 0.3 per cent TiO_2.

Libya

The only known deposit is the oolitic ironstone of the Shatti Valley in Fezzan Province. It is a mixture of hematite and goethite with high phosphorus and silica contents. A provisional estimate of tonnage and grade is as follows:

From 700 million at 48% Fe, 0.26% P and 17% SiO_2;
To 1,400 million at 42% Fe, 0.35% P and 27% SiO_2.

Tunisia

The main deposit is Djerissa which accounted for over 700,000 tons of the total of 760,000 tons of iron ore produced in 1962. The ore is hematite of 54 per cent Fe with a low silica and phosphorus content. The reserves are estimated at 15 million tons. The other producer is Tamera with reserves of 12 million tons assaying 49-52 per cent Fe and a little arsenic.

The oolitic ironstone of Djebel Ank is being explored at present. It is believed to represent 30 million tons at 53 per cent Fe.

UAR (Egypt)

Up to the present, the entire Egyptian production, which in 1962 amounted to 459,500 tons, has come from the Aswan deposit in Upper Egypt. The ore is oolitic hematite of 44 per cent Fe and 14 per cent SiO_2; the reserves are 20 million tons.

Another known deposit is located in the Eastern Desert. The ore is of the Lake Superior type, highly siliceous and assaying 43 per cent Fe; the total available tonnage is estimated at eighty million tons.

Present planning calls for the Baharya project to go into production in 1966. The deposit is located in the oasis of the same name, some 300 km south-west of Cairo. The estimated reserves are around 200 million tons of goethite with an Fe content of 50 per cent and about 10 per cent of manganese.

Egypt's iron ore production is scheduled to reach 1.2 million tpy in 1966 and 3 million tpy by 1970.

East Africa

Sudan

The most important iron ore deposits are those of Sofia and of Abu Tulu. The first produced 20,000 tons in 1962 from a deposit containing 12 million tons of magnetite with a 60 per cent Fe content and is scheduled to produce 100,000 tons of ore per year in the near future. The reserves at Abu Tulu are estimated at thirty-six million tons of magnetite with a grade of 61 per cent Fe.

Three smaller deposits have a total tonnage of 3 million of hematite with a +60 per cent iron content: amongst these is the Fodikwan deposit near the Red Sea which is to be exploited at the rate of 100,000 tons per year.

Ethiopia

The Agametta deposit in Eritrea has been considered a potential mining project for many years. The ore is magnetite of 60 per cent Fe and the probable reserves are around 3 million tons.

Another small deposit is being explored at present: it is at Yubdo in western Ethiopia. The tonnage has not yet been determined, but appears to be of the order of 5 million tons of magnetite assaying 60 per cent Fe.

Somalia

An ironstone occurrence to the west of Mogadiscio has not been explored to date as it is of doubtful value. A possible 100 million tons at 50 per cent Fe have been estimated.

Kenya

Deposits of iron ore have been prospected but are probably too small for production purposes. A pyritic lode at Bukara is estimated to contain 17 million tons. The hematite orebody at Homa mountain has an estimated tonnage of 10 million to a depth of thirty metres.

Uganda

The Tororo magnetite deposit has 10 million tons of proved reserves averaging 65 per cent Fe and 1 per cent P.

Tanganyika

The Liganga titaniferous magnetite deposits in southern Tanganyika were drilled in 1956-1957. The indicated tonnage is 45 million averaging 49 per cent Fe and 13 per cent TiO_2.

CENTRAL AFRICA

Cameroon

The deposit known as Les Mamelles is located in the coastal area, 40 km south of Kribi. The deposit forms part of a small mountain range, 7 to 8 km long and 200-300 m above the surroundings. The ore is a ferruginous quartzite. The reserve tonnage is estimated at 120 million of 33 per cent Fe.

Central African Republic

The Damara deposit is the only known occurrence of possible economic interest; it is a mixture of magnetite and hematite which was studied in detail in 1962. Iron ore formations have been reported in other parts of the country, e.g., in the M'Bari river basin and near Roandui, and might be prospected at a later date.

Congo (Brazzaville)

Iron ore outcrops in the north-west indicate possible extentions into Congolese territory of the Mekambo deposit in Gabon territory. There is also a good chance of the Tchibanga deposit in south-east Gabon extending across the border into the Mayombe district and this is being investigated. The Zamaga ironstone outcrop which was given much publicity recently is unlikely to be of real economic importance.

Gabon

The Mekambo deposit in eastern Gabon ranks amongst the most important in the world. It consists of a number of iron-bearing mountain ranges only three of which have been explored to date. The Boka-Boka's reserves are around 190 million tons of hematite, the Belinga tonnage is estimated at 570 million and the Batouala at 100 million. The average over-all grade is reported as 62.24 per cent iron. A transportation study is being carried out at present by the International Bank, and Mekambo is likely to become the biggest single iron ore producer in Africa in a few years' time.

The Tchibanga deposit has been known for many years since it is located only 80 km from the coast in southern Gabon. The proved reserves are 126 million tons averaging 40-45 per cent Fe but most of the ore does not lend itself to upgrading.

The Mebanga-N'Gama iron ore formations in northern Gabon near Mitzic are being explored at present. The Mebaga mountain has an indicated tonnage of 20 million of ferruginous quartzite with an iron content around 60 per cent. Similar conditions are found in the N'Gama range, 15 km to the south, on which information is not yet available.

Another deposit of titaniferous magnetite is at Hundusi in the eastern region. The possible reserves are 8 million tons at about 40 per cent Fe and 6 per cent TiO_2.

The banded ironstone deposit at Manyoro on Lake Tanganyika has not yet been closely examined. Estimates speak of a possible tonnage of 68 million at about 30 per cent Fe.

Northern Rhodesia

The total possible reserves are of the order of 300 million tons. The most important deposit is at Nambala, west of Lusaka. A conservative estimate indicated about 180 million tons of breccia type ore averaging 57 per cent iron and 18 per cent silica, and 10 to 50 million tons of shale replacement ore with 62 per cent iron and 9 per cent silica.

Several smaller replacement deposits are known in the Sanje area near Lusaka. The total reserves are about 25 million tons of hematite ore varying from 57 per cent to 69 per cent Fe, low in silica but with some phosphorus. Sedimentary ironstone formations occur around Lusaka. The most important is Nagaibwa with 27 million tons of 50-60 per cent iron and 15-20 per cent silica: the deposits at Pamba and Chongwe total 20 million tons of magnetite and specular hematite ore with a 60 per cent iron content.

The Kambumba orebody near Broken Hill contains hematite, magnetite and manganese. It is of the replacement type and has a tonnage of 33 million averaging 40 per cent iron and 18 per cent manganese.

Southern Rhodesia

The total proved and possible reserves of iron ore (mainly hematite) exceeding 55 per cent Fe are around 90 million metric tons. These are located in the Salisbury area and to the south of it.

The Bukwa area in the Bulawayo district has been partly drilled and the possible reserves are of the order of 100 million tons of high-grade ore containing up to 65 per cent Fe. Several substantial deposits are located between Salisbury and Que Que: amongst these are the Amyuma, Chikurubi and the Que Que deposit itself.

The Mongula and Manyoka deposits near the Mozambique border are estimated to contain 10 million tons at + 60 per cent Fe and a further 37 million at 30-45 per cent Fe.

Iron ore production in Southern Rhodesia was 618,614 metric tons in 1962, most of which was used for the production of iron and steel for the home market and for export.

The Monts Bilan range is located 40 km north-east of Kango and also forms part of the present prospecting campaign in this area. The ore has a very high silica content with an average of 33 per cent. The iron content is estimated at 45 per cent Fe. Several million tons of ore are indicated.

Congo (Leopoldville)

Iron ore deposits are known at Ituri in the Oriental Province, in South Katanga, in Maniema and in Kasai. The Ituri orebody is hematite ore with a 65 per cent Fe content. The other deposits average from 50 to 69 per cent iron. The orebodies have not yet been closely examined since their geographical location made them unlikely producers for export. The reserve tonnages are estimated at 10-50 million per deposit.

A small production is being maintained in South Kasai to serve the copper industry: the output in 1962 was 5,947 tons averaging 55 per cent Fe.

WEST AFRICA

Niger

The ironstone formation in the Niger basin south of Niamey has been studied in recent years. It is an oolitic goethite deposit which outcrops on the river banks. The ore is siliceous, high in phosphorus, with an iron content varying from 42-50 per cent. It does not lend itself to upgrading. The workable reserves are estimated at 16 million tons of 49 per cent Fe around Say and 80 million tons of 42 per cent Fe on the adjacent Kolo plateau.

Nigeria

Two main deposits are known and have been explored: Agbaja near Lokoja in the Northern Region is an oolitic deposit of twenty-four-feet thickness with an overburden of twenty feet of cemented laterite. The proved reserves of a portion of the deposit amount to about 30 million tons with 48 per cent Fe, 0.8 per cent P and 7 per cent SiO_2.

Enugu in the Eastern Region is a laterite deposit with a low grade iron content. The reserve of unscreened ore amounts to about 60 million tons of 32 per cent Fe. The ore can be upgraded by screening off fractions below 1/8" but this decreases the reserves to 20 million with an average content of 40 per cent Fe, 0.2 per cent P, 20 per cent SiO_2 and 0.8 per cent TiO_2.

There is no iron ore production in Nigeria at present but the Federal Government is planning an integrated iron and steel plant to utilize local raw materials. The mill is scheduled to move on stream by 1970.

Dahomey

Oolitic ironstone outcrops occur along the Niger in the north of the country. The mineral is goethite and assays around 50 per cent Fe, 0.8 per cent P and 7.25 per cent SiO_2. The Kandi iron ore deposit contains workable reserves of 250 million tons and may be considered an extension of the Say-Tamou deposit located eighty miles to the north in the Niger Republic.

Togo

The iron ore deposit at Banjeli in northern Togo was prospected from 1954-1956. The reserves are estimated at 42 million tons of highly siliceous ore of which 12 million average 48 per cent Fe whilst the other 30 million tons have an iron content of only 35 per cent.

Ghana

The only known occurrence is near Sheine in the northern region: about one million tons are available with an iron content averaging 46-51 per cent.

Ivory Coast

Iron ore mineralization has been prospected near the western border. A substantial low-grade deposit of itabirite is located on the eastern slopes of the Nimba range. In the vicinity of Guiglio, the Gao mountain is believed to contain some 150 million tons of magnetite ore averaging 42 per cent Fe.

A sedimentary ironstone deposit is known at Sassandra on the coast, west of Abidjan. The oolitic type ore forms a layer of 2 to 6 m thickness below an overburden of clay, 1-2 m deep. The reserves are estimated at 194 million tons averaging 40 per cent Fe.

Liberia

There are four principal iron-ore deposits:

(1) Bomi Hill. In 1962 the Liberia Mining Co. produced the following types of ore:

Open-hearth	697,000 tons	66.5% Fe, 0.1% P, 4.0% SiO_2
Blast furnace	742,000 tons	62.6% Fe, 0.12% P, 4.7% SiO_2
Fines	331,000 tons	62.0% Fe, 0.12% P, 5.8% SiO_2
Concentrates . .	1,376,000 tons	64.0% Fe, 0.08% P, 0.2% SiO_2
	3,146,000 metric tons	

(2) Mano River. The deposits contain two types of ore, siliceous and aluminiferous, both with an average Fe content of 56 per cent. Extraction started in December 1961: the following tonnages were produced up to 31 March 1963:

Crude ore	1,852,000 mt
Concentrates	1,143,000 mt

(3) Nimba. Production is scheduled for the second half of 1963 at an initial rate of six million tpy. The ore is a mixture of martite and goethite with an average Fe content of 65 per cent.

(4) Bong. Production and export are due to start in 1965. The mineral is itabirite and the run of mine ore averages 37.5 per cent Fe and 42.0 per cent SiO_2. The

project calls for concentration into a shipping product with 65.0 per cent Fe, 6.5 per cent SiO_2, 0.05 per cent P and 0.02 per cent S.

SUMMARY OF LIBERIAN IRON ORE RESERVES IN MILLION METRIC TONS AS OF 1 APRIL 1963

	Proven	Probable	Total
Bomi Hill	42	8	50
Mano River	20	26	46
Nimba	227	86	313
Bong	269	35	304
	558	155	713

The Liberian authorities expect an annual production rate of 19-21 million tons when all the mines are in full operation.

Sierra Leone

The Marampa deposit has an estimated tonnage of 100 million. The ore is hematite averaging 48 per cent Fe which can be upgraded to 65 per cent. The annual production for 1962 was 1.9 million tons of concentrates.

The Tonkolili deposit is also substantial but unlikely to be developed in the near future. Its estimated reserves are in excess of 100 million tons of magnetite and hematite with an Fe content of 56 per cent.

Guinea

The Conakry deposit has been worked since 1953. It covers practically the entire peninsula of Kaloum which extends over 35 km with a width of 1 to 6 km between Conakry and the mainland. The lateritic ore is divided into two layers: the upper is 8 to 10 m deep and consists of hard, compact mineral which averages 51.5 per cent Fe, 0.06 per cent P, 0.10 per cent S and 12.1 per cent H_2O. This ore is divided into two types depending on whether the chromium content is below or above 1.2 per cent. The bottom layer is 8 to 25 m deep and consists of soft light ore containing 56 per cent Fe, 0.5-0.6 per cent Cr and 0.3-0.4 per cent Ni. Present production is confined to the hard ore at an annual rate of around 500,000 tons. Because of its chromium content the demand for this type of ore is limited.

To date only one-third of the deposit adjoining Conakry has been fully explored. The total reserves of the Kaloum peninsula are of the order of 1,000 million tons.

The Kade deposit in north-western Guinea is a fine-grained sedimentary orebody with indicated reserves of fifteen to twenty million tons. The Fe content is not known.

The Yomboieli deposit is located 110 km east of Conakry in the Marampa formation which is adjoining Sierre Leone and encloses the deposit of the same name. The reserves at Yomboieli are estimated at 4.5 million tons with an average Fe content of 46 per cent.

The Nimba-Simandou deposits near the Liberian border contain a considerable tonnage of high grade ore. Reserves of 250 million tons have been reported at Nimba and 700 million tons at Simandou. In both locations the ore is hematite containing more than 65 per cent Fe. A 200-million-dollar project has been drawn up and initial production is scheduled for 1966.

Senegal

The only known deposit is at Saraya on the western bank of the Faleme River, some 800 km from the coast. The reserves are estimated at eighty million tons of martite and magnetite averaging 60 per cent Fe. There are an additional forty-five million tons of lower grade material of 53-54 per cent Fe which can be upgraded to 58-59 per cent.

Mauritania

Port Gouraud occupies a leading place amongst the high-grade iron ore producers of the world. The Kédia Idjil mountain range is 25 km long and 10 km wide. Massive quartzite outcrops on the eastern and northern flanks of the range and some ten major concentrations of hematite of +60 per cent Fe occur along this outcrop. It is estimated that 150 million tons can be extracted by open pit methods. Two of the deposits, Tazadit and Fderik, are being exploited at present. Their reserves are 90 million and 27 million tons respectively, averaging 65.5 per cent Fe, 0.04 per cent P and 0.0025 per cent S.

In 1962 785,000 tons were extracted and stock-piled at the mine. The first shipment to Port Etienne on the 650 km railroad occurred in June 1963.

The annual production target is 1.8 million tons for 1963 and 4.5 million tons as from 1964. A production rate of 6 million tpy is scheduled after 1966.

Three possible sources of iron ore are known in the region of Akjoujit:

(*a*) The copper project of Guelb Moghein could yield some 10 million tons of magnetite concentrates averaging 67-68 per cent as a by-product from the treatment of the oxide and sulphide copper minerals.

(*b*) The hematite deposit of Legheilat El Kader has reserves of fifteen million tons assaying 52-53 per cent Fe, 0.13 per cent P and 0.9 per cent Mn. The mineralized surface lenses have a thickness of 10 to 20 m.

(*c*) Quartz-magnetite outcrops form the crest of a 100 km range south of Akjoujit. The ore in sight is estimated at 160 million tons averaging 40 to 50 per cent Fe.

Mali

A limestone replacement deposit has been prospected at Nioro in western Mali. The total tonnage is estimated at 10 million tons of magnetite with an iron content of 63 per cent Fe.

Upper Volta

The titaniferous magnetite deposit of Tin Edia is located some 250 km north-east of the capital, Ouagadougou. A possible tonnage of fifty million has been estimated, averaging 52-54 per cent Fe and 7-15 per cent TiO_2.

SOUTHERN AFRICA

Madagascar

Several deposits have been studied in recent years with a view to establishing an iron and steel industry on the island.

Fasintsara is located in the eastern coastal range, 90 km west of the port of Mananjary. There is a substantial tonnage of ferruginous quartzite ore 20-45 m thick, but the iron content is low and decreases in depth. Some 30 million tons of 36 per cent ore are at the surface and a further 15 million of 34 per cent are from 100-200 m below the surface.

A little further to the south and 120 km from Fianarantsoa is the deposit of Bekisopa. The mineralization consists of magnetite veins and lenses in a small mountain range. A recent study indicates 10 million tons of 60 per cent Fe and an additional 60 million averaging 30-35 per cent Fe.

The Moramanga deposit is favourably located 90 km from Tananarive and close to the railroad leading to the coast. It is a lateritic deposit with an important content of nickel, chromium and titanium (1.5-2.1 per cent). The estimated reserves are 38 million tons averaging 46 per cent Fe.

Betioky is only 40 km from the Sakoa coalfield in south-eastern Madagascar. The ore is a low grade mixture of limonite and hematite. It is easily crushed and might lend itself to electro magnetic concentration. The probable reserves are estimated at 10 million tons of 28 per cent Fe: an additional 20 to 30 million tons are considered possible.

Mozambique

The Machedua orebody in the Tete district has been computed at 50 million tons. The mineral is titaniferous magnetite averaging 50 per cent iron, 18 per cent TiO_2 and 0.7 per cent vanadium.

A recent aeromagnetic survey of the Fingoe region confirmed some known magnetite deposits and led to the discovery of others. The total tonnage of the orebodies already discovered is estimated at 3 million tons.

Bechuanaland

A high-grade iron ore deposit occurs at Bikukunuru, some 30 km south-east of Serowe. The deposit consists of two low hills and is associated with limestone. The orebody is mainly massive hematite with a 64 per cent iron content. The reserve tonnage has been provisionally estimated at 250,000 tons but the extension of the orebody in depth is at present unknown. A similar iron ore occurrence is located 80 km further south where a layer of banded magnetite of 1.0 to 1.5 m thickness has been traced for some 5 km.

Swaziland

The Ngwenya deposit, previously known as Bomvu Ridge, lies 50 km north-west of Mbabane. The ore is of sedimentary origin, hematite in banded ironstone. The two constituent orebodies have been closely explored and the following probable reserves established:

Castle Block	31.6 million tons at 62.6% Fe plus 450,000 tons float ore at 64.3%
Lion Block	11.0 million tons at 61.1% plus 100,000 tons float ore at 62.6%

The ore also contains 0.4 per cent manganese and 4.2 per cent silica.

Preparations for mining the deposit are well advanced: the initial production rate is set at 720,000 tpy and this is to be stepped up to 1.1 million tons for the subsequent nine years.

The Iron Hill deposit lies east of the Transvaal border. This orebody also consists of hematite in banded ironstone. The probable reserves are 4.5 million tons of 54.8 per cent Fe and nine million of 45.4 per cent.

Three other iron formations are probably not of immediate interest to the iron and steel industry in spite of substantial reserves:

(1) The Gege deposit has a probable tonnage of 55 million plus a prospective 90 million of limonite which averages 40 per cent Fe, 6.5 per cent Mn and 20 per cent SiO_2.

(2) The Maloma orebody contains 30 million probable tons of magnetite of 30 per cent Fe and 42 per cent SiO_2, and an additional possible tonnage of 45 million.

(3) The siderite deposit of Forbes Reef has a total of 6 million tons of probable and prospective ore. A borehole sample gave the following analysis: 38 per cent Fe, 2.9 per cent SiO_2, 0.1 per cent TiO_2.

South Africa

The 1962 production was 4,331,336 metric tons averaging 60 per cent iron.

The bulk of the production came from the Thabazimbi deposit in the Transvaal which has proved and potential reserves of several hundred million tons of hematite ore with an iron content of 57-60 per cent and low in phosphorus and sulphur.

Another substantial deposit is located near Postmasburg in the Cape Province. The mineral is hematite and the proved tonnage is about 200 million averaging 61 per cent Fe, 3.5 per cent SiO_2 and 0.05 per cent P.

A sedimentary deposit of oolitic chamosite occurs near Pretoria. The siliceous ore has an iron content ranging from 40 to 50 per cent and contains 0.1-0.3 per cent of phosphorus. The indicated reserves are of the order of several thousand million tons.

The Minerals Bureau in Johannesburg has transmitted the following figures on the estimated iron ore reserves of the Republic of South Africa:

	Million metric tons
High grade (+55% Fe)	1,200
Low grade (40-55% Fe)	5,400
Titaniferous ore	2,000

South West Africa

There are relatively large iron ore deposits in South West Africa, but reserve tonnage figures are not yet available. The Windhoek deposit has been estimated to contain 300 million tons of potential ore with a high silica content. No production is reported since 1958 when some 8,000 tons of iron ore were extracted.

Angola

Practically no information on Angola's iron ore resources is available. The most important known deposit appears to be Cassinga in southern Angola which is scheduled to produce at an annual rate of 2.5 million tons. In central Angola the iron ore mines of Cuima are the main deposit from which it is hoped to extract 250,000 tons in 1963.

Summary of coal production and reserves in Africa

(Million tons)

	1962 production	Reserve tonnages *(a)*	*(b)*	*(c)*
North Africa				
Morocco	0.370	100	—	—
Algeria	0.053	60	—	—
Egypt	—	—	70	—
East Africa				
Ethiopia	—	—	—	10
Tanganyika	0.001	20	280	43
Northern Rhodesia	—	—	—	50
Southern Rhodesia	2.826	800	-	15
Central Africa				
Congo (Leopoldville)	0.076	120	—	—
West Africa				
Nigeria	0.634	40	190	72
Southern Africa				
Madagascar	—	—	60	—
Mozambique	0.297	4	—	5
Bechuanaland	—	—	—	500
Swaziland	—	250	—	—
South Africa	41.275	42,745	—	—
TOTAL	45.532	44,139	600	695

Coal and lignite

North Africa

Morocco

The Jerada coalfield is at present the most important producer in North Africa. In 1962 370,000 tons of anthracite were extracted: the acual productive capacity is double this figure. The reserves are estimated at around 100 million tons.

Algeria

Considerable reserves are reported at Colomb Bechar, site of the Houillères du Sud-Oranais. The coal is of poor quality with an 18-25 per cent ash content. Narrow seams render the extraction uneconomic.

Tunisia

No coal deposits are known, but a lignite deposit on the Cap Bon peninsula has been prospected. The reserves are estimated at 20 million tons with a 45 per cent C content and 40 per cent volatile matter.

Egypt

Two deposits are found on the Sinai Peninsula; the coal seams outcrop at Maghara and are 500 m below surface at Ayen Moussa. Exploration is taking place at present and indicates a total tonnage of 40-100 million. Although this coal is young, it has a low ash content and relatively high calorific value. Preliminary tests show that it has coking qualities, attributed to the presence of resin.

A substantial deposit of carbonaceous shale is also known on the Sinai peninsula. The indicated reserves are several hundred million tons of material averaging 30 per cent carbon, 30 per cent ash content and with a calorific value of 1,700-2,200 cals/kg.

East Africa

Ethiopia

The Nejo deposit in Wollega province is being prospected at present. The indicated reserves are 10 million tons of semi-coking coal.

Tanganyika

The Ruhuhu coalfields represent a valuable reserve of coal; there has been no extraction to date because of the remoteness from markets and lack of good communication. Extensive exploration has established over 280 million tons of proved reserves and another 28 million tons of possible coal. The material is bituminous, non-coking with a calorific value of 7,000 cals/kg and a high ash content.

Amongst smaller deposits is the Songwe-Kiwira coalfield at the northern end of Lake Nyasa with proved reserves of 20 million tons. It produced 1,200 tons in 1962 for local consumption.

Mhukuru near Songea in south Tanganyika has a possible tonnage of 8 million of poor quality coal. The reserves of the Galula coalfield near Mbeja are unknown. Isolated deposits near Lake Rukwa have an indicated tonnage of 7.5 million.

Northern Rhodesia

The Kandabwe coalfield near Choma is the best known deposit of coal in the territory: it has been explored by shafts and drillholes. A coal seam averaging about 4 m in thickness has been proved over a strike length of 8 km and to 150 m below the surface along the dip. It is very likely that the seam persists to a depth of several hundred metres but the required drilling has not yet been completed. The potential reserve is estimated at 50 million tons of all types of coal. About three-quarters of this tonnage is of inferior quality, averaging more than 20 per cent ash and less than 5,500 cals/kg.

Numerous other coal occurrences are known but have so far not been considered to be of economic interest.

Southern Rhodesia

The Wankie and West Sebungwe coalfields have proved reserves of coking coal estimated at over 800 million tons and additional possible reserves of 250 million tons. The 1962 production amounted to 2,826,000 metric tons.

An approximate analysis of an air dried sample is as follows:

	Per cent
Moisture	1.5
Ash	11.0
Volatiles	25.5
Fixed carbon	62.0
	100.0

Sulphur is 1.6-2.4 per cent and the calorific value is 13,320 BTU/lb or 7,400 cals/kg.

Another deposit of economic interest is the Bubye coalfield in the south-eastern part of the country which is reported to have 15 million tons of proved reserves.

There are also substantial tonnages of poorer quality coal:

Wankie	300 million tons of 25-30% ash
W. Sebungwe	160 million tons of 14-32% ash
Sabi	4,530 million tons of 32-37% ash

Central Africa

Congo (Leopoldville)

The Luena and Albertville coalfields in Katanga have proved reserves of 120 million tons. The coal is young with a high ash content and a high percentage of volatile matter. The annual production was 247,000 tons in 1960 but the installations suffered heavy damage during the recent fighting and the output dropped to 76,253 tons in 1962.

West Africa

Nigeria

The main coalfield extends northwards from Onitsha and Enugu in the Eastern Region. The geological survey of 1960 divided the deposits into six main areas; the total probable reserves are 230 million metric tons, with an additional possible tonnage of 72 million.

The Enugu area has been the sole producer to date. About 20 million tons have been extracted so far, of which 633,930 metric tons represent the 1962 production. The probable reserves of the Enugu coalfield are estimated at 40 million tons with another possible tonnage of 12 million. The Enugu product is bituminous, non-coking coal with good gas-making qualities. It is proposed to use Nigerian coal rather than coke for the projected iron and steel plant by employing a pre-reduction technique.

Deposits of lignite are reported around Sokoto and Kano in the Northern Region and around Ibadan and Lagos in the Western Region. The reported reserves in this last area are 75 million tons.

The total tonnage of Nigerian lignites is of the order of several hundred million although it is not known how much of this can be exploited economically.

A sample taken from a fifteen-foot seam in the Onitsha area showed the following composition:

	Per cent
Moisture	12.3
Volatiles	52.2
Fixed carbon	30.7
Ash	4.8
	100.0

Cal. value 6,100 cals/kg

No lignite is being mined in Nigeria at present.

Sierra Leone

The lignite reserves are estimated at 2 million tons. The various deposits are dispersed, of poor quality and with much overburden; they are therefore considered to be without economic importance.

Southern Africa

Madagascar

The Sakoa coalfield in south-east Madagascar has been under study for the last twenty years. There are five distinct seams. The coal from four of these has an excessive ash content. The seam of present economic interest, No. IV, has a working thickness of three metres and contains 50 to 60 million tons of coal within 400 m of the surface.

The coal is of the non-coking type and similar to the material extracted from the Witbank field in South Africa: 25 per cent volatile matter, 17 per cent ash and 0.6-1.3 per cent S. Production to date has been on a small scale to satisfy local needs.

Mozambique

The Moatize coalfield in the district of Tete produced 297,000 tons in 1962. The reserves are as follows:

	Tons
Proved	1,350,000
Probable	2,962,000
Possible	5,113,000

The coal has 16-20 per cent volatile matter, 14-27 per cent ash content and some sulphur.

Apart from the Moatize coalfield there are indications of other substantial coal reserves in the Tete district.

Bechuanaland

The Protectorate has important reserves of coal which are favourably situated near the railroad in eastern Bechuanaland. The known resources are bituminous, non-coking coals of good steam-raising quality. The Mamabule coalfield has two principal seams close to the surface: the upper coal is over five metres thick and the reserves developed over a limited area total 220 million tons. The lower coal is of better quality and has a 10.7 per cent ash content; the reserves proved to date are around 150 million tons. The area investigated so far forms a small part of the full coalfield area.

The Morapule coalfield has proved reserves of 130 million tons down to 120 metres depth, with ash contents of 12 to 18 per cent. The coal of the Mookane area is of a highly volatile type with a considerable ash content.

Swaziland

The Mpaka deposit has been explored by drilling and two inclined shafts. The main seam is first-grade anthracite and has an average thickness of three metres. A coal seam with coking properties has been intersected by drillholes some 30 m below the main seam, but has not yet been fully explored.

It is expected that the Mpaka colliery will go into production very shortly to supply the Swaziland railway, the sugar mills and sundry consumers in the territory. The coal should be suitable for export because of its high calorific value of 7,450 cals/kg, reasonably low ash content of 12.3 per cent and almost smokeless characteristics.

South Africa

Has almost unlimited bituminous coal reserves in the Provinces of Transvaal, the Orange Free State and Natal. The proved reserves of coking coal are 5,870 million tons, the proved reserves of other coal are reported as 36,875 million tons. Total coal production, including coking coal for 1962 was 41,275,000 tons. The output of the fifty-three mines represented about 90 per cent of the coal production of the entire African continent. In 1962 production costs in South Africa were the lowest in the world.

Deposits of lignite occur in nearly all the provinces. Most of the reserves are small and the lignite is of such an inferior quality as to be of no economic importance.

Limestone

North Africa

There are substantial deposits in every North African country. Production figures are not available excepting for the United Arab Republic where 4.2 million tons were extracted in 1962.

East Africa

Sudan

No exact estimate is available, but the reserves are of the order of hundreds of millions of tons. The two main occurrences are at Atbara and at Jebelein: both orebodies are marble averaging 98 per cent calcite.

Ethiopia

Substantial limestone deposits lie around Addis Ababa in the canyons of the Blue Nile.

Kenya

The resources of limestone are extensive: present production is obtained from deposits ar Mombasa, Turoka near Kajiado and at Koru. There are also large reserves in south Nyanza and in north-east Kenya.

Uganda

The reserves are extensive.

Tanganyika

Limestone deposits occur in many places along the coast.

Rwanda

The main deposit is at Ruhengeri which produced 1,000 tons in 1962.

Burundi

Several large deposits of fairly pure limestone are known. The present production is 840 tpy.

Northern Rhodesia

The output for 1962 was 460,000 tons. The Ndola deposits accounted for over half of the production. Substantial limestone formations are also known around Lusaka; the Chilenga deposit produced some 150,000 tons in 1962.

Southern Rhodesia

There are various deposits of limestone throughout the country. The estimated reserves of high-grade material are reported at 700 million tons. Production in 1962 was 615,400 tons.

Central Africa

Cameroon

A limestone deposit of about 1.2 million tons is being investigated in northern Cameroon, near the Chad border.

Chad

The only known outcrops are near Cameroon's border; the indicated tonnage is around 70,000 tons of impure limestone.

Central African Republic

Limestone formations occur in the Oubangui river basin, some 40 km downstream from Bangui. No tonnage estimate is available: the calcium carbonate content is reported at ninety per cent. The overburden is considerable.

Congo (Brazzaville)

Substantial deposits are located near Dolisie in the Niari river basin.

Gabon

The Achouka limestone deposits in the Ogoué river basin will be prospected in the near future. The indicated reserves are about 1.5 million tons averaging 73-74 per cent $CaCO_3$.

Congo (Leopoldville)

Numerous limestone deposits are known in the Lower Congo, Kasai, Kivu, Oriental Province and in Katanga where 197,090 tons were extracted during 1962. The total reserves are reportedly of the order of tens of millions of tons.

West Africa

Niger

A substantial outcrop crosses the country from north to south, into Nigeria. Exploration work at Malbaza near the frontier has proved some ten million tons.

Nigeria

Limestone occurs in almost every province in Nigeria. Limestone deposits suitable for cement manufacture are located near Enugu in the Eastern Region, near Aveokuta in Western Nigeria and at Sokoto in the north. A chemically pure limestone, almost a marble, is found near Lokoya, some forty miles from the Niger River. Extensive drilling has proved at least 20 million tons averaging 98.5 per cent $CaCO_3$. Limestone also outcrops some thirty-five miles north east of Enugu and within three miles of the railway: the reserves are estimated at 8 million tons.

The total production of limestone in 1962 was 722,159 metric tons.

Dahomey

The only known limestone deposit of commercial interest is at Arlhan, sixty miles north of Cotonou, where the installation of a cement plant is under study. The deposit is estimated at 9 million tons with a calcium carbonate content exceeding 80 per cent. The area is affected by seasonal flooding.

Togo

Some minor limestone occurrences have been reported in southern Togo.

Ghana

The Nauli deposits are considered sufficient for all the country's future needs.

Senegal

Substantial limestone deposits are at Bargny which supply a cement plant with an output of 200,000 tpy.

Mauritania

Limestone has been reported in the Akjoujit region.

Upper Volta

Limestone is found in the extreme north of the country at Oursi near the Mali border. The isolated location and apparent lack of water have so far discouraged a systematic exploration programme.

Southern Africa

Bechuanaland

Limestones are widespread throughout the territory. Massive pure calcite veins are known in the northern part of the Bamangwato area.

Swaziland

At only one place have any appreciable quantities of calcite been discovered. This is on the slopes of Nsalishe Hill, south-east of Hluti, where prospecting has proved two veins with 97 per cent calcium carbonate. The probable reserve tonnage exceeds 10,000.

South Africa

There are considerable reserves of limestone in the Republic but actual figures are not available. The 1962 production of lime and limestone was 687,506 tons.

South West Africa

Limestone occurs in South West Africa: total limestone production in 1962 was just below 3,000 metric tons.

Refractories

North Africa

Morocco

There is no actual production of magnesite. An orebody at Beni Buxera near Tetnan contains 30,000 tons of 90 per cent magnesite. A substantial deposit of good quality dolomite is known at Oued Beth in the Meknès area.

Silica sands are found in the vicinity of Oudja and of Meknès.

Algeria

There are plentiful supplies of dolomite and magnesite and the reserves of silica are considerable. The deposit in the Oran region produced 27,700 tons of Kieselgur (diatomite) in 1962.

Tunisia

Substantial occurrences of silica and dolomite. No magnesite.

Egypt

Dolomite is produced from a deposit near Suez: 36,000 tons in 1962. Silica is also common. No magnesite deposits are known.

East Africa

Sudan

There are three occurrences of magnesite but no detailed information is available. Silica is found as quartz in many locations.

Ethiopia

Some small outcrops of dolomite and magnesite are known.

Kenya

Magnesite veins occur in several localities and have been worked sporadically at Kinyiki Hill, Kipiponi, where there are substantial reserves of low-grade material. Quartz deposits have been worked at Kinyiki Hill and also in the Sultan Hamud area. Quartzites also occur near Nairobi.

Tanganyika

Small deposits of magnesite are known at Gelai near the Kenya border and at Chambogo in north-east Tanganyika. Reserves have not been established but Chambogo has an indicated tonnage of about one million with 34 per cent magnesite.

High grade silica sands are present near Dar es Salaam and in various places on the shores of Lake Victoria, notably near Bukoba.

Northern Rhodesia

Dolomite is found in various parts of the country and is being mined for road making and building materials. There are no known occurrences of magnesite.

A deposit of silica sands is located near Kapiri Mposhi to the north of Broken Hill. The estimated reserves amount to 100,000 tons, and the material has the following content after a heavy media separation: 99.0 per cent silica, 0.3 per cent alumina, 0.08 per cent ferric oxide and 0.2 per cent combined lime and magnesia.

Southern Rhodesia

Reserves of high grade dolomite are found in the Sincia and Urungwe districts and are estimated at 550 million tons.

The 1962 production of magnesite amounted to 10,540 tons from the Gatooma area where the reserves are substantial but no tonnage estimate is available.

Silica occurs in numerous parts of the country and the indicated reserve tonnage is about ninety million. The 1962 output of 10,575 tons came from the Gwelo area.

Central Africa

Cameroon

An alluvial deposit of aluminium silicate near Edea in western Cameroon is being investigated. The reserves are of the order of 20-50 thousand tons and the material seems suitable for the manufacture of high-alumina refractories.

Congo (Brazzaville)

Substantial formations of silica occur near Pointe Noire in the coastal region.

Congo (Leopoldville)

Silica sands and quartzite are found in several localities in the Lower Congo. They serve at present for glass manufacture and construction purposes. No information is available on several dolomite occurrences which are worked for local uses. There is as yet no knowledge of any magnesite deposit.

Western Africa

Nigeria

Dolomitic limestone occurs in several provinces but there has been no extraction to date. There are very large deposits of sand in the sandstones near Enugu; no tonnage estimate is available.

Upper Volta

The dolomite deposit of Samandeni north of Bobo-Dioulasso has probable reserves in excess of 15 million tons and averaging 16-18 per cent MgO and 22-26 per cent CaO. A very much smaller deposit is that of Tiara to the west of Bobo-Dioulasso where the calcium and magnesium contents are a little higher.

Deposits of quartzite clay abound around Bobo-Dioulasso: this rock might be a source of raw material for the manufacture of silica refractories.

Southern Africa

Swaziland

Silica of extreme fineness occurs on Simelane Hill in the Mankaiena District. The deposit has an estimated strike length of 120 m with an average width of 45 m. To a depth of 15 m the reserves are estimated at 200,000 tons.

South Africa

Reserves of dolomite and silica are known to be large but actual figures are not available. Total silica production during 1962 was 199,492 metric tons.

Actual figures of estimated reserves of magnesite are not available either: the 1962 production was 92,852 tons.

Summary of manganese ore production and reserves in Africa

(Tons)

	1962 production	Estimated reserves (a)	(b)	(c)
North Africa				
Morocco	571,000 *	5,500,000	1,500,000	—
Algeria	—	—	—	1,500,000
Tunisia	—	—	—	60,000
East Africa				
Egypt	151,000 *	n. a.	n. a.	n. a.
Sudan	500	1,000,000	—	1,000,000
Ethiopia	—	n. a.	—	—
Kenya	—	—	—	600,000
Northern Rhodesia	46,721	1,000,000	—	—
Southern Rhodesia	7,238	—	—	—
Central Africa				
Gabon	203,000	200,000,000	—	100,000,000
Congo (Leopoldville)	300,000	5,000,000	n. a.	n. a.
West Africa				
Niger	—	—	—	50,000
Ghana	379,434	10,000,000	—	—
Ivory Coast	102,953 *	1,000,000	—	3,000,000
Mali	—	—	—	3,000,000
Upper Volta	—	—	—	10,000,000
Southern Africa				
Bechuanaland	24,000	500,000	n. a.	n. a.
South Africa	1,464,740	60,000,000	—	30,000,000
Angola	14,068 *?	n. a.	—	—
TOTAL	3,264,654	284,000,000	1,500,000	149,210,000

* Concentrates.

Manganese

NORTH AFRICA

Morocco

The 1962 production figures were:

457,000 tons concentrates, 30-50% Mn

and 114,000 tons concentrates, 80% Mn.

The most important deposit is Dmini, south-east of Marrakech in the Atlas mountains. The reserves are estimated at 3.5 million tons with an average metal content of 48 per cent.

The oldest known deposit is Bou Arfa in western Morocco near the Algerian border. Most of the ore is friable and averages only 25 per cent Mn; it contains some iron but practically no silica and is upgraded to two products of 30 per cent and 45 per cent respectively. The ore reserves are about two million tons.

Other important deposits in the Atlas mountains are Tiarantine (51 per cent Mn), Tiouine (44 per cent Mn), and the vein-like structures around Ourzazate from which 18,173 tons averaging 50 per cent Mn were extracted in 1962: ore reserve estimates have not been made but the total tonnage is likely to be from one to two million.

Algeria

The Guettara deposit is located 200 km to the south-west of Colomb Béchar. The reserves are estimated at 1.5 million tons of 46 per cent Mn, but one-quarter of this tonnage is arsenical ore containing over 2 per cent As. The remainder averages around 0.5 per cent As. The ore has a silica content of ten per cent.

Tunisia

One small deposit is known with an estimated tonnage of 60,000 at 43 per cent Mn.

Egypt

The Sinai Manganese Co. produced 151,000 tons of concentrates in 1962 with a 40 per cent metal content. No reserve figures are available.

EAST AFRICA

Sudan

There are two big deposits, each of one million tons. The ore averages 45 per cent at Halaib and 50 per cent Mn at Sinkat. In 1962 there was a token production of 500 tons from Halaib, a village on the Red Sea, 300 km north of Port Sudan.

Ethiopia

There are a number of small deposits in Dankalia (Eritrea) from which high-grade ore is produced only for export. No sales were effected in 1962; the 1961 tonnage amounted to 11,000.

Kenya

Deposits of manganese ore were discovered in the 1930s at Mrima Hill, south-west of Mombasa, but have not proved of economic interest to date. The reserves amount to over 600,000 tons with an average manganese content between 20 and 30 per cent. Very small deposits are known in other parts of the country.

Northern Rhodesia

The main manganese deposit is in the Port Rosebery area. The mineral occurs in tabular veins associated with rubble beds. In these circumstances the assessment of ore reserves is difficult: they are estimated to be about 500,000 tons over a widespread area. Mining operations ceased in 1961 because of high transportation costs. Cleaning-up operations in 1962 yielded some 2,000 tons at 48 per cent Mn.

Over half of the 1962 output of 46,721 tons came from the Kampumpa deposit near Broken Hill. The total proved and possible reserves amount to 400,000 tons averaging 52-53 per cent Mn. Another smaller deposit is at Lubembe, also in the Borken Hill district: it contains 35,000 tons of pyrolusite of 30 per cent manganese. The ore is used as metallurgical flux at the Broken Hill mine.

The Mkushi deposits are situated north-east of Broken Hill and produced some 11,000 tons of 45 per cent Mn in 1962. Mining operations ceased in January 1963 owing to world market conditions. The known reserves are very small but recent prospecting is proving an additional tonnage of high grade ore.

Southern Rhodesia

Small deposits are known at Que Que and at Sindia. The 1962 production of low-grade ore came from the Tank mine at Que Que.

Central Africa

Congo (Brazzaville)

No manganese deposit has been discovered as yet although an extension of the Tchibanga deposit in Gabon is thought to contain manganese on the Congo side of the border.

Gabon

The Moanda mines are the world's largest new source of high-grade manganese ore: 203,000 tons were produced in the last four months of 1962. The official inauguration occurred on 2 October 1962 and a production rate of 4-500,000 tpy is scheduled for 1963. The proved and probable reserves exceed 200 million tons of 50 per cent Mn. An additional tonnage of 100 million averaging 40-45 per cent Mn is considered possible.

Congo (Leopoldville)

Two important deposits are known in South Katanga, at Dilolo and south of Jadotville. The proved reserves are 5 to 6 million tons. The 1962 output was 300,000 tons averaging 53.5 per cent Mn.

West Africa

Niger

A small deposit north of Tera has a possible tonnage of 50,000 with a 39 per cent metal content.

Ghana

Ghana is the largest producer in tropical Africa and the fifth largest in the world. The present production is at the rate of 400,000 tpy. The deposits are at Nsuta and their reserves are estimated at 10 million tons.

Ivory Coast

The deposit of Grand Lahou near the coast has an estimated tonnage of one million of 46 per cent Mn. The 1962 production amounted to 106,953 tons of concentrates. A new deposit with potential reserves of 3-4 million tons has recently been found at Ziemoulaga in the north-west and is now being investigated: the metal content is 45-50 per cent Mn.

Mali

The Ansongo deposit adjoining the Niger river in eastern Mali is estimated to contain 3 million tons of manganese ore averaging 40-50 per cent Mn.

Upper Volta

The Tambao deposit is situated 320 km north-east of Ouagadougou. The proved reserves are 5 million tons and another 5 million are considered possible. The average grade is 50 per cent Mn.

The Tiere deposit near Bobo-Dioulasso has probable reserves of 900,000 tons of 46-48 per cent Mn, and 11-13 per cent silica.

Southern Africa

Madagascar

Several small occurrences are reported neat Maevatanana in the centre of the isle.

Bechuanaland

Since 1957 mining has taken place at three different manganese ore occurrences in the south eastern part of the country. Two of these are in the Bamalete territory. The Ramoutsa deposit is shallow and low-grade with a high silica content. The more important occurrence is on and around Ootse Hill where a new sorting and loading plant is expected to produce 5,000 tons per month of 46 per cent ore. The reserves available for open pit extraction are estimated at 350,000 tons.

Production is also being obtained from the Kwakgwe Hill deposits in the Bangwaketse territory where the ore appears to be a replacement deposit. Because of the thickness of the overburden the ore has to be extracted by underground methods.

South Africa

Estimated reserves of high grade manganese ore (+48 per cent Mn) are over 60 million tons with an additional 30 million of lower grades. The main deposits are in the Postmasburg and Kuruman districts.

Total production for 1962 was 1,464,740 tons of ore of which just over half contained over 40 per cent Mn.

South West Africa

Manganese does occur but reserve figures are not available: production ceased during 1961.

Angola

There is no information on the deposits which in 1962 produced some 14,000 tons of concentrates averaging 47 per cent Mn.

Petroleum and natural gas

	Crude petroleum (million metric tons)		Natural gas (million cu. m.)	
	Prod. 1962	Est. reserves	Prod. 1962	Est. reserves
Morocco	0.129	2	n. a.	n. a.
Algeria	20.400	930	1,500	1,500,000
Tunisia	—	—	7	n. a.
Libya	9.250 [a]	640	100	120,000
Egypt	5.220	100	—	n. a.
Nigeria	3.372	60	30	n. a.
Senegal	0.001	[b]	1	n. a.
Gabon	0.950	20	9	n. a.
Congo (Brazzaville)	0.123	1	n. a.	n. a.
Angola	0.500	10	—	n. a.
TOTAL, Africa	39.945	1,763	±1,650	—
TOTAL, World [c]	1,230	40,000	600,000	20,000,000

[a] The tested production rate was 20 million tpy in mid-1963.

[b] 60,000 tons.

[c] Approximate figures.

Scrap iron

Practically all the authorities which were approached declared themselves unable to supply information on scrap production in their respective countries. The following are the only estimates which could be obtained:

	Tpy
Morocco	40,000
Algeria	60,000
Tunisia	20,000
UAR	60,000
Nigeria	13,000

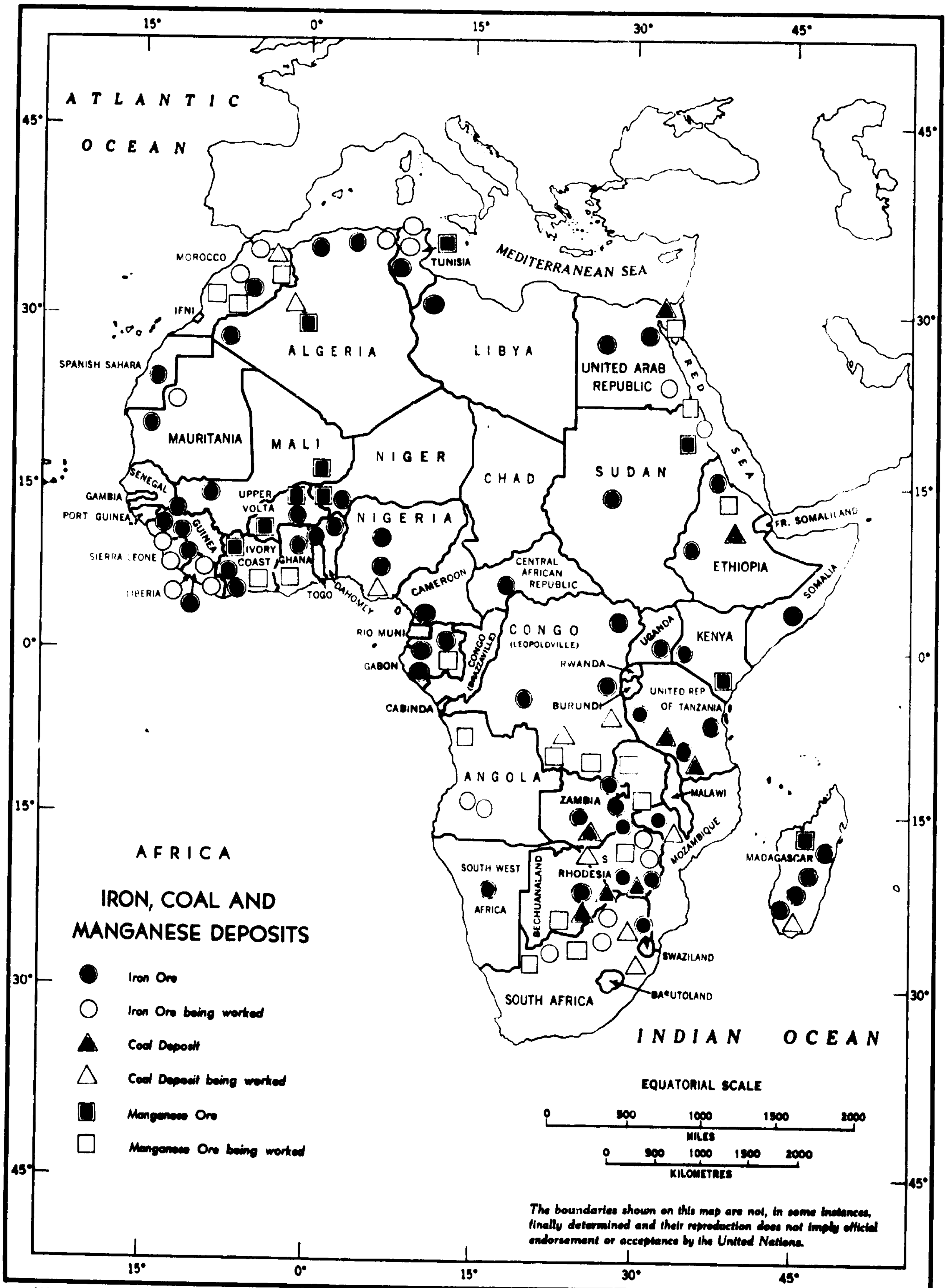
Conclusion

Africa supplies a large percentage of world mineral requirements but still plays a minor role in the production of the two basic raw materials required by steel industries: iron and coal.

The 1962 production of iron ore in Africa represents 3 per cent of the world production for that year: the corresponding coal output was 2 per cent of the total from the main producing countries. The present low production rate of these two commodities is not due to any lack of resources. There are substantial high-grade iron ore reserves in central, west and southern Africa in addition to numerous medium- or low-grade deposits in practically every country. In 1962 the world iron ore resources were estimated at 250,000 million tons; African deposits represent about 6 per cent of this total. The African continent is perhaps less well endowed with coal resources which are concentrated mainly in the southern hemisphere. However, the present annual production is only one tenth of one per cent of the proved reserves. This output could be doubled with the existing installations if there were a demand for the coal: likewise substantial reserves remain untapped because there is at present no prospect of utilizing the product.

The African continent is well endowed with manganese, limestone and refractory minerals: the 1962 production of mangenese ore represents 20 per cent of the world output and this figure is likely to increase in 1963 owing to the first full year's operation of Gabon's Moanda mines.

This report did not deal with metals required for the manufacture of ferro-alloys for stainless and high-quality steels. Africa accounts for over two-thirds of the world's present output of cobalt, columbium and tantalum, 30 per cent of the chromite and twenty per cent of the vanadium production.



MAP NO. 1563 UNITED NATIONS
NOVEMBER 1964

ANNEX

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D03914

RAW MATERIALS FOR IRON AND STEEL MAKING IN THE ECAFE REGION

(DOCUMENT ECAFE.1)[1]

General

It is becoming clear to the countries of the ECAFE region that the development and the maximum utilization of their mineral resources are essential for their industrial growth. An assessment, however, at this stage of the availability of raw materials (particularly iron ore and coal) for the production of iron and steel in these countries should be considered incomplete. Many of the countries of the region, especially the less developed areas, have not been covered by detailed geological studies, mapping or exploration. This work is being vigorously continued in some of these countries, under contracts with independent foreign consulting firms and/or with the assistance of the agencies of the United Nations in collaboration with their respective Governments. The results of past explorations and the recent mineral surveys have generally indicated the existence of potential reserves of iron ore and coal deposits of varying characteristics and magnitude which could perhaps be used as raw materials for the production of iron and steel, with the use of either the conventional methods and/or by the latest techniques in iron and steel technology which are now being practised in some of the highly industrialized countries.

Countries of the region[2]

AFGHANISTAN[3]

Afghanistan is endowed with rich mineral resources, particularly iron ore and coal deposits. Absence of adequate capital, transport facilities and dearth of technical personnel have deterred exploitation of these resources in the past.

Iron ore. Substantial deposits of high grade (Fe 64 per cent) hematite and magnetite ores were recently located in the Khakrez Kandahar area and also in Jabelseraj, Herat and other parts of the country. Potential reserves are estimated at over 20 million tons.

Coal. Coal deposits, of coking quality, of approximately 60 million tons exist at the Karkar and Ishpushta mining areas and the Daraa-il Suf deposit. Coal production has reached about 50 thousand tons yearly with the improvement of facilities. The programme of mineral resources development under the second five-year plan (1962-1967) has two objectives: (*a*) establishment of raw material basis for the construction of the first iron and steel plant; (*b*) development of mineral resources for export to improve the foreign exchange position.

Power generation sources. The installed generating capacity aggregated 59 MV in 1961.

BURMA

Iron ore.[4] Exploratory work in northern part of Burma (Tavoy and Taunggyi areas) by German experts indicated deposits of hematite and limonite ores, estimated at 6.5 million tons with an average Fe content of 47 per cent, Mn 0.8 per cent, SiO_2 1.55-15 per cent, P 0.04 per cent and TiO_2 0.5 per cent. Magnetite ores were also found in the area with a Fe content of 60 per cent and low in P and S.

Coal. Coals of bituminous non-coking quality have been found in Kalewa. They has low ash and sulphur contents. The mines are not accessible by good roads. Transport by water is possible. Reserves were estimated at about 6 million tons.

Scrap. Present scrap resources are inadequate for the electric smelting furnace. Imports of billets or scrap will be necessary to maintain continuous operation.

Power generation sources. The installed generating capacity in Burma in 1961 aggregated 190.9 MW.

CAMBODIA

Iron ore. Exploration of iron ore and coal deposits has been given priority in the (1960-1964) development plan. The Phnom Deck region contains iron ore deposits. Limestone deposits in the Kampot province have also been explored.

Power generation sources. In 1961, the over-all installed generating capacity amounted to 26.7 MW.

CEYLON

Iron ore.[5] Recent explorations for iron ores in Ceylon have revealed good grade deposits of limonite of Fe 50 per cent in the south-west area of the country. The estimated quantity is about 5 to 6 million tons. In the Chilaw, Tambakanda area, magnetite ores have been located with an estimated quantity of not less than 3.5 million tons. Further geological surveys and explora-

[1] Prepared by the secretariat of the Economic Commission for Asia and the Far East. See page 121 for discussion.

[2] *Mineral Resources Development Series* — E/CN.11/565, United Nations-ECAFE publication.

[3] *Survey of Progress 1960* — Ministry of Mines and Industry, Afghanistan.

[4] *Report No. 2. Geological Survey of Iron Ore Deposits*, vol. I, 1955 — Burma Ehrenberg-Koch.

[5] *State Industrial Projects, Bulletin 1*, Development Division, Ministry of Industries, 1961.

tions of mineral resources are being undertaken in the country. Limestone deposits are also found in various places.

Coal. There is no coal in Ceylon. All coal used for industrial purposes is imported. There are, however, wooded areas in the country, from which charcoal could be produced for a small steel industry. Organized and systematic reforestation and planting of rubber-wood trees will have to be introduced in order to provide continuity of charcoal supply.

Power generation sources. The installed capacity in Ceylon was about 94.2 MW in 1961.

CHINA (TAIWAN)[6]

Iron ore. China (Taiwan) has no significant iron ore deposits. However, limited supply of magnetic beach placers occur on the shores, north of the Tatum Volcanic Group between Tanshui and Keelung, along the coast east of the Taitung coastal range. The northern iron sands contain an average of about 80 per cent magnetite and about 15 per cent of ilmenite. In the concentrated form, the Fe contents average about 55 per cent and Ti about 3.5 per cent. The beach sands in the Tanshui coast contain a high percentage of ilmenite, ranging from 50 to 70 per cent and magnetite from 4 to 20 per cent.

Manganese ore. Deposits of manganese ores are also limited in the country. Good grades of psilomelane manganese ores are found in the south-eastern part of the Simaoshan area. Characteristics of the deposit contain Mn 40 per cent, SiO_2 about 11 per cent, S about 0.03 per cent and P about 0.03 per cent. Production is limited and the total reserves are estimated at less than 500,000 tons.

Scrap. The scrap used in the electric arc furnaces is imported. In 1960, imported scrap amounted to about 144,558 metric tons and in 1961 import was 108,841 metric tons.

Coal. There are deposits of coal in the northern part of the country estimated at about 200 million tons of workable reserves. Existing reserves have been estimated at about 415 million tons. The coal areas are mostly located in the northern part of the country and are divided into four regions: Keelung, Taipeh, Hsinchu and Chunan. Coals found in these regions range from good coking quality to non-coking or weak coking. These coals have the following general characteristics: fixed carbon, 41 to 55%; ash, 6 to 10%; moisture, 3 to 7%; volatile matter, 36 to 40%; sulphur, 0.6 to 3 %; phosphorus, 0.02%; and B.T.U./lb, 13,000.

Production of coal reached 3.7 million tons in 1960. The target output for 1964 has been set at 4.9 million tons. Coke is produced by numerous small beehive ovens and by about 22 by-product coke ovens. A new modern by-product oven was installed about two years ago In 1962, about 32,000 tons of good quality coal was exported to Japan.

Mineral oil and natural gas. Petroleum and natural gas have been produced in the past in the country. A new large source of natural gas was located recently in the Chinshui area.

Limestone. Limestone deposits of commercial importance have been found in the south-western and north-eastern part of the country.

Power generation sources. The aggregate installed generating capacity in the country was 923.4 MW in 1961.

INDIA

Iron ore.[7] India has large iron ore deposits. Deposits of high grade hematite ores are found in Bihar, Orissa, Madya Pradesh, Bombay, Madras, Andra and Mysore. Reserve potentials are estimated at about 21,000 million tons of high grade ores, 60-65 per cent Fe content. New ore deposits are being developed to meet additional future requirements of the steel industries in the country and also for export.

The consumption of iron ore in the iron and steel industry is about 7 to 8 million tons yearly. This consumption is expected to double in the third plan and export is also predicted to increase to 10 million tons for the same period. The Kiriburu iron deposits in Bihar-Orissa; Bailadila in Madya Pradesh and Radi in Marashtra are being intensively developed to meet these additional requirements. The production of iron ore rose from 2.97 million tons in 1950 to about 10.5 million tons in 1960. About 3.2 million tons of high grade ores ranging from 62 to 65 per cent Fe content were exported in 1961.

Manganese ore. Manganese ores exist in considerable quantities in the country to support the present and future domestic demands and for exports. About one million tons are exported annually. It is estimated that the present rate of consumption of manganese ores for all purposes amounts to 400,000 tons and it is expected to increase to one million tons in 1970.

Coal. The total workable coal reserves are estimated at about 50,000 million tons and about 2,000 million tons of lignite deposits. The coal deposits are located in Bihar and West Bengal with small outlying fields in Assam, Madya Pradesh, Maharashtra Orissa and Andra Pradesh. Lignite deposits are found in parts of Madras, Rajasthan, Gujarat and Jamnu and Kashmir. The reserves of good quality coal for metallurgical purposes are limited. Coking coal reserves are mainly found in Jharia, Ranigary and Bokaro coal fields. The Indian coals are generally high in ash content and need beneficiation. Coal from some of the other coal fields in central India can be used, after washing and blending with Jharia coals, for the manufacture of metallurgical coke.

The production of coal in India was 38.2 million tons in 1955 and 54 62 million tons in 1961. The target for the third plan is 97 million tons.

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[6] *Mining Development in Asia and the Far East, 1960, Mineral Resources Development, Series No. 16* — E/CN.11/565. *The Industrial and Mining Programme under Taiwan's Third and Fourth-Year Plan*; Industry of Free China — vol. XIX, No. 3 — March 1963.

[7] *The Third Five-Year Plan,* Government of India Planning Commission. *Progress of Industrial Development of India, 1956-1961,* Government of India Planning Commission.

Mineral oil and natural gas. The oil and natural gas commission of the Indian Government undertook intensive geological and geophysical surveys in parts of Punjab, Ganga valley and other areas. Natural gas was also found in the country.

Power. The total installed capacity in the country amounted to 5,183.3 MW in 1961.

INDONESIA

Iron ore [8] Large deposits of iron ores have been found in the Archipelago, but most of these are complex ores with nickel and chromium contents. These deposits located in central Celebes and Borneo are estimated to exceed 500 million tons. The deposits in central Java are about 35 million tons with a Fe content of 60 per cent but adulterated by a 10 per cent titanium content. The only workable ores are found in Lampong (Sumatra), about 2 million tons, and about 2 million tons in Pleihari (south-east Kalimantan).

Coal. Bituminous and sub-bituminous coals abound in several islands of the Archipelago, in south Sumatra, east Borneo and a few areas in Java. These are of the non-coking quality. It is estimated that the coal reserves amount to 500 million metric tons. Indonesia is also rich in lignite deposits. In the Bukit Azam area, the amount of lignite is estimated at 2,000 million tons.

Pre-war production of coal in the Ombilin (central Sumatra), Bukit Asam (south Sumatra), Paropattan (north-eastern Borneo), east Borneo and three other private mines reached about 2 million tons. Investigation of the coal resources and large-scale coking tests with samples from Ombilin and east Bukit Asam showed: (*a*) that the Ombilin coal is suitable for producing a metallurgical coke in the vertical oven; the tumbler strength of the coke produced makes it suitable for use in a blast furnace with an output of 150 tons of pig iron per day; (*b*) preliminary investigation of the Bukit Asam coal showed that the coal had no coking properties and the double coking process was tried for producing metallurgical coke from the coal. The results showed that double coke could be produced when high temperature coke was used as a primary product.

Charcoal and oil. Sufficient quantities of charcoal can be produced to maintain a charcoal blast furnace in east Sumatra. Oil is available in south-east Sumatra in considerable quantities.

Power. The total installed generating capacity was 310.8 MW in 1961.

IRAN [9]

Iron ore. Iran has substantial deposits of iron ores occurring principally in three regions: (*a*) the north-east near Simnan: magnetite ores with an average Fe content of 60 per cent and low in P and S; no estimate of reserves has been made; the deposits are close to the Trans-Iranian Railways; (*b*) Kerman Province in various places (Bafgh Narikaw and Zirkan): magnetite ores with an average Fe content of 55 per cent with slight impurities of phosphorus and titanium. This area is near the coal mines. Reserves are estimated at 30 million tons; (*c*) Shams Abad-Arak: limonite and hematite deposits with average Fe content of 47 per cent and Cu of 0.217; estimated reserves range from 30 million (possible) to 100 million tons (probable); the southern railway passes through this region. Other iron deposits are in Ghasr, Fironzeh, near Tehram and southern isles of the Persian Gulf (Foroor island and Amoy).

Coal. Coal deposits are found in:

(*a*) The Elburz area with a reserve of about 10 million (possible) to 40 million tons (probable). Many of the coals are of the coking quality. The "Zirab" coals (slightly inferior) when blended with the Eleca and Gelandrood high-grade coals produce a coke suitable for blast furnace operation.

(*b*) The Kerman area with a probable reserve of about 100 million tons. The most promising is at the Hodjedt mines, with large deposits of coking coals suitable for metallurgical purposes; proven reserves are estimated at 25 million tons and probable reserves at 48 million tons. In the Badamuyeh area, the coking quality coal reserve is estimated to be about 44 million tons. Coal production is about 200,000 tons per year.

Manganese ore and petroleum gas. Manganese deposits are found in two areas: Ardestan and the province of Tehran. The ores in Ardestan contain about 54 per cent manganese. In the Tehran region, the manganese contents average about 30 per cent and by concentration, the purity can be increased to about 44 per cent. Total reserve is estimated to be about 500,000 tons.

JAPAN

Iron ore.[10] Japan's iron and manganese ore resources are inadequate for its needs. The deposits consist mainly of magnetite, hematite, and limonite and iron sands. Most of the ores are found in the north-eastern part of Japan (Hokkaido) and northern Honshu. The Fe contents range from 28 to 53 per cent Fe. The average Fe content of ores, however, is 37 per cent. The iron sand deposits (placer) are distributed along the seashores and in the foothills of the coastal ranges located also in Hokkaido and in various areas in Honshu (Aomori, Chinba). The Fe content of these placer deposits generally runs from 12 to 30 per cent Fe, and in concentrate form the average Fe content is about 57 per cent.

In 1958, about 1 million tons of iron ore and about 1 million tons of iron sand concentrates were produced. Pyrite and phrrhotite cinders are rapidly being used in the iron and steel industry in the country. Production reached a total of approximately 4.67 million tons in 1962.

The estimates of iron ore reserves in Japan including areas with 25 per cent Fe content are about 37 million

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[8] *Mining Development in Asia and the Far East, 1960, Mineral Resources Development Series No. 16.*

[9] *Mining Development in Asia and the Far East, 1959, Mineral Resources Development Series No. 15,* E/CN.11/565. Information on Iranian Mineral Resources, Dr. T. Ziai, 28 November 1959.

[10] *Geology and Mineral Resources of Japan,* Second Edition, 1960, by Geological Survey of Japan.

tons and about 160 million tons of iron sand with an average Fe content of 13.9 per cent. Because of the paucity of domestic ores, the Japanese iron and steel industry depends greatly on the importation of iron ore. The principal sources of iron ore imports in 1962 were from Malaya (29.2 per cent), India-Goa (21.3 per cent), Chile (13.6 per cent) and the balance from Canada (7.1 per cent), Philippines (6.7 per cent), United States (3.9 per cent), South Africa (2.7 per cent), Brazil, Korea and others (4.2 per cent). Recent figures indicate a total consumption of about 27 million tons of iron ore, 80 per cent of which were imported. The Japan Iron and Steel Federation estimates an importation of 45 million tons of iron in 1970 to meet the target output of crude steel of 48 million tons for that year.

Manganese ore and scrap. Estimates show a possible reserve of about 5.6 million tons of metallurgical manganese ore with an average 30 per cent Mn. Annual production in the country amounts to approximately 300,000 tons. Metallurgical manganese ores are imported from India, the Philippines and from western countries. Japan also imports scrap from various countries to supplement the great quantities of home scrap generated in the country. About 20 to 30 per cent of the total scrap consumption in 1962 (13.3 million tons) was imported from the United States (74.2 per cent), from the United Kingdom (7.1 per cent), and the balance from India, Canada, Australia and Hong Kong (18.7 per cent).

Coal. In Japan, there is almost no production of metallurgical coal except for a small quantity in northern Kyushu. All the metallurgical coals are imported from foreign countries. The coal types in the country percentage wise are mostly bituminous and sub-bituminous (94.5 per cent), anthracite (2.7 per cent) and low-rank lignite (2.8 per cent) located in Hokkaido and Kyushu. The total theoretical recoverable coal reserves (1958) [11] are estimated at 20.8 million tons. The bitunious (high-grade) coals are of coking quality, the anthracite and lignite types are non-coking. The low-grade sub-bituminous types however are either weak coking or non-coking. Local production in Japan, excepting lignite, amounted to 52.6 million tons in 1960 and 60 million tons in 1962. The scarcity of metallurgical coals in Japan makes it indispensable to import this raw material. In 1962, imports of high grades of coal amounted to approximately 9.64 million tons. The projected crude steel output of 38 million tons in 1965 and the target output of 48 million tons in 1970 will mean coal imports of 20 and 24.5 million tons respectively. Estimated total workable reserves are about 30,000 million tons.

Limestone. Limestone is available in abundance in Japan. About 400 mines are working at present. These mines are located in Saitama, Tokyo, Fukuoka, Oita, Yamaguchi, Shiga, Shizuoka, Niigata and Tochigara prefectures. The characteristics of the limestone deposits are generally as follows: CaO, 52 to 55%; MgO, 0.16 to 0.21%; SiO_2, 0.25 to 0.18%; and ignition loss, 42 to 44%.

Power generation sources. The total installed generating capacity in Japan was 22,755 MW in 1961.

[11] *Ibid.*

Republic of Korea [12]

Iron ore. The iron ore deposits in South Korea are relatively low grade in quality and with an average Fe content of 30 per cent. Production increased from 261,000 tons in 1958 to about 500,000 tons in 1961. Emphasis is being given to further exploration for the ores.

Coal. The great reserves of coals in South Korea are anthracites and recent estimates indicate a potential reserve of about one thousand million tons. Accelerated development of these coal deposits have been emphasized in the new programme of mineral development. Production of coal increased from 867,000 tons in 1953 to about 5,900,000 tons in 1961 and to about 6,886,000 tons in 1962.

Power generation sources. The total installed capacity is about 367.3 MW in 1961.

Federation of Malaya [13]

Iron ore. The Federation of Malaya has large high-grade iron ore deposits with an Fe content ranging from 50 to 60 per cent. The possible reserves of known areas are estimated at 50 million tons. No extensive geological surveys has been made particularly in the east Malaya jungles, which geologists believe have large and undisclosed deposits of ore. Most of the good grades of iron ore are exported to Japan and small quantities to Europe and China (Taiwan). Production in the mining areas has reached about 6 million tons yearly against about 3 million tons in 1957 and about 500,000 tons in 1950.

Coal. There is no coal production at present. Coals found in the various areas in the Federation are lignites and low-grade sub-bituminous types. The good quality coal field area is located at the Batu-Arang field. Other coal areas of lower grades are known in Selangor near Engger, Perak on the border of Porlis and lower Thailand and Johore. These coals are non-coking and not suitable for metallurgical purposes, particularly in blast furnace operation.

Power generation sources. The installed capacity in 1961 was 315.2 MW.

Pakistan [14]

Iron ore. Iron ore deposits in quantities are known near Chagai in north-west Baluchistan, at Damnar Nissar in Chitral, and at Kalabagh and Chichali in north-west Punjab. The deposits in Chagai and Damnar Nissar are of relatively high-grade quality with an Fe content of 60 per cent. These areas are isolated and difficult of access. The ores at Kalabagh and Chichali are of inferior grade with an Fe content of 30-35 per cent. These deposits are fairly accessible. The deposits are extensive in both

[12] *The Status of Progress of Industrialization in Korea, 1963*, Ministry of Commerce and Industry, Republic of Korea.

[13] *Mining Development in Asia and the Far East, 1959, Mineral Resources Development Series No. 15*, C/EN.11/565 — E/CN.11/I & NR/44.

[14] *The Second Five-Year Plan, Pakistan, 1960-1965*, Government Planning Commission.

these areas and the potential reserves are believed to be over 100 million tons. Emphasis has been placed in the second five-year plan for iron ore development for possible use in the proposed integrated steel mill in the country.

Coal. Large coal reserves are found in several areas in Pakistan, but no accurate estimate can be made, owing to the lack of detailed mapping and prospecting. Sizable deposits exist at Makerwal and in the western Salt Range; at Sharing Deghari and in the Sor Ranges, south and east of Quetta; and in the vicinity of Jhimpir in the Hyderbal Division. Local mines at present in the Makerwal and Quetta areas are predominantly narrow seams and mechanization of the operation presents a problem. The coal is friable and high in sulphur and ash content and thus unsuitable as metallurgical coke for blast furnace operation. By subjecting this coal to low carbonization, a coke briquette can be produced for use in foundries, lime kilns, brick kilns and as boiler fuel. In east Pakistan, a deposit of coal has been reported from Bogra and Rajshabi.

Local production in 1959 reached a total of 723,000 tons and the second plan proposed to increase this to 1,500,000 tons annually to reduce substantially imports of coal which amounted to 1.34 million tons in 1958. There is a plan also to consolidate small mining units to achieve more efficient operation. Government assistance will be extended to this small group in the form of financing new equipment purchases through the Pakistan Industrial Investment Credit Corporation and the Bureau of Mineral Resources for securing the foreign exchange requirements.

Crude oil and natural gas. Crude oil is produced in small scale in the area near the Potwar Basin. Oil was struck in 1959 near Balkasar, south-west of Rawalpindi, but reserves are small. The search for oil uncovered valuable fields of natural gas. The most important fields were discovered at Sui, where reserves of high quality gas with calorific value of 930 B.T.U./cu.ft. and estimated at 6,000,000 million cubic feet. The recently discovered field at Mari is estimated at 3,500,000 million cubic feet. Both of these fields will supply West Pakistan with gaseous fuel (and petrochemical materials) for many decades. In east Pakistan, the most important fields of natural gas were found near Chattak of about 20,000 million cubic feet. Projected combined output of these two fields will reach 7,500 million cubic feet in 1965. There are prospects for the discovery of new fields in east Pakistan.

Scrap. There is no significant scrap generation in Pakistan to maintain a stable operation of the electric furnaces and scrap is imported.

Power generation. The installed capacity was 687.7 MW in 1961.

PHILIPPINES

Iron ore.[15] The Philippines has substantial deposits of iron ore, which is being exported to Japan in large quantities. The mines are located in these areas: Luzon (northern Philippines); Samar and Marinduque islands (central Philippines); and Mindanao (southern Philippines). The largest and best developed mine in the Luzon area is located at the south-east portion of the island at Larap, province of Camarine Norte. It has an estimated ore reserve of about 20 million tons and is operated by the Philippine Iron Mines, the largest producer in the country. Present production for export is about one million tons of magnetite ores with an Fe content of 42 per cent, sulphur content from 0.6 to 2 per cent and low in phosphorus. A beneficiation plant has been installed and presently a concentration plant (magnetic separation) is under construction. A new source of iron ore of high Fe content (57-62 per cent) has been explored and is being developed in central Luzon in the Sta. Inez area (Bulacan). Estimated workable reserves in this area are about 20 million tons. Ore content is about 1 to 4.6 per cent in sulphur and low in phosphorus. In the northern tip of this island (Luzon), recent explorations show a good grade of magnetite-hematite ore with Fe content of 50 to 70 per cent. The iron ore deposits in Mindanao are estimated at 20 million tons of good grade ores with an Fe content of 50 to 55 per cent, low in sulphur (less than a per cent) and traces of P. Most of the ores are located at the Sibuguey range. In the north-eastern tip (Surigao province) if this island are extensive deposits of lateritic ores with an average Fe content of 45 per cent and estimated at about 232 million tons. The ore, however, is of the complex type with nickel content of about 0.8 to 1.70 per cent and chrome content of about 1 to 3 per cent.

Manganese ore. Manganese abounds in various parts of the country with manganese contents from 37 to 48 per cent. The most prominent areas are located in the northern tip of Luzon (Ilocos provinces), Siquijor island (central Visayas) and in Busuanga island (Palawan group). Present production is about 15,000 to 19,000 tons yearly for export to Japan.

Coal. Coals are found in some parts of the Philippines in Luzon, Mindanao and in the central Visayas. The coal in the Malangas area (Mindanao) has been found to be of coking quality when blended. A small beehive oven of small tonnage has been in operation since 1960 and is being used by some electric furnace operators. Production of coal in Cebu and in Malangas is about 200,000 tons yearly. Extensive exploration is now being made to determine the potential and workable reserves in the Malangas area, for possible utilization by the proposed integrated steel plant. Malangas coal has the following analysis: fixed carbon, 50%; volatile matter, 30-35%; ash, 9% (max.); moisture, 4%; sulphur, 0.6%; and heating value, 10,000-12,000 B.T.U./lb.

The present estimate of reserves is about 10 million tons. All the coals found in the Philippines excluding Malangas are of non-coking quality. The biggest lignite deposit is located at Batan island in the southern tip of Luzon island. Sulphur content ranges from 0.8 to 2 per cent.

Limestone. Limestone is abundant in the Philippines.

Charcoal.[16] The destructive distillation of *ipil ipil*, *bakawan* woods and coconut shell which abound in the

[15] *Annual Report*, Bureau of Mines 1962 — E/CN.11/I&NR/44.

[16] *Annual Report*, Bureau of Mines, 1962.

country for possible metallurgical purposes have shown the following results:

	Bakawan	Ipip Ipil	Coconut shell
Product yield (%) dry basis			
Charcoal	33.5	27.9	30.1
Liquor	31.8	30.2	37.5
Tar	10.8	10.2	9.6
Proximate analysis of charcoal (%)			
Moisture	2.90	7.16	4.76
Ash	7.33	6.03	2.50
Volatile matter	24.02	9.38	19.10
Fixed carbon	65.75	77.43	73.64
Heating value B.T.U./lb.	12,474	12,515	12,164

Scrap. The generation of scrap is very inadequate and the scrap shortage has reached serious proportions. It might be necessary to import scrap or billets from foreign sources during the next few years until the integrated steel project is completed.

Mineral oil and natural gas. Extensive explorations for oil in some areas have been in progress for the past few years. Indications of natural gas sources have been associated with these explorations.

Power generation sources. The installed plant capacity in the Philippines was 652.6 MW in 1961.

THAILAND

Iron ore. Thailand has deposits of iron ore in various areas. The largest deposit was discovered in Changwat Lopburi. The primary ore is hematite with an Fe content of 66.4 per cent, S of 0.08 per cent and Mn of 3.6 per cent. Other promising areas of ores are located in Kanchanaburi and Kanburi. Estimated reserves are 6 million tons. Lateritic ores are widely distributed in the country in small quantities. Magnetite pyrites exist in a few areas. Recent explorations show indications of considerable ore deposits in north-eastern parts of the country.

Coal. Coal occurs in widely scattered areas in the country. The deposits in northern Thailand are lignites with low calorific value. The coals in southern Thailand are rather dense and black with an HV of 8,000 to 10,000 B.T.U./lb. This could be considered as sub-bituminous in rank. The fixed carbon content on the average is between 40 and 49 per cent; volatile matter from 30 to 50 per cent; ash from 8 to 30 per cent; sulphur from 3 to 6 per cent and moisture content 8 to 30 per cent. Production is low and whatever is available is used by the thermal stations.

Power. The installed capacity was 264.5 MW in 1961.

VIET-NAM, REPUBLIC OF [17]

Mining activity during the last few years was concentrated on the improvement of the existing coal mines and on the investigation and assessment of other mineral resources.

Coal. Coal reserves in the Nong Son coal mine was estimated at 10 million tons. Other coal outcrops were discovered in this general area. Coal production in 1960 was about 27,300 tons.

Power. The installed generating capacity was 102.1 MW in 1961.

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[17] *Mining Development in Asia and the Far East, 1960, Mineral Resources Development Series No. 16* — E/CN.11/596.

DD3915

TRENDS IN THE PRODUCTION AND CONSUMPTION OF IRON AND STEEL MAKING RAW MATERIALS IN EUROPE AND IN THE UNITED STATES OF AMERICA

(DOCUMENT ECE.I)[1]

Summary

This paper describes the present situation of production and consumption of iron ore, coke and scrap in European countries and in the United States, and shows some of the development trends which have emerged over the last few years. In particular, attention is drawn to the changing geographical pattern of iron ore supply, i.e., the growing share of overseas resources in total ore supply of the main consuming countries to the falling trend of specific coke consumption in pig-iron making due to improved preparation of the charge and other measures to increase blast-furnace productivity; and to the eased situation of the scrap market, owing to the impact of a series of factors, leading to falling over-all specific consumption in steel-making and relatively higher availabilities of scrap. It is also pointed out that no major problems have arisen in recent years in the supply of other raw materials or sources of energy in European countries and in the United States. The general conclusion is that the present situation of raw material supply for iron and steel making is satisfactory, from the point of view of quantity and quality as well as from that of prices. It may be expected that for Europe and the United States the present trends in development of iron- and steel-making technology will further reduce specific consumption of energy as well as of raw materials.

Introduction

In 1962 European countries and the United States together produced 296 million tons of crude steel (Western Europe: 106 million tons; United States: 89 million tons; USSR: 76 million tons; Eastern Europe: 25 million tons) or more than 80 per cent of total world output. Since scrap is used in a considerable measure for production of crude steel in the countries of Europe and in the United States, total output of pig-iron and blast-furnace ferro-alloys is somewhat lower than crude steel production; these equalled 206 million tons or 75 per cent of the world total.

It is evident from these data that Europe and the United States are also the main consumers of iron- and steel-making raw materials. While in the early days of the iron and steel industry most of the main producing countries were self-sufficient in their raw materials supply (indeed, the availability of ore and coal was one of the important factors of growth of these industries), the situation has changed gradually during the last twenty years: many of the principal steel-producing countries are seeking to satisfy their requirements of iron ore and coking coal in overseas countries, since their own supplies — or the supplies available in neighbouring countries — do not any longer meet their demand from a quantitative or qualitative point of view.

[1] Paper prepared by the secretariat of the Economic Commission or Europe. See page 121 for discussion.

Production and consumption of iron ore

World output of iron ore increased from 202 million tons in 1929 to 527 million tons in 1962. The increase was somewhat smaller than that of pig-iron output, the main destination of iron ore, 160 per cent compared with 178. This is attributable mainly to the increased Fe content of iron ores mined and to improved blast-furnace performance, which depends, in turn, on better preparation of the charge and lower flue-dust losses. The evolution of iron production by selected regions and countries is given in table 1.

Table 1. Production of iron ore in selected regions and countries

(Thousands of tons, annual tonnage)

	Western Europe		*Eastern Europe*		*USSR*		*United States*		*World*	
	1,000 t	*Per cent*	*1,000 t*	*Per cent*	*1,000 t*	*Per cent*	*1,000 t*	*Per cent*	*1,000 t*	*Per cent*
1929	98,963	48.9	2,815	1.4	7,997	4.0	74,198	36.7	202,235	100
1937	89,548	41.4	3,048	1.4	27,770	12.8	73,243	33.9	216,329	100
1950	75,683	31.1	3,588	1.5	39,651	16.3	99,614	40.9	243,576	100
1955	115,075	30.8	7,113	1.9	71,862	19.3	104,650	28.1	373,051	100
1960	142,476	28.1	9,341	1.8	106,541	21.0	89,040	17.5	507,425	100
1961	143,672	28.2	10,083	2.0	117,633	23.1	72,704	14.2	510,220	100
1962	138,177	26.2	10,665	2.0	128,102	24.3	73,488	13.9	526,884	100

SOURCE: *Long-Term Trends and Problems of the European Steel Industry*, ECE, Geneva, 1959, page 72; *The European Steel Market in 1962*, ECE, Geneva, 1963.

It will be seen that production increased in all regions and countries shown, except in the United States, where, in 1962, it was at about its 1929 level. The combined output of Europe and the United States grew between 1929 and 1962 by a little more than 90 per cent, while the world total has increased by 160 per cent during the same period; this confirms the development mentioned further above that especially western European countries and the United States are relying to a growing extent on overseas sources for their iron ore supply.

The USSR is at present by far the most important individual producer of iron ore; its iron ore, which has an average Fe content of between 50 and 60 per cent, is also used in many of the countries of eastern Europe, as will be shown later on. The principal western European producer (in terms of crude ore weight) is France, having in 1962 an output of over 66 million tons, at an average Fe content of 31 to 33 per cent. The most important western European supplier of high-grade ore remains Sweden, producing in 1962 almost 22 million tons, of about 61 per cent average Fe content. Most of the other western European countries have their own iron ore resources, which are, however, insufficient to cover their needs. Many of the eastern European countries, with the exception of Bulgaria and Romania, cannot satisfy their iron ore requirements exclusively from domestic production. Output has increased in all of them during the last ten years, reaching the following levels in 1962 (in thousands of tons, actual tonnage; figures in parentheses represent the average Fe content):

Bulgaria	628	(62)
Czechoslovakia	3,477	(34)
Eastern Germany	1,700 [a]	(30)
Hungary	682	(39)
Poland	2,436	(34)
Romania	1,742	(45)

[a] Estimate of ECE secretariat.

The data in table 2 show that many of the countries in Europe, and also the United States, are depending on supply of iron ores from outside sources. In 1962, individual countries imported the following proportions of their apparent iron ore consumption from abroad:

	Per cent
Netherlands	100
Italy	79
Poland	77
Belgium-Luxembourg	77
Germany (Fed. Rep. of)	73
Czechoslovakia	71
United Kingdom	46
United States	34
Austria	22
Yugoslavia	15

It should be borne in mind that these data are calculated on crude ore weight; since many of the countries listed produce lean ores and import high-grade ores, the percentages would be still higher in terms of Fe content.

As was mentioned above, the geographical pattern of iron ore supply in Europe and in the United States has undergone some change during the last decade. Data in table 3 on the origin of iron ore imports into the principal importing countries show that, apart from Belgium-Luxembourg which traditionally rely on French ores, western European countries import increasing proportions of their requirements from Latin America, Africa and the Far East. The availability of large ore carriers, together with the fall in ocean freight rates during the last years, and the improvement in loading and harbour facilities have contributed to this development. Most of the major producers or groups of producers have founded their own mining companies or hold a financial interest in mining development schemes overseas. This is particularly true for the United States; where almost no European ores are any longer imported, their place having been taken by ores from Canada. Imports from Latin America have also grown in importance (from 42.4 per cent of the total to 47.1 per cent); the increase of imports from Venezuela is noteworthy (from 4.6 million tons in 1955 to 10.5 million tons in 1962).

The origin of iron ore imports into Poland and Czechoslovakia has changed in so far as for both countries the share of Swedish ore in the total has decreased; this is largely explained by the fact that Swedish ores are principally used in steel furnace and ores from the USSR for the increasing pig-iron production.

Before the development of sintering and other ore preparation techniques the principal outlet for iron ore was the blast-furnace. Data in table 4 on the consumption of iron ores by consuming sector show that during the last few years ore preparation grew in importance; in many countries ore consumption for sintering is equal or greater than for direct use in blast-furnaces, *viz.* in Austria, Sweden, United Kingdom, Poland, the Netherlands and Western Germany. Use of ore in steel-making is significant only in those countries which produce most of their crude steel output in open-hearth furnaces.

Data on production of sinter in selected countries of Europe and in the United States are given in table 5. It is evident that production of sinter more than doubled during the last six years in Czechoslovakia, the ECSC taken as a whole, and in Yugoslavia. Poland and the USSR nearly doubled their sinter output during the same period.

A word should be added about the development of iron ore prices in Europe. A peak was reached in 1958 and Swedish ore (Kiruna D type, 60 per cent Fe; 1.8 per cent P; c.i.f. Rotterdam) was $13.20 per ton in 1958; it had fallen to $10.88 by the beginning of 1963. Since Swedish mines were for a long time virtually the main western European source of high-grade ores, their trend can be regarded as characteristic for the development referred to above, i.e., that good ores are available in sufficient quantities in western Europe, since new mines have been opened in overseas regions and transport costs are such as to make hauls over long distances economically feasible. This development was particularly felt in the Federal Republic of Germany, where, in 1962, certain low-grade ore mines discontinued operations.

Table 2. Apparent consumption of iron ore in selected countries, 1959 to 1962

(Thousands of tons, actual tonnage)

Country	Production 1959	Production 1960	Production 1961	Production 1962	Imports 1959	Imports 1960	Imports 1961	Imports 1962	Exports 1959	Exports 1960	Exports 1961	Exports 1962	Apparent consumption 1959	Apparent consumption 1960	Apparent consumption 1961	Apparent consumption 1962
Belgium-Luxembourg	6,652	7,137	7,573	6,588	18,123	20,600	20,537	20,919	124	128	189	236	24,651	27,609	27,921	27,271
France [a]	60,887	66,991	66,579	66,319	955	1,505	1,698	1,896	20,030	27,156	25,855	25,684	41,812	41,260	42,422	42,531
Italy	1,238	1,252	1,200	1,151	1,634	2,642	3,307	4,424	2	8	26	—	2,870	3,886	4,481	5,575
Netherlands	—	—	—	—	1,918	2,314	2,251	2,310	—	—	—	—	1,918	2,314	2,251	2,310
Germany (Fed. Rep. of) [b]	12,962	13,543	13,085	11,431	19,976 [c]	33,529 [e]	33,856 [c]	30,196 [c]	297	244	258	283	32,641	46,828	46,683	41,344
TOTAL, ECSC	81,739	88,843	88,437	85,489	42,606	60,590	61,649	59,745	20,453	27,536	26,328	26,203	103,892	121,897	123,758	119,031
Austria	3,382	3,542	3,692	3,751	636	1,612	1,297	1,043	—	20	10	—	4,018	5,134	4,979	4,794
Spain	4,939	5,493	6,098	5,849	..	..	..	..	..	..	..	..	3,518	3,950	4,660	..
Sweden	18,351 [d]	21,787 [d]	23,131 [d]	21,857 [d]	3	4	4	4	15,459	19,813	20,264	19,397	2,895	1,978	2,871	2,464
United Kingdom	15,108	17,362	16,783	15,522	13,528	18,302	15,215	13,177	1	1	1	—	28,635	35,663	31,997	28,699
Yugoslavia	2,097	2,199	2,184	2,190	125	130	345	353	16	90	124	102	2,206	2,239	2,405	2,441
Czechoslovakia	2,968	3,120	3,294	3,478	6,369	7,151	7,971	8,318	—	—	75	2	9,337	10,271	11,190	11,794
Poland	2,014 [e]	2,182 [e]	2,386 [e]	2 436 [e]	3,259	7,300 [f]	7,670 [f]	8,104 [f]	6	72	8	—	5,267	9,410	10,048	10,540
USSR	94,390	106,541	117,633	128,102	—	—	—	—	13,446	15,182	16,283	..	80,944	91,359	101,350	..
United States	60,444	89,040	72,704	73,488	36,196	35,146	26,225	34,299	3,020	5,320	4,995	5,992	93,620	118,866	93,934	101,795

SOURCE: *Quarterly Bulletin of Steel Statistics for Europe*, ECE, Geneva.

[a] Including the Saar until July 1959.

[b] Including the Saar as from July 1959.

[c] Including manganiferous iron ores.

[d] Including an annual production of approximately 1 million tons of concentrates.

[e] Including small quantities of iron-pyrites.

[f] As from January 1960 data refer to crude ores (net weight); previously Fe-content was indicated.

Table 3. Imports of iron ore into selected countries, 1950 and 1962

(Percentages of total imports and thousands of tons, annual tonnages)

Destination → / Origin ↓	Belgium-Luxembourg		Austria		Italy		Netherlands		United Kingdom		Western Germany		Czechoslovakia		Poland		United States	
	1950	*1962*	*1950*	*1962*	*1950*	*1962*	*1950*	*1962*	*1950*	*1962*	*1950*	*1962*	*1950*	*1952*	*1950*	*1962*	*1950*	*1962*
Western Europe	98.9	94.2	89.9	56.2	0.4	8.7	61.0	35.0	57.7	42.7	89.8	64.4	42.6	2.7	41.4	6.7	27.1	0.1
Of which from																		
France	80.3	74.4	—	—	—	—	22.0	—	4.4	2.6	2.7	31.2	—	—	—	—	—	—
Sweden	18.4	19.8	29.8	5.1	—	8.7	25.6	32.2	41.0	31.8	77.1	27.2	41.8	2.7	37.7	6.7	24.8	0.1
USSR	—	—	—	30.0	—	—	—	—	—	—	—	0.8	57.3	63.7	55.2	78.1	—	—
North America	0.1	1.2	—	—	—	2.5	—	5.2	1.5	13.1	0.7	3.2	—	..	..	..	22.4	50.4
Of which from																		
Canada	—	1.2	—	—	—	2.5	—	5.2	1.5	13.1	0.7	3.1	—	..	—	..	22.4	50.4
Latin America	0.1	—	—	0.1	—	36.9	5.4	3.3	0.2	13.0	0.6	18.1	—	..	—	..	42.4	47.1
Of which from																		
Brazil	0.1	—	—	0.1	—	13.7	5.4	2.6	0.2	3.5	0.6	9.7	—	..	—	..	8.4	4.5
Chile	—	—	—	—	—	3.4	—	0.1	—	—	—	1.5	—	..	—	..	31.3	10.2
Venezuela	—	—	—	—	—	14.4	—	—	—	9.5	—	3.8	—	..	—	..	—	30.8
Africa	0.8	—	10.0	8.6	99.2	24.4	33.6	48.6	40.4	25.7	8.9	9.2	—	..	—	..	7.9	2.3
Of which from																		
Algeria	0.8	—	—	—	72.8	8.4	21.8	2.3	17.6	10.9	0.1	0.8	—	..	—	..	6.0	—
Morocco	—	—	10.0	—	—	—	—	—	3.4	2.0	2.0	0.7	—	..	—	..	—	—
Sierra Leone	—	—	—	2.8	—	—	—	27.4	8.7	4.4	4.3	2.5	—	..	—	..	—	—
West Africa	—	—	—	—	—	—	—	—	—	—	0.2	—	—	..	—	..	—	—
Liberia	—	—	—	—	—	12.1	—	19.0	—	5.7	—	3.7	—	..	—	..	—	2.3
Far East	—	—	—	5.1	—	23.3	—	7.5	0.1	—	0.6	4.1	—	..	—	..	0.4	0.1
Of which from																		
India	—	—	—	5.1	—	23.3	—	7.5	—	—	0.6	4.1	—	..	—	..	—	—
Malaya	—	—	—	—	—	—	—	—	0.1	—	—	—	—	..	—	..	—	—
Philippines	—	—	—	—	—	—	—	—	—	—	—	—	—	..	—	..	0.4	0.1
TOTAL IMPORTS (1,000 t)	8,254	21,143	198	1,044	184	4,424	812	2,310	8,515	12,913	4,870	29,069	2,195	7,971	1,918	7,670	8,348	33,968

SOURCE: National foreign trade statistics (import data).

Table 4. Consumption of iron ores by consuming sectors, in selected countries

(Thousands of tons)

Country	Sinter				Blast-furnaces				Steel-making				Total			
	1959	*1960*	*1961*	*1962*	*1959*	*1960*	*1961*	*1962*	*1959*	*1960*	*1961*	*1962*	*1959*	*1960*	*1961*	*1962*
Belgium-Luxembourg	3,803	5,100	6,326	8,485	20,981	22,429	21,117	19,194	28	28	35	55	24,812	27,557	27,478	27,734
France	3,888	6,290	7,956	. .	32,531	33,564	33,303	28,295	97	120	140	147	36,516	39,974	41,399	. .
Italy	1,210	1,389	1,704	1,878	1,751	2,372	2,610	3,443	185	254	269	325	3,146	4,015	4,583	5,646
Netherlands	745	862	1,598	1,782	1,056	1,190	473	522	33	29	28	12	1,834	2,081	2,099	2,316
Germany (Fed. Rep. of) [a]	12,178 [b]	16,251 [b]	18,282 [b]	20,026 [b]	25,917	28,461	25,944	20,377	598	923	835	886	38,693	45,635	45,061	41,289
TOTAL, ECSC	21,824	29,892	35,866	. .	82,236	88,016	83,447	71,831	941	1,354	1,307	1,425	105,001	119,262	120,620	. .
Austria	1,890	2,379	2,277	2,506	2,037	2,266	2,439	2,104	46	85	88	47	3,973	4,730	4,804	4,657
Spain	. .	1,395	. .	1,740	2,377	2,478	2,548	2,533	104	113	165	212	. .	3,986	. .	4,485
Sweden	2,340	2,539	. .	. .	55 [c]	60 [c]	. .	. .	83	96	. .	. .	2,478	2,695	. .	. .
United Kingdom	13,024	16,953	17,005	18,045	13,362 [d]	15,271 [d]	13,390 [d]	9,698	1,051 [e]	1,381 [e]	1,208 [e]	987 [e]	27,437	33,605	31,603	28,730
Yugoslavia	1,119	1,094	1,091	. .	1,553	1,451	2,468	2,470	. .	. .	. .	. .	. .	. .	. .	. .
Czechoslovakia	3,086	3,357	. .	. .	3,594	3,902	3,664	3,427	330	271	275	307	7,010	7,530	. .	. .
Poland	3,810	4,193	5,120	5,680	3,408	3,438	3,399	3,924	384	425	440	534	7,602	8,056	8,959	10,138
USSR	. .	. .	. .	. .	23,565	23,664	. .	21,922	. .	. .	. .	. .	. .	. .	. .	. .
United States	37,861	55,336	35,144	. .	49,824	46,733	42,418	. .	6,285	6,707	6,395	. .	93,970	108,776	83,957	. .

SOURCE: *Quarterly Bulletin of Steel Statistics for Europe*, ECE, Geneva.

[a] Including the Saar as from 1959.

[b] Consumption for sinter produced at works only.

[c] Excluding raw materials consumed in the production of sponge iron.

[d] Including consumption of calcined ores.

[e] Including consumption of manganese ore (in 1962: 627 tons).

Table 5. Production of sinter in selected countries, 1957 to 1962

(Thousands of tons)

Country	1957	1958	1959	1960	1961	1962
Belgium	693	927	1,661	2,231	3,216	4,871
Luxembourg	1,843	2,002	2,408	2,928	2,966	3,211
France	1,978	2,711	3,807	6,350	7,412	10,047
Italy	1,558	1,824	1,846	2,129	2,394	2,444
Netherlands	598	693	809	968	1,805	1,994
Saar	3,269	3,427	3,566	[a]	[a]	[a]
Germany (Fed. Rep. of)	10,354	11,034	12,354	19,793	21,234	23,094
TOTAL, ECSC	20,293	22,168	26,451	34,399	39,027	45,661
Austria	2,036	1,915	2,050	2,573	2,406	2,486
Sweden	2,699	2,453	2,612	2,878	...	
United Kingdom	9,390	9,562	11,643	15,024	14,841	15,942
Yugoslavia	480	752	934	1,008	1,048	1,056
Czechoslovakia	2,828	3,174	3,744	4,011	4,837	5,606
Poland	4,050	4,454	5,147	5,494	6,370	7,044
USSR	44,909	50,832	56,837	65,135	74,190	83,360
United States	28,250	27,000	30,064	40,681	39,082	...

SOURCE: *Quarterly Bulletin of Steel Statistics for Europe*, ECE, Geneva.
[a] Included under Federal Republic of Germany.

Production and consumption of coke

The iron and steel industry is by far the most important consumer of coke-oven coke; between 65 and 100 per cent of total output finds its way into iron and steel production in European countries. As is evident from data given in table 6 on supply of coke-oven coke, many of the countries listed are net-exporters of coke, e.g., the Netherlands, Federal Republic of Germany, United Kingdom, Czechoslovakia, Poland, the USSR and the United States. The following countries are meeting part of their coke requirement from outside sources: Belgium-Luxembourg (about 30 per cent), France (25 per cent), Austria (30 per cent). Spain (10 per cent), Sweden (80 per cent) and Yugoslavia (20 per cent).

Coal had been a scarce material in the late forties and in the first half of the fifties. This situation has, however, changed during the last few years, and prices for coking coal in 1962 were substantially below their 1958 level; Swedish import prices had fallen since 1954 by about 15 per cent. The same tendency prevailed in many countries for prices of metallurgical coke. Although consumption in the iron and steel industry is, generally speaking, increasing in absolute terms, specific consumption in pig-iron making is falling, due to better charge preparation and other measures to improve blast-furnace productivity. Even if consumption of coke breeze in sinter production, etc. is taken into account, the net results are savings in specific coke consumption. The trend of specific consumption of raw materials for pig-iron making is shown by data in table 7. It is evident that specific coke consumption fell considerably as the proportion of sinter in the total ore charge increased. The low rates achieved in Sweden (572 kg in 1962), the USSR (670 kg) and Austria (677 kg) are noteworthy; in this context it should be mentioned that in Japan the average specific consumption rate of coke in pig-iron production was 552 kg during 1962.

Availabilities and consumption of scrap

There are basically three sources of scrap: first, the arisings of scrap in the rolling and finishing of steel (circulating scrap); second, the arisings of scrap in the process of transforming finished iron and steel products by manufacturing industries and by other steel-using sectors of the economy (process scrap); and third, scrap salvaged from waste products, i.e., products which are no longer used for their original purpose, like ships, motor-cars, tin cans, etc. (capital scrap). While arisings of circulating scrap vary with the activity of the steel industry itself, arisings of process scrap are dependent on the activity of steel-transforming industries; airsings of capital scrap depend in a large measure on the durability of a given steel-containing product, the level of steel utilization in a given period of the past, the type of product used, its cost of scrapping and collection, and also on the general level of demand for scrap. It has been estimated [2] that about half of total scrap used in a country arises in the steel plant itself or is returned from steel-using industries.

Between 1945 and 1959 scrap was in short supply; this situation has changed radically since. The reasons for this development in Europe and the United States may be assumed to be the following: the pig-iron/scrap ratio in steel-making was changed in favour of pig-iron since iron-making capacity was expanded in many countries at a rate more than proportionate to the expansion of steel-making capacity; the average pig-iron/scrap ratio was further influenced by the introduction on a larger scale of oxygen-blown vessels in steel-making; circulating scrap arisings tended to be increased because

[2] *Long-term Trends and Problems of the European Steel Industry*, ECE, Geneva, 1959, page 76.

Table 6. Supply of coke-oven coke in selected countries, 1959 to 1962

(Thousands of tons)

Country	Production				Imports				Exports				Apparent consumption			
	1959	1960	1961	1962	1959	1960	1961	1962	1959	1960	1961	1962	1959	1960	1961	1962
Belgium-Luxembourg	7,217	7,541	7,253	7,363	3,709	4,157	4,161	4,006	636	752	636	415	10,290	10,946	10,778	10,954
France	13,424	13,933	13,753	13,787	4,334	5,070	5,531	4,693	149	130	105	160	17,609	18,873	19,179	18,320
Italy	3,055	3,716	3,897	4,330	197 [a]	238 [a]	245 [a]	325 [a]	35 [a]	110 [a]	151 [a]	178 [a]	3,217	3,844	3,996	4,477
Netherlands	4,128	4,558	4,647	4,392	413	371	311	361	2,057	2,306	2,478	2,222	2,484	2,623	2,480	2,531
Germany (Fed. Rep. of) [b]	42,967	44,754	44,535	43,197	338	429	274	314	9,283	10,864	10,773	10,306	34,022	34,319	34,036	33,205
TOTAL, ECSC	70,791	74,502	74,090	73,069	8,991	10,265	10,522	9,699	12,160	14,162	14,143	13,281	67,622	70,605	70,469	69,487
Austria	1,763	2,046	1,783	1,655	641	794	721	764	—	—	—	—	2,404	2,840	2,504	2,409
Spain	2,418	2,573	2,616	2,709	4	42	293	214	—	—	—	—	2 422	2 615	2 909	2 923
Sweden	121	134	266	344	1,515	1,825	1,593	1,513	19	11	5	5	1,617	1,948	1,854	1,852
United Kingdom	17,321	19,136	18,068	15,785	—	—	—	—	977 [a]	1 148 [a]	1,149 [a]	1,448 [a]	16,344	17,988	16,919	14,337
Yugoslavia	1,069	1,083	1,099	1,107	242	304	196	..	—	—	—	—	1,311	1,387	1,295	..
Czechoslovakia	7,878	8,458	8,536	8,930	—	—	—	—	1,209	1,317	1,370	1,570	6,669	7,141	7,166	7,360
Poland	10,879	11,283	11,948	12,573	—	112	53	103	2,063	2,086	2,139	2,145	8,816	9,309	9,862	10,531
USSR	53,400	56,200	58,600	60,900	630	658	648	598	2,466	2,646	3,016	..	51,564	54,212	56,232	..
United States	50,679	51,917	46,911	47,082	112	113	115	129	418	318	404	386	50,373	51,712	46,622	46,825

SOURCES: *Quarterly Bulletin of Steel Statistics for Europe*, ECE, Geneva: *Statistical Handbook*, British Iron and Steel Federation, London; Mineral Yearbooks, Bureau of Mines, Washington.

[a] Including gas coke.

[b] For reasons of comparability, figures for the Saar have been included under Federal Republic of Germany as from January 1959.

Table 7. Specific consumption of raw materials for pig-iron making, 1959 to 1962

(Kilogrammes per ton of pig-iron produced and percentages)

Country	Specific coke consumption				Specific scrap consumption				Proportion of sinter in total ore charge (per cent)				Specific consumption of iron ore and sinter			
	1959	1960	1961	1962	1959	1960	1961	1962	1959	1960	1961	1962	1959	1960	1961	1962
Belgium	861	844	826	792	179	94	79	47	6.4	15.0	22.3	32.2	2,064	2,255	2,225	2,236
France	1,029	972	955	915	120	88	83	63	6.0	15.9	18.2	26.2	2,855	2,821	2,796	2,748
Italy	927	777	739	708	37	19	18	11	40.1	47.1	47.5	41.6	1,807	1,652	1,607	1,645
Luxembourg	1,073	1,092	1,074	1,058	98	53	57	30	15.8	22.9	23.0	26.2	12	3,444	3,432	3,391
Netherlands	982	790	728	703	—	—	—	—	—	45.3	79.2	79.2	1,878	1,617	1,562	1,597
Germany (Fed. Rep. of) [a]	949	834	803	753	73	36	35	34	29.3	41.0	44.9	53.0	1,833	1,875	1,852	1,787
Austria	746	730	728	677	17	25	23	34	..	52.6	49.2	53.7	2,033	2,142	2,122	2,144
Spain	1,166	1,121	1,065	1,037	4	..	..	..	16.4	36.1	40.3	37.7	2,345	2,055	1,982	1,946
Sweden [b]	634	576	582	572	26	49	..	..	91.4	97.6			1,697	1,619	1,647	1,652
United Kingdom	986	825	818	774	66	93	93	103	28.1	49.6	52.6	62.1	2,084	1,892	1,885	1,840
Yugoslavia	1,148	1,127	1,072	1,018	71	70	81	78	28.4	41.0	30.0	29.9	2,588	2,530	3,536	3,358
Czechoslovakia	1,154	988	943	929	78	76	70	69	43.7	50.7	56.9	62.1	1,780	1,686	1,710	1,745
Poland	1,177	1,041	1,006	1,002		22	19	21	..	61.4 [c]	65.1 [c]	64.2 [c]	2,058	2,097	2,200	2,223
USSR	815	724	671 [d]	670	..	..	..	..	61.6	73.0	76.2 [d]	78.7	1,820	1,871	1,865 [d]	1,866
United States	850	770	728		45	53	54	..	23.2	52.5	55.2	..	1,630	1,612	1,598	

SOURCES: *Quarterly Bulletin of Steel Statistics for Europe*, ECE, Geneva.

NOTE: Specific coke consumption has been calculated by relating coke consumption in blast-furnaces to output of coke pig-iron. Specific scrap consumption likewise concerns only blast-furnaces. Consumption of scrap in electric furnaces has been excluded.

[a] Including the Saar as from 1959.

[b] Specific coke consumption represents consumption of coke-oven coke in blast-furnaces, electric furnaces and low-shaft furnaces.

[c] Including some quantities of concentrates.

[d] Based on 9 months only.

Table 8. Consumption of and trade in scrap, in selected countries, 1959 to 1962

(Thousands of tons)

Country	Total consumption 1959	1960	1961	1962	(—) Imports 1959	1960	1961	1962	(+) Exports 1959	1960	1961	1962	Domestic supply 1959	1960	1961	1962
Belgium-Luxembourg	2,708	3,014	2,837	2,539	244	196	197	121	272	446	335	362	2,736	3,264	2,975	2,780
France [a]	7,081 [b]	7,426 [b]	7,508 [b]	7,006 [b]	311	493	742	367	1,240	1,226	1,161	1,190	8,010	8,159	7,927	7,829
Italy	5,935	7,104	7,706	7,829	2,628	3,220	3,399	3,965	1	1	1	1	3,308	3,885	4,308	3,865
Netherlands	1,110	1,254	1,211	1,311	65	96	38	82	278	332	397	234	1,323	1,490	1,570	1,463
Germany (Fed. Rep. of) [c]	15,757	18,567	18,413	18,165	622	1,025	942	621	1,009	1,311	1,534	1,250	16,144	18,853	19,005	18,794
TOTAL, ECSC	32,591	37,365	37,675	36,850	3,870	5,030	5,318	5,156	2,800	3,316	3,428	3,037	31,521	35,651	35,785	34,731
Austria	1,197	1,523	1,433	1,372	41	122	79	42	—	—	—	3	1,156	1,401	1,354	1,333
Spain	..	..	..	..	118	115	247	..	—	20	13	..	..	..	..	..
Sweden	..	..	..	..	202	302	166	29	10	13	14	11	..	..	..	..
United Kingdom	15,645	18,349	16,999	15,874	3	283	23	5	951	19	30	1,102	16,593	18,085	17,006	16,971
Yugoslavia	721	827	854	740	20	64	125	80	—	2	7	8	701	765	736	668
Czechoslovakia	3,666	4,015		.	20	16	..	..	5	4	..	..	3,651	4,003	..	..
Poland	4,211	4,462	4,824	5,101	—	—	—	—	—	—		-	4,211	4,462	4,824	5,101
USSR	..	..	..	..	—	—	—	—	106	170	223	..	..	..	..	..
United States	59,932	60,299	58,357	..	284	165	246	241	4,399	6,522	8,814	4,639	64,047	66,656	66,925	..

SOURCES: *Quarterly Bulletin of Steel Statistics for Europe*, ECE, Geneva; *Statistical Handbook*, British Iron and Steel Federation, London.

[a] Including the Saar until July 1959.

[b] Consumption in the production of pig-iron and crude steel only.

[c] Including the Saar as from July 1959.

Table 9. Consumption of scrap in different sectors, in selected countries, 1959 to 1962

(thousands of tons)

Country	Blast-furnaces 1959	Blast-furnaces 1960	Blast-furnaces 1961	Blast-furnaces 1962	Steel-making 1959	Steel-making 1960	Steel-making 1961	Steel-making 1962	Iron founderies 1959	Iron founderies 1960	Iron founderies 1961	Iron founderies 1962	Other uses 1959	Other uses 1960	Other uses 1961	Other uses 1962	Total 1959	Total 1960	Total 1961	Total 1962
Belgium	640	617	512	317	1,258	1,458	1,368	1,384	..	..	..	..	59	81	95	101	..	..	..	..
Luxembourg	187	197	214	109	530	629	612	698	24	32	36	31	—	—	—	—	751	858	862	838
France	1,176	1,243	1,215	876	5,380	6,183	6,293	6,130	..	..	..	..	78	88	73	..	..	..	..	..
Italy	29	44	50	36	5,099	6,132	6,614	6,773	665	752	856	827	142	176	186	193	5,935	7,104	7,706	7,829
Netherlands	—	—	—	—	923	1,045	1,000	1,102	187	209	211	209	—	—	—	—	1,110	1,254	1,211	1,311
Germany (Fed. Rep. of) [a]	862	919	891	834	12,164	13,848	13,611	13,528	3,235	3,780	3,896	3,790	21	20	15	13	15,242	18,567	18,413	18,165
TOTAL, ECSC	2,894	3,020	2,282	2,172	25,354	29,295	29,498	29,615	..	..	..	..	300	365	369	..	..	..	..	..
Austria	56	56	53	73	963	1,258	1,175	1,101	178	209	205	198	—	—	—	—	1,197	1,523	1,433	1,372
Spain	..	..	..	..	889	960	1,166	1,155	..	71	..	45	..	17	..	36	..	..	..	..
Sweden	70	75	..	..	1,819	2,000	2,164	2,141	..	..	..	..	..	..	..	..	..	..	..	..
United Kingdom	1,124	1,484	1,400	1,440	10,993	12,850	11,650	10,633	3,268	3,731	3,641	3,490	254	284	308	311	15,645	18,349	16,999	15,874
Yugoslavia	58	61	73	74	556	649	654	540	107	117	127	126	—	—	—	—	721	827	854	740
Czechoslovakia	330	358	348	358	2,724	3,024	3,141	3,398	612	633	..	..	—	—	—	—	3,666	4,015	..	..
Poland	66	92	84	105	3,365	3,631	3,987	4,188	780	739	753	808	—	—	—	—	4,211	4,462	4,824	5,101
USSR	..	..	..	..	24,997[b]	26,838[b]	29,340[b]	31,164[b]	..	..	..	..	..	..	..	..	..	..	..	..
United States	2,893	3,260	3,221		44,983	45,960	44,701	..	9,608	8,909	8,486		2,448	2,170	1,949	..	59,932	60,299	58,357	..

SOURCES: *Quarterly Bulletin of Steel Statistics for Europe*, ECE, Geneva; *Statistical Handbook*, British Iron and Steel Federation, London.

a Including the Saar as from 1959.

b For open-hearth steel only.

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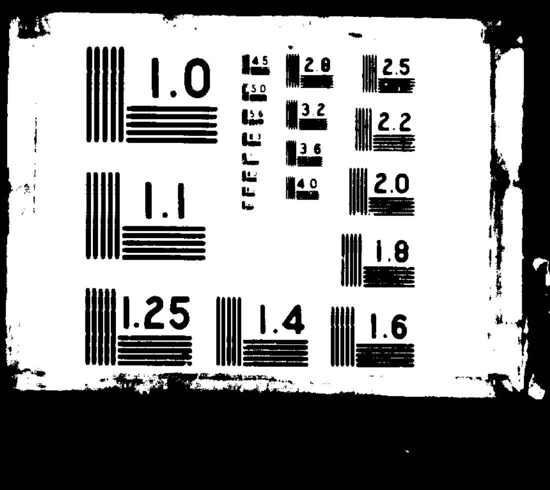


Table 10. Specific consumption of scrap [a] in crude steel production, in selected countries, 1959 to 1962

(Kilogrammes per ton of crude steel output)

Country	Total steel				Converter steel				Open-hearth steel				Electric steel				Other steel			
	1959	1960	1961	1962	1959	1960	1961	1962	1959	1960	1961	1962	1959	1960	1961	1962	1959	1960	1961	1962
Austria	460	398	379	371	—	—	—	—	482	566	548	547	863	968	863	979	148	175	186	184
Belgium	211	203	195	188	88	101	94	92	923	920	933	923	661	624	657	745	—	—	—	—
France	353	358	358	356	43	69	72	75	838	828	825	818	796	784	784	767	—	429	303	266
Germany (Fed. Rep. of) [b]	433	406	407	415	63	55	58	61	685	675	674	668	964	936	934	947	—	156	124	141
Italy	774	745	725	714	—	—	—	55	690	622	607	570	1,020	1,029	1,023	1,029	—	—	—	—
Luxembourg	113	154	149	174	109	153	147	147		—	—	—	265	222	267	266	—	—	—	231
Netherlands	726	538	507	528	—	—	—	—	..	..	..	..	..	..	..	..	—	—	—	—
Norway	627	500	558	607	15	..	—	—	..	..	—	..	772	902	874	874	—	—	—	—
Spain	521	500	501	525	9	45	22	16	499	515	468	467	1.036	844	1.022	1.174	—	—	—	—
Sweden	575	622	608	593	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
United Kingdom	543	520	519	511	44	47	51	63	545	526	525	523	1,011	983	983	987	868	956	570	291
Yugoslavia	473	450	427	339	—	—	—	—	..	..	375	..	..	..	942	..	—	—	—	—
Czechoslovakia	435	447	446	445	9	12	..	..	416	394	..		729	955	..	..	—	—	—	—
Poland	545	544	551	545	—	—	—	—	514	504	514	505	985	1,006	998	1,007	..	826	839	854
USSR	..	..	..	..	..	..	..	..	459	487	489	480	..	..	..	..	..	..	..	..
United States	555	510	503	..	58	12	12	..	482	459	448	..	976	1,164	1,145	..	..	344	346	..

SOURCE: *Quarterly Bulletin of Steel Statistics for Europe*, ECE, Geneva.

[a] Includes for some countries consumption of scale, slag and other Fe-bearing materials.

[b] Including the Saar as from 1960.

of a growing share of flat steel products in total output;[3] the arisings of capital scrap were relatively higher since the base period in which the steel-containing manufactured products had been put into use was of a high level of steel utilization; the methods of preparing and collecting capital scrap had been perfected and gave rise to greater availabilities of scrap. The result was a considerable fall in scrap prices; while a ton of No. 1 heavy melting steel scrap was $40.75 in Pittsburgh on an average during 1959, it was only $24 in November 1962.

Data in table 8 on consumption of and trade in scrap illustrate the situation prevailing at present in Europe and in the United States. It will be seen that many European countries and the United States are net-exporters of scrap, *viz.* Belgium-Luxembourg, France, Federal Republic of Germany, the United Kingdom (in 1962) and the USSR; on the other hand considerable quantities were imported into Italy (in 1962: almost 4 million tons).

Table 9 shows the importance of individual sectors of the iron and steel industry as consumers of scrap. As is to be expected, steel making is by far the main outlet for scrap consumption, taking between 70 and 85 per cent of total supply, the share varying with the relative size of the iron foundry industry, the other principal consumer of scrap. Blast-furnaces, which normally use a lower grade of scrap, are of some importance as outlets for scrap only in those countries where the Fe content of the ore burden is relatively smaller. Other uses of scrap, i.e., mainly for re-rolling, are of minor importance in most European countries and in the United States.

Specific consumption of scrap for crude steel making is shown in table 10. The data show that for those countries which produce a high share of their crude steel in Thomas converters or in oxygen converters, the absolute level of specific scrap consumption for total output is rather low; examples are Belgium and Luxembourg, but also France and Austria. The highest specific consumption of scrap is shown for Italy where electric steel making holds a predominant place. It is also evident that steel-melting practice in conventional converters varies widely between European countries; while Luxembourg uses up to 153 kg per ton of scrap (in 1960), other countries consume much less scrap in converters. The pig-iron/scrap ratio in open-hearths differs also to a considerable extent between countries (from 923 kg of scrap in Belgium to 480 kg in the USSR). The general trend appears, however, to be for a falling share of scrap in the steel-furnace charge.

In conclusion it can be said that the present situation of raw material supply for iron and steel making in Europe and the United States is satisfactory, from the point of view of quantity and quality as well as from that of prices. Other raw-material resources and sources of energy appear also to be adequate: no major problems have been encountered recently in the supply of fuel oil, gas, electric power, tonnage oxygen, limestone or manganese ore. In view of the present trends of technical developments in the field of iron and steel making it can be expected that specific consumption of raw materials, as well as energy, per ton of output will be further reduced; so that over-all demand for iron and steel making raw materials will grow less than proportionate to iron and steel output.

[3] It should be mentioned that many modern integrated steel plants, using top-blown oxygen converters and producing mainly flat-rolled finished products, have become entirely self-sufficient in scrap.

DC3916

STEEL-MAKING RAW MATERIALS IN LATIN AMERICA

(DOCUMENT ECLA.1)[1]

Introduction

Latin America has important iron ore reserves, of which 20,500 million tons can be considered as actual reserves of immediate economic value and some 34,500 have to be classified as potential reserves. There is also abundance of the other resources necessary for steel production, coking coal being the only exception as the few existing formations are badly located. Therefore, in order to produce adequate coke in most of the Latin American integrated steel plants, it is necessary to import either all, or at least some coal for blending. Of course, not all of these resources are evenly distributed among the twenty republics so that the need to keep assembly costs as low as possible tends to determine several locations which are more favourable for the development of the steel industry, the same as happens in other continents. Another set of considerations which influences the location of the steel industry in Latin America is the concentration of demand in a few countries or regions of some of the countries, added to the general scarcity of population and the need for long and costly transports between one more industrialized centre and the other.

From its resources for steel making, Latin America exports iron ore, manganese ore and ferro-manganese as well as petroleum and, of course, also considerable quantities of the non-ferrous metals which are used for various purposes in the steel industry: zinc, tin and copper. Concerning iron ore, exports amounted in 1962 to some 34.2 million tons of from 59 of 63 per cent iron content, out of a total production of some 39 million. Manganese ore exports equalled (1961) 1.1 million tons of 45 per cent grade out of a total production of 1.2 million tons. Petroleum exports from the Region have been 185 million tons out of a total production of 214 million tons. Figure 1 shows the main resources for steel making existing in the region.

Latin American present steel production

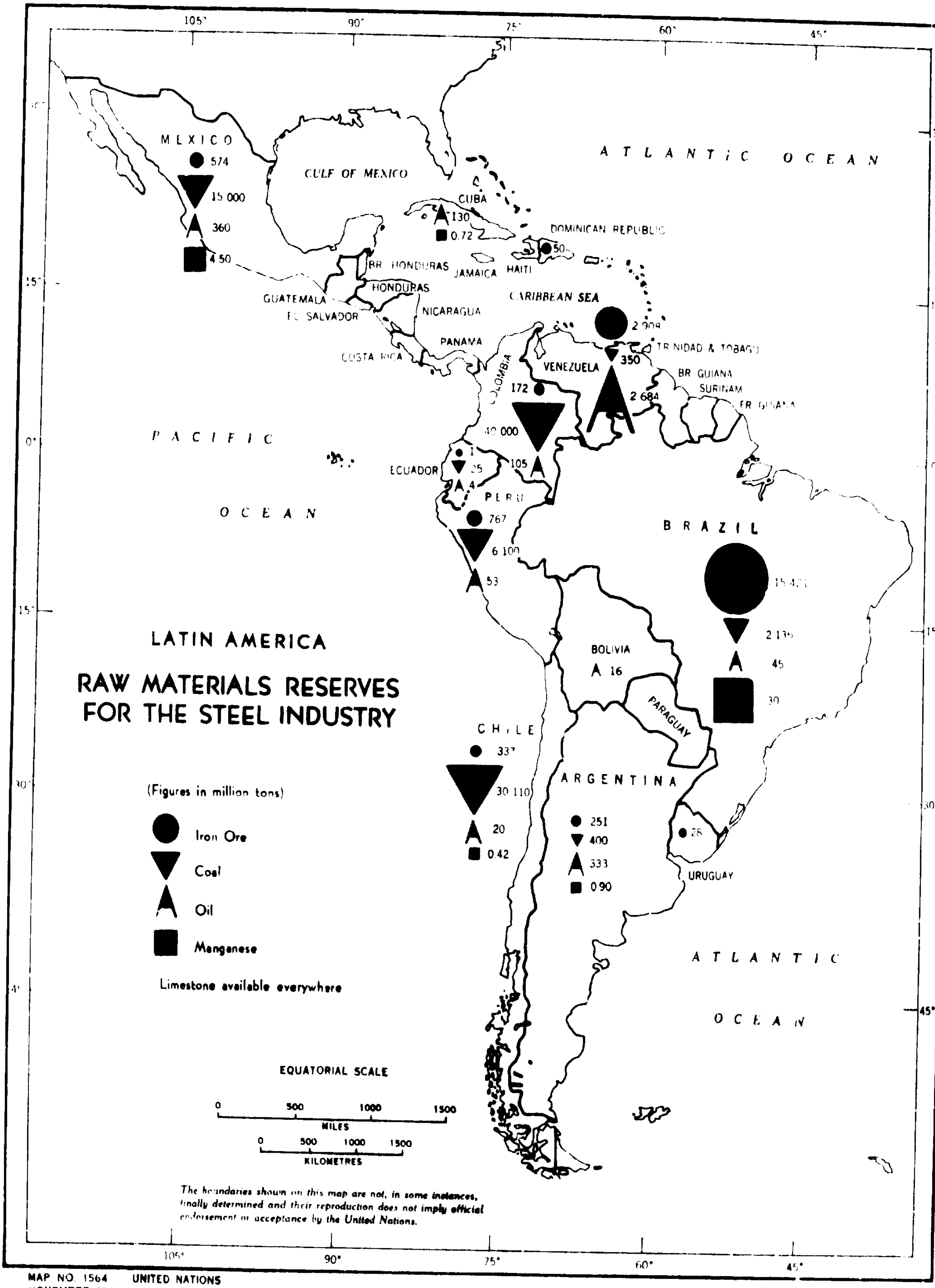
In 1962 Latin American steel production amounted to the equivalent of 5,8 million tons of ingot steel and imports totalled 3.6 million of finished steel products, or the equivalent of some 4.5 million tons of ingot. Although production has been rising at a considerable rate, it has kept, persistently, below apparent consumption. There are several reasons for this. Among them we may mention: (*a*) the high investment per annual ton of steel production which makes building of steel-making facilities difficult in countries where capital is as scarce as it is in Latin America; (*b*) the considerable influence of the scale of operations on the unit investments and costs in the industry, which is responsible for the fact that although there are raw materials and resources available in some of the smaller countries, erection of a plant for service of the internal market has not been justified by the small size of steel demand; (*c*) transport facilities between most of the Latin American countries have been both scarce and expensive. Ocean freight between two adjoining Latin American countries or even within one single country are usually more expensive than those from New York or Amsterdam; (*d*) the trend towards a Latin American free trade zone is still too new to have influenced existing industry. Incidentally, except for the General Treaty on Central American Economic Integration no progress in mutual concessions for trade in steel production has been achieved so far by the integrated plants of the Region.

The influence of the above factors is responsible for the fact that, with only two exceptions, the Latin American steel industry has been planned for substitution of imports in the respective country and, what is more, not even for the substitution of all imports of finished steel products, as the current product-mix of the demand within the countries comprises several products which it is not economic to manufacture on a small scale. The exceptions to this rule are Chile and Venezuela, which have planned the production of some items far above the requirements of their internal market with a view to exporting the surpluses.

Table 1 shows the pattern of Latin American steel production and apparent consumption in 1962.

An analysis of the above factors which have shaped the present pattern of steel production in Latin America shows that there are several forces at work which will tend to influence the future picture of the industry in the region. These forces are: (*a*) during the last decade, at least, considerable technological progress has been achieved in the various steps of the steel industry, such as: (i) increase in the daily output of the blast furnaces with only very small additional investments and an important saving in fuel; (ii) use of oxygen in the open-hearth furnaces, thus increasing also their output with only the addition of an oxygen plant or the use of oxygen blown converters, which demand a much smaller investment per annual ton of output; (iii) use of continuous casting. The possible results of these innovations include: (*a*) the reduction of the total investment in a steel plant per unit of output, thus making it to some extent easier to finance new facilities; (*b*) direct influence on economies of scale of the industry in such a way as to permit construction of plants, considerably smaller than those

[1] Paper prepared by the secretariat of the Economic Commission for Latin America. See page 121 for discussion.



MAP NO. 1564 UNITED NATIONS
NOVEMBER 1964

Table 1. Latin America: Steel production [a], imports and apparent consumption in 1962

(Thousands of metric tons of ingot steel)

Country	Steel production ingot	Steel imports (finished and semifinished steel)	Apparent consumption Total	Per capita
Argentina	644	1,398	2,500	76
Brazil	2,587	370	2,957	39
Chile [b]	528	89	580	70
Colombia	156	300	400	27
Mexico [c]	1,712	207	1,890	53
Peru	71	120	190	16
Uruguay	8 [d]	110	120	44
Venezuela	142	650	850	76
Others	3	400	500	
TOTAL	5,851	3,644	9,987	

SOURCE: Several numbers of *Revista Latinoamericana de Siderurgia*, published by the Latin American Iron and Steel Institute and statistical yearbooks of foreign trade of some of the countries.

[a] Both from integrated and non integrated plants.

[b] Chile exports 63 thousand tons of steel.

[c] Mexico exports 40 thousand tons of pig iron.

[d] From imported billets.

of ten years ago, which may still be economic; (*c*) if, instead of considering steel production and demand as a definite product-mix, the many types of finished steel products are taken individually, one finds that the influence of economies of scale for individual products is so large that there is room for specialisation within Latin America in spite of high transport costs, and especially if trade within the Region is based on barter exchange of one type of steel product for others rather than foreign hard currency settlement; (*d*) it might well be that as soon as the above is appreciated by Latin American Governments and the steel industry itself, negotiations to facilitate such specialization may receive a strong impetus.

Latin American resources of iron ore

As a whole, Latin America is richly endowed with iron ore resources. The latest information available shows reserves of 20,529 million metric tons of ore. Of these a

Table 2. Latin America: Iron ore reserves and potential resources

(Millions of metric tons)

Country	Ore reserves	Yield iron (per cent)	Potential resources	Yield iron (per cent)	Total
Argentina	251 [a]	48	500	4 [b]	751
Bolivia			540	60	540
Brazil	15,421	58	28,059	35	43,480
Central America	20	60	—	—	20
Chile	337	62	1,250	51	1,587
Colombia	172 [a]	48	380	325	552
Cuba	—	—	2,500 [c]	45	2,500
Dominican Republic	50	67	—	—	50
Ecuador	1	66	—	—	1
Mexico	574	62	—	—	574
Peru	767	60	—	—	767
Uruguay	28	40	72	48	100
Venezuela	2,908	62	1,225	45	4,133
TOTALS	20,529	60	34,526	40	55,055

SOURCE: United Nations *Study of the Iron Ore Resources of the World*, 1954 (ST/ECA/27), data submitted by the geological bureaus of various of the countries and several numbers of *Revista Latinoamericano de Siderurgia*, published by the Latin American Iron and Steel Institute.

[a] Phosphoric ores with 0.8 to 1.0 per cent phosphorous.

[b] Ferriferous sands.

[c] Although there is plenty of high grade ore in well known deposits, these resources are considered to be only potential on account of varying contents of other ferrous metals, like chromium and nickel which complicate the production of iron and steel.

small fraction — some 420 million tons — consists of 48 to 50 per cent iron with a high phosphorous content of between 0.8 and 1 per cent. The rest is, in general, very rich ore, ranging from 58 to 68 per cent iron content and with low percentages of phosphorous and sulphur.

These ores are generally of hematites at the surface, blended with magnetite, the Fe content of which usually increases with the depth at which the sample is taken. Other ferrous minerals, like limonite and others, are also frequently present, but in smaller proportions.

Table 3. Latin America: Geological information and analyses of iron ore reserves [a]

Country and deposit	*Type of formation*	*Type of mineral*	*Reserves (millions of tons)*	*Analysis, percentages*			
				Fe	*SiO₂*	*P*	*S*
Argentina							
Sierra Grande	Minette	Magnetite [b]	145	56	6	1.5	0.5
Zapla	Lake Superior	Hem. & Lim.	106	40	35	0.3	0.1
Brazil							
Minas Gerais	Lake Superior	Hematite	2,096	66	0.5	0.03	0.01
Minas Gerais	Lake Superior	Hematite	3,000	50	6.0	0.14	0.01
Minas Gerais	Lake Superior	Itabirite	10,000	35	20.0	0.12	0.01
Urucum	Lake Superior	Itabirite	300 [c]	62	4.5	0.16	0.04
Parana	Massive	Magnetite	21.6	60	0.2	0.02	0.01
Chile							
Carmen	Kiruna	Magnetite	10	63	3.5	0.30	0.10
Las Adrianitos	Magnitnaya	Mag. & Hem.	10	64	4.0	0.01	0.04
El Algarrobo	Kiruna	Mag. & Hem.	120	64	5.5	0.15	0.05
Cristales	Kiruna	Mag. & Hem.	15	64	4.0	0.02	0.40
Banduna	Kiruna	Hematite	50	60	6.0	0.02	0.01
El Plaito	Kiruna	Hem. & Mag.	10	60	3.5	0.17	0.02
El Romerai	Kiruna	Hem. & Mag.	80	63	7.0	0.25	0.12
Colombia							
Pas del Rio	Minette	Hematite [b]	130	48	10.0	1.00	0.07
Cerro Matoso	Laterite	Hem. & Mag.	40	50	6.0	0.10	0.20
Dominican Republic							
Hatillo	Bilbao	Magnetite	50	67	1.5	0.03	0.09
Mexico							
Cerro El Marcado	Kiruna	Hem. & Lim.	70	62	3.9	0.70	0.25
La Perla	Magnitnaya	Hematite	50	60	7.0	0.11	0.30
Santa Urzula	Magnitnaya	Hematite	30	62	3.7	0.10	0.20
El Mamey	Magnitnaya	Hematite	131	65	12.6	0.10	0.20
El Encino	Magnitnaya	Hematite	16.5	60	4.5	0.32	0.13
Las Truchas	Magnitnaya	Hematite	73	59	7.5	0.04	1.14
Zaritza	Magnitnaya	Hematite	30	65	1.7	0.03	0.37
Peru							
Marcona	Magnitnaya	Hem. & Lim.	670	60	4.0	0.18	0.40 [d]
Huacraviloa	Bilbao	Hematite	64	60	4.0	0.10	0.60
Tambo Grande	Bilbao	Hematite	32	46	8.0	0.20	0.40
Venezuela							
Cerro Bolivar	Lake Superior	Hematite	1,686	62	0.7	0.15	0.01
El Pao	Lake Superior	Hematite	242	64	0.3	0.03	0.03
San Isidro	Lake Superior	Hematite	830	60	3.0	0.15	0.01
Maria Luisa	Lake Superior	Hematite	150	64	0.9	0.15	0.01

SOURCE: United Nations *Study of the Iron Ore Resources of the World*, 1954 (ST/ECA/27); information received from the geological bureaus of some countries of Latin America and data obtained from several numbers of the *Revista Latinoamericana de Siderurgia* of ILAFA, the Latin American Institute for Iron and Steel.

[a] In the table only the countries with known "reserves" are mentioned and only deposits with 10 million tons or more.

[b] Magnetite and colythic hematite.

[c] Urucum has, in addition, 10,000 tons of ore with 50 per cent grade which are considered as potential resources due to the unfavourable location.

[d] Marcona has also 1.5 per cent copper or additional impurity.

In addition to these reserves, potential resources of about 34,526 million tons have been located.[3] The average yield in iron ore of these potential resources is relatively low, about 40 per cent. Some high grade ore deposits have been tabulated as potential resources, like the Mutun formation in Bolivia and the Laco deposit in Chile, because transport costs to consuming centres or to tide water for export, would be too high at present. Similarly, some high grade ores which contain chromium or nickel have been included as potential resources, due to the metallurgical difficulties in smelting such ores.

Table 2 shows the currently known reserves and potential resources of iron ore in Latin America, by countries, as well as their average iron content. In addition to the deposits tabulated in table 2, there are many countries and sites with outcrops and indications of possible existence of iron ores, that would justify exploration work. Unless such work and studies have been carried out, the possible formations have not been considered here at all.

Comparing the 55,083 million tons of total reserves, actual and potential, shown in table 2 with the corresponding figure for the whole of the Latin American Region published in the 1954 *Study of the Iron Ore Resources of the World*, one finds that the latter was only 49,775 million tons. The increase of some 5,000 million tons is the consequence of considerable study and exploration work carried out in several Latin American countries, especially Venezuela, Chile and Mexico, in that order. While making this comparison it must be regretted that the limitation of time available for the preparation of this study did not make it possible to investigate in more detail the latest developments in Cuba and Peru, countries regarding which no new information was received.

[3] After this paper was written, United Nations experts arrived at the conclusion that the deposit at Mutun, Bolivia, to a depth of 200 metres, is a potential resource containing 45,000 million tons of ore of 54 per cent iron, 20 per cent silica, 0.13 per cent phosphorous and 0.15 per cent sulphur. The older data, which gave Mutun a potential of 540 million tons, have been used in this paper.

Table 3 gives an indication of the geological data and the analysis of the impurities contained in the main formations comprising the deposits included as reserves. More detailed information for each one of the deposits is given in the annexes in which the data have been compiled country by country.

Of the thirteen Latin American countries shown in table 1, in which iron ore deposits have been identified, those resources are being exploited in only seven of them. Table 4 shows the iron ore production and its destination in 1962. The figures of table 4 show that less than 20 per cent of the iron ore mined in Latin America is used within the region for steel production. The destination of the exports in 1962 is shown in table 5.

Table 4. Latin America: Exploitation of iron ore resources and use of the ore in 1962

(Millions of metric tons)

Country	*Production*	*Consumption*	*Exports abroad or within the Region*
Argentina	0.13	0.65	−0.51
Brazil	10.50	3.00	+7.50
Chile	8.09	0.60	+7.50
Colombia	0.42	0.42	—
Mexico	1.30	1.30	+0.15
Peru	5.23	0.18	+5.00
Venezuela	13.20	0.80	+14.00
TOTAL, Latin America	38.77	6.95	+33.64

SOURCE: Statistical yearbooks of foreign trade of some countries and several numbers of the *Revista Latinoamericana de Siderurgia*, published by the Latin American Iron and Steel Institute.

Table 5. Latin America: Destination of iron ore exports in 1962

(Millions of tons)

Country of destination	*Country of origin*				
	Brazil	*Chile*	*Peru*	*Venezuela*	*Total*
North America					
Canada	0.33	0.07	—	—	0.40
United States	4.40	3.40	0.70	10.00	18.50
Europe					
Italy	0.35	0.30	0.30	0.80	1.75
United Kingdom	0.27	—	0.30	1.70	2.27
Federal Republic of Germany	1.10	0.58	0.30	1.50	3.48
Czechoslovakia	0.25	—	0.35	—	0.60
Poland	0.30	—	—	—	0.30
Asia					
Japan	0.50	2.95	2.75	—	6.20
Latin America					
Argentina	—	0.20	0.30	—	0.50
TOTAL	7.50	7.50	5.00	14.00	34.00

SOURCE: Some handbooks of foreign trade statistics from the countries and several numbers of *Revista Latinoamericana de Siderurgia*, published by the Latin American Iron and Steel Institute.

As a matter of fact, exploitation of some of the very rich iron deposits of Latin America was started at the turn of the century by a few captive mines belonging to some of the large American steel companies: Cuba and Mexico were the first countries in which this type of mining began, to be followed later by Chile and now more particularly by Venezuela. From the outset, the mining companies undertook to sell at cost to local companies in the country concerned the amounts of iron ore which they might need for internal steel production. The organization of iron mining companies in Latin America exporting ore in the free market is a more recent development and was probably started in Brazil by the Companhia do Vale do Rio Doce, the biggest free exporter at present in the Region. Table 6 shows, as far as is known, the iron ore exports by free and by captive mines in Latin America in 1962.

Table 6. Latin America: Iron ore exported in 1962 by captive and by free mines

(Millions of metric tons of iron ore)

Country	Captive mines	Free mines	Total
Brazil	—	7.50 [a]	7.50 [a]
Chile	2.20	5.30 [a]	7.50 [a]
Mexico	—	0.15	0.15
Peru	—	5.00 [a]	5.00 [a]
Venezuela	14.00	—	14.00
TOTAL	16.20	17.95 [a]	34.15 [a]

SOURCE: Estimates by the ECLA secretariat.

[a] Contains 0.51 million tons exported to Argentina jointly by Brazil, Chile and Peru.

Although steel production in Latin America began in Monterrey, Mexico, in the first years of this century, the real landmark of the growth of the industry is the beginning of operations at Volta Redonda, Brazil, in 1946. This, in spite of the fact that there had been earlier some developments at Monlevada in Brazil, Corral in Chile and Monclova in Mexico. Since 1946 the growth of the Latin American steel industry has been both sustained and impressive, with new plants starting production almost every year. Even so, the region is still a net importer of finished steel and will probably remain so for many years to come.

Concerning exports of ore, the organization of new mining ventures and the growth of the existing ones has been the result of the expansion of steel production in the industrialized countries, as a consequence of which ore prices have stayed relatively high and stable for the last five years. Only in 1962 was there a general drop in export prices of some 0.50 dollars per ton. Originally, these exports were due to the high iron content of the corresponding Latin American iron ores and their very low content of impurities, such as sulphur and phosphorus, which made lumps of Latin American ore an ideal material for addition to the open hearth furnaces for cooling of the bath, assisting in the refining process through the liberation of oxygen to oxydize some of the impurities contained in the molten bath. Technological developments of the latest years, particularly the use of oxygen in the open-hearth furnaces, are changing these conditions to the disadvantage of Latin American exporters. Progress in the knowledge of the blast furnace operations are now causing a change in emphasis, from lump ore used in the open-hearth charge to well sized and washed or otherwise beneficiated ore for the blast furnace.

As a result of the tendency to use high grade ores for blast furnace charge, thus permitting a considerable increase in the output of the blast furnace with the corresponding saving in the coke rate, the industry in the industrialized countries is using more and more beneficiated material in the charge; be it sinter, washed and concentrated ore or pellets. This, together with the reduction of available high grade iron ore reserves in some of those countries, has motivated considerable research in relation to the beneficiation and concentration of iron ore deposits of lower grades.

In the blast furnace, at present, there is a tendency to use the natural high grade ore sized from 3/8" to 2 inches for hematites and 3/8" to 1 inch for magnetites. Preference is given to hematite on account of its greater reductibility but, in most of the Latin American mines, there is a tendency for the ore to get richer in magnetite as the depth increases. With the development of the technique called pelletization (grinding, magnetic concentration and semi-fusion through calcination in rotary kilns to form pellets) and of sintering, a charge of some 68 per cent of iron can be obtained even from rather low grade ores (30 to 40 per cent). These events are responsible for the fact that several of the Latin American iron ore exporters are either producing pellets, or are planning to do so, or wash the ore to eliminate most of the clay contained as impurity or, at least, to classify their product carefully. It is noteworthy that Japan is still importing lump ore which is crushed and beneficiated in Japan to obtain very high grade ore.

Leading in this tendency to improve the type and classification of their ore have been Marcona Mining Co. of Peru and Vale do Rio Doce in Brazil, followed later by Algarrobo in Chile. In spite of the fact that the above trends have been noticeable in recent years, Latin American iron ore production has grown steadily, as can be seen from the figures shown in table 7. It is expected that exports will continue to rise and may reach some 45 million tons in a few years time.

Manganese ore resources of Latin America

In addition to the high grade manganese ores, that are known in some of the countries, low grade formations are abundant in Latin America but as concentration to raise the area from 42 per cent manganese content to the 48 per cent required for export presents serious technological problems on the one hand, and with instability of world manganese prices on the other, the studies and exploration of manganese deposits are very far from being exhausted. Table 8 presents the latest known figures about manganese reserves in Latin America and the average annual production of the last few years:

Table 7. Latin America: iron ore production from 1950 to 1962

(Millions of metric tons)

Year	*Million tons*
1950	5.6
1951	7.2
1952	8.0
1953	10.2
1954	13.1
1955	16.6
1956	21.0
1957	27.4
1958	27.8
1959	30.5
1960	33.4
1961	36.8
1962	38.9

SOURCE: *Revista Latinoamericana de Siderurgia*, published by the Latin American Iron and Steel Institute.

Table 8. Latin America: manganese ore reserves and production

(Tons of manganese content in 45 per cent ore)

Country	*Reserves*	*Production*
Argentina	900,000	7,000
Bolivia	[a]	—
Brazil	30,000,000	440,000
Chile	420,000	14,500
Cuba	720,000	9,000
Mexico	4,500,000	35,000
Peru	[b]	1,000
TOTALS	36,540,000	506,500

SOURCES: *Minerals Yearbook*, US Bureau of Mines, information received from several Latin American Geological Institutes and Foreign Trade Yearbooks of the Governments.

[a] It is known that manganese ore exists, probably in considerable quantities, at the Mutun iron ore deposit, but the resource has not been sufficiently studied.

[b] In Southern Peru there are several manganese ore formations but little is known about their size and they are not being regularly exploited.

With the iron and steel-making processes currently employed there is a consumption of from 6 to 7 kg of metallurgical grade of manganese ore per ton of steel. Of the steel producing countries: Brazil, Chile and Mexico meet their own requirements and have a surplus for export; Argentina covers its internal demand while Colombia, Peru and Venezuela import their manganese ore of the corresponding ferro-alloy.

Fluxes for the Latin American steel industry

As almost everywhere in the world, lime deposits are abundant in Latin America and may be found in close vicinity to almost any plant location. For this reason when speaking of resources for producing iron and steel in the region, one may omit the problem of the provision of lime aside. Or course, when coming to the actual planning of a steel plant, this may not always be the case. It happens that the Chilean steel plant at Huachipate brings its limestone from an island in the far south of the country with an ocean haulage of some 1,500 kilometres. The deposits closer to the plant are of unsatisfactory grade. In the same way, in relation to the possibility of erecting a steel plant at Mutun, in Bolivia, one finds that the limestone deposits in the vicinity are only about 50 per cent grade. Whether better limestone can be brought from other more distant places in the country, or from large deposits of very high grade limestone in the South of Paraguay on river barges, or if it has to be obtained through flotation of the limestone close by, is a problem which has to be solved in due time but its importance is very great during the preliminary studies.

Concerning dolomite, there are large deposits of high quality in Brazil, Guatemala, Mexico and Uruguay. In most of the Latin American steel producing countries – Argentina, Chile, Colombia, Peru and Venezuela — there are usually some known deposits but the quality is not satisfactory for the steel industry and, therefore, the needs of the countries are supplied by imports.

Availability of scrap in Latin America

As no thorough survey has been made on the availability and production of scrap in Latin America, little is known about the possibilities and prospects of this important raw material for the steel industry. At least two factors would tend to restrict the present availability of scrap: on the one hand, steel consumption was rather small in most of the Latin American countries twenty or thirty years ago, so that the investments then made might now be ready for discard. The only exception to this general rule is Chile, where a considerable number of nitrate plants installed between the end of the last century and the great Depression, are being scrapped either because, a tightening market has made them uneconomical or because their nitrate ore reserves have been exhausted. On the other hand, capital being scarce in Latin America, there is a tendency to continue operations in existing installations long after they would have been discarded in more industrialized countries.

Nevertheless, the impression exists that it would be possible to collect much greater amounts of scrap than is being done at present, provided that the proper organizations were created, and fair prices paid for such material. In general, scrap prices range at present between 18 and 28 dollars per metric ton, depending on the country, the location and the quality of the material. In spite of this low scrap price, most of the integrated Latin American steel plants use a considerably higher proportion of hot metal and much less scrap in their open hearth furnaces than is customary in more advanced countries although the cost of hot pig iron ranges between 45 and 60 dollars per metric ton.

Another factor which makes it difficult for the large integrated steel plants to increase their supply of scrap is the fact that they are usually located at a considerable distance from the centres in which the metal working industries are located, which makes necessary long haulages to the plants. An exception here is Argentina, where the Somisa plant at San Nicolas has been located at a very short distance from Buenos Aires and Rosario, centered between these two cities where a high percentage of the countries' steel transforming industries operates. The usual pattern in Latin America is that small, non-integrated steel mills either with electric or open hearth furnaces, operate close to the industrial centres where scrap is generated, and used mainly for manufacturing wire and merchant bars. Even so, the availability of scrap for these small plants is insufficient in many cases, and some of them operate only at a fraction of their capacity, as is the case of the 70,000 tons a year rolling mill at Rio Grande do Sul in Brazil.[3] Others supplement their available raw steel with billets, either imported from industrialized countries or purchased from the integrated steel works in the region. Some plants, particularly in Mexico, are based on imported scrap.

The case of Chile has been cited above as the one country in which a large source of scrap exists. Unfortunately for the Huachipato steel mill, they have to face the competition of the copper mining industry which uses large amounts of iron scrap for the lixiviation of oxydized ores. As a result of the demand from the copper industry. Chile has been traditionally an importer of iron scrap. In fact, the scrap situation is so tight that considerable thought has been given to the possibility of producing sponge iron, using the finest of exported iron ore, both for the Huachipato steel mill and the copper mining industry.

Coal reserves and supply of coking coal in Latin America

Although total coal reserves and resources in Latin America are estimated at some 94,000 million tons, the supply of coking coal from indigenous resources in the region constitutes the major raw materials problem of the steel industry. There is little knowledge about the tonnage existing in the known formations and in only a few instances: has a study been conducted concerning the coking properties and techniques to produce metallurgical coke from some of the deposits. The explanation for this fact is probably that at the time when coal constituted the sole or at least the major source of fuel for transport and industry, the latter was very little developed and consumption small, thus justifying exploitation of only the closest and most favourable deposits. In fact, the demand for fuel started to increase steeply long after petroleum was introduced and preferred for almost all heating and steam producing purposes. And at times there was almost no interest in spending the huge sums necessary for a thorough exploration of the coal resources.

It has been only lately that some Governments have attempted to study their coal reserves and the properties of the fuel. Noteworthy in this sense are Argentina, Chile, Mexico and Venezuela. But the results of these studies have seldom covered the whole territory and in few cases have comprehensive reports been prepared. Almost no studies have been made in Colombia, undoubtedly the best endowed country of the region. In this connexion, credit should be given also to the non-ferrous metals mining enterprises of some of the countries, notably Mexico and Peru, which studied some of the coal basins in order to find a source of supply for metallurgical coke for their smelters.

Concerning the steel industry, the fact is that in none of the countries has it exhausted the research conducive to total, or at least increased, consumption of local coals. The reasons for this vary from plant to plant but, in general it may be said that the following appear among the most important: (*a*) the starting and operation of an integrated steel industry in a country without a solid industrial base in in itself a complicated task. To add difficulties to it by using complicated processes for making coke, adequate for blast furnace operation, from non-coking coals has naturally been avoided as much as possible; (*b*) usually, for one reason or another, local coals involve higher production costs than in the United States, in spite of the lower labour cost generally prevailing in Latin America. Under these conditions, the price of well known imported coal is generally cheaper at the plant than the local coal. In part, this disadvantage is increased, due to low ocean freight rates on iron ore carriers returning to the United States; (*c*) the supply of coal from local mines is often irregular, both as regards quality as well as quantity of the deliveries. As several of the Latin American better coals lose a considerable part of their coking properties through prolonged storage, especially those with a high content of volatile matter, the building up of reserve stocks is not always the answer to irregularity in deliveries.

Thus the Latin American steel industry, where difficulties exist in regard to coking coal, has carried out an extensive research of coking properties and possibilities of the coals available with the following aims:[4] (*a*) to know the coking properties of the coal, and (*b*) to establish the percentage and type of imported coal necessary to produce a satisfactory coke. Apparently, in no case has the study been carried further to determine how much of the imported coal can be substituted by local material previously charred or submitted to some other process. This is the case of Argentina, Brazil, Chile and Venezuela. An exception here is Peru, where extensive and costly research was carried out with a view to making metallurgical coke starting from anthracite which is abundant in the vicinity of the plant.

From existing literature the figures shown in table 9 regarding the total coal reserves of some of the Latin American countries have been compiled. As the definition and methods followed vary from country to country, the figures are not very reliable, especially those referring to Chile, Colombia, Mexico and Peru, where large territories have been considered, with very little factual survey work. In spite of these uncertainties regarding the accuracy of the data, the figures are given as an illustration rather than as a basis for any policy decisions.

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[3] Siderurgica Riograndense is the only installation using continuous casting in Latin America and it is operating at some 40,000 tons a year, compared with a rated capacity of some 70,000 tons.

[4] In the case of Volta Redonda in Brazil, the steel company organized the coal industry at Santa Catarina in order to supply the steel works with up to 40 per cent of its coal consumption.

With a similar element of uncertainty, an attempt has been made in table 9 to separate bituminous coal according to their known coking properties.

Of the three countries listed in the column corresponding to straight coking coal, only Mexico and Colombia have based their main steel industry on their resources, while Peru is using it only for making coke for one of its non-ferrous metal smelters. The reason for the latter is that the bulk of the reserves are on the east slope of the Andes and transport to the steel plant at Chimbote, should there be enough reserves available to serve both purposes, would be too costly. Peru has installed electric reduction furnaces at Chimbote and the reducing agent is imported coke. Of the afore mentioned two countries which have rich reserves, those known are badly located for export, with long or complicated land transport to port and cannot, therefore, be exported at present to other countries of the region. In Colombia, it has frequently been stated that some of its coal deposits at Cali close to the Pacific port of Buenaventura are straight coking coals, but the reserves of these seams have never been completely investigated nor have the properties of the variety of coals available there been the subject of a complete study. The same is true in the case of the important coal formations between Santa Marta and the Gulf of Maracaibo where, reputedly at least one of the seams consists of straight coking coal. If both these deposits are investigated and it proves true that an important part of them could be used for production of good coke, they could probably become a source of solid fuel for the steel industry of various countries of the region. In that case, it would be necessary, in addition to developing the mines, to build transport facilities to the Atlantic as well as a port at Santa Marta with mechanical loading facilities. Brazil imports 60 per cent of shrinking coal for blends with its swelling *tubarao* coal and has based some of its steel plants on charcoal, imported coke, etc. Chile imports 20 to 30 per cent of swelling coal for blending with its shrinking coals whereas Argentina imports all the coal they are currently using at San Nicolas, the indigenous coal being employed exclusively for production of steam. Finally, Venezuela, has electric reduction furnaces and imports the reducing fuel in the form of coke.

Use of charcoal in the Latin American steel industry

The difficulties for supplying most of the Latin American steel plants with indigenous coking coal have

Table 9. Latin America: estimated coal reserves

(Millions of metric tons)

Country	*Anthracite*	*Bituminous coal*	*Sub-bituminous coal*	*Lignites*	*Total*
Argentina	—	—	400		400
Brazil	—	2,136	—	—	2,136
Chile	—	110	1,000	29,000	30,110
Colombia	—	40,000	—		40,000
Ecuador	—	—	25		25
Mexico	—	15,000	—		15,000
Peru	6,000	100	—		6,100
Venezuela	—	—	350		350
TOTALS	6,000	57,346	1,775	29,000	94,121

SOURCE: *A study of the iron and steel industry in Latin America*, vol. II, 1952 (E/CN.12/293/Rev. 1), supplemented by recent information from Argentina, Ecuador and Venezuela.

Table 10. Latin America: breakdown of the bituminous coals in accordance with their coking properties

(Millions of metric tons)

Country	*Swelling coals*	*Straight coking*	*Shrinking coals*	*Non coking*	*Total*
Brazil	500	—	—	1,636 [b]	2,136
Chile	—	—	80	30	110
Colombia	—	500 [a]	—	39,500 [b]	40,000
Mexico	—	2,600	—	12,400 [b]	15,000
Peru	—	100 [a]	—	—	100
TOTALS	500	3,200	80	53,566	57,346

SOURCE: Estimates by the ECLA secretariat.

[a] Figure is a very rough estimate and may be exaggerated. The difference would probably be shrinking coal.

[b] No knowledge exists regarding the breakdown of this tonnage. In all probability a substantial part of it is shrinking coking coal.

been described in the preceding section. In cases where the steel plant is located close to deep water, the scarcity of coal has been mostly overcome by imports of coal or coke and in two instances, Chimbote in Peru and Orinoco in Venezuela, electric reduction furnaces use imported coke as reducing agent. In other instances, some of the plants use charcoal as a fuel and reducing agent. This is the case with the steelworks at Zapla in Argentina (annual capacity: about 160,000 tons) and Monlevade in Brazil (400,000 tons of ingot steel per year). In Brazil, in addition to Monlevade, there are many small integrated and non-integrated pig iron producers using charcoal for a total production of 1.5 million tons of pig iron. One of the bigger steel makers, Acesita (85,000 tons per year) is based on charcoal which it supplements with imported coke. In total, in Brazil some 320,000 cubic metres of charcoal are used annually for the iron and steel industry and it is estimated that this amount will continue to grow due to the expected expansion of the steel industry.

In Brazil, charcoal production for these industries started by using natural forests, mostly of *leguminosae*, as a source for the timber, but as the reserves close to the plants became scarcer, more and more use has been made of artificial forestation with eucalyptus, some varieties of which grow very rapidly in Latin America. The Zapla works in Argentina, for their part, are also based on artificial eucalyptus forests and the plant has been expanded gradually so as to keep its growth in line with the growing availability of charcoal. At the present time it is believed that there will be no further expansion at Zapla.

Another place where it would be feasible to use charcoal in Latin America would be Mutun in Bolivia, should it prove economical to install either a complete steelworks, or at least charcoal blast furnaces. It is said that in the vicinity of the ore deposit there are at least 1 million hectares of fiscal forests with a probable yield of some 175 cubic metres of wood for charcoal per hectare, in addition to fine timber.

In addition a new steel works using charcoal may be built in Honduras. This is now under study as a means of supplying steel to the Central American Common Market. Honduras has plenty of forests and the distances should not be prohibitive for the transport of wood or charcoal to the plant.

Some of the Latin American charcoal plants are very efficiently operated and have a charcoal rate comparable with the best European practice. One of the few drawbacks of this method for using solar energy in the industry, on land which is of almost no other possible use, is the variation of moisture content of the charcoal, depending on the rainfall after it has been carbonized. In order to overcome this difficulty there is a trend to carbonize the wood close to the steel plant and keep the charcoal under roof, where it would be protected against rain.

Although there are impressive reserves of natural forests in Latin America, probably no further use of them for steelmaking will be envisaged. The present forest areas are extremely sparsely populated and transport costs to the steel consuming centres would be excessively high. On the other hand, the diseconomies of scale would not permit the economic operation of a unit small enough to match its sales to the local market.

Availability of crude petroleum and natural gas in Latin America

The petroleum and gas resources of Latin America are abundant but quite unevenly distributed. Much has been done during the last decade in order to find new fields and to establish the reserves of the existing deposits but there is still much work to be done. The estimated reserves and production in 1962 are shown in table 11.

Table 11. Latin America: estimated crude petroleum reserves and production in 1962 and estimated natural gas reserves

Country	*Petroleum production in 1962 (Thousands of metric tons)*	*Estimated reserves*	
		Petroleum in millions of metric tons	*Natural gas in millions of cubic metres*
Argentina	13,542	333	240
Bolivia	450 [a]	16	?
Brazil	4,368	45	12
Chile	1,850	20	300 [b]
Colombia	7,176	105	?
Cuba	10	130	?
Ecuador	387 [a]	4	?
Mexico	15,996	360	230
Peru	2,592 [a]	53	?
Venezuela	167,412	2,684	950
TOTALS	214,293	3,760	1,732

SOURCE: *United Nations Statistical Yearbook*, 1962.

[a] Figures corresponding to 1961.

[b] Chile's gas reserves are very poorly located on the island of Tierra del Fuego south of the Magellan Straits.

Of the countries which are currently steel producers, Venezuela, Colombia and Mexico, in that order, are exporters of petroleum and its products. Peru produces enough for its internal market and has a small surplus for export. Argentina covers its own needs since the development of its petroleum industry in the last few years, whereas Chile and Brazil have to import a considerable part of their consumption.

The countries which do not appear in table 11 have no production. Thus, some of the countries in which erection of a steel industry is currently under consideration, like Honduras and Uruguay, have no production and no known petroleum deposits.

The only Latin American steel plant which is at present a large consumer of natural gas is Hojalata y Lamina, producing some 170,000 tons a year of sponge iron reduced by gas through the HyL process. An expansion of the plant to some 500,000 tons a year is under consideration.

Electric power resources of Latin America

Table 12 shows the installed power generating capacity of the Latin American countries. The figures include both public utilities, that is power generated for sale to the public, as well as power produced for private

Table 12. Latin America: installed electric power generating capacity in 1961

(Thousands of kilowatts, watts per capita and per cent)

Country	*Total capacity Thermo and Hydro (A)*	*Of the total shown in a participation of Hydro plants (B)*	*Percentage of installed Hydro power B : C (C)*	*Installed capacity watts per capita*
Argentina	3,723	319	8.5	174
Bolivia	140 [b]	?	?	40 [b]
Brazil	5,172	3,769	72.5	69
Chile	995	574	58	125
Colombia	911 [a]	505 [a]	55 [a]	62 [a]
Costa Rica	108 [b]	79 [b]	73 [b]	84 [b]
Cuba	932	—	—	133
Ecuador	106 [b]	35 [b]	33 [b]	23 [b]
El Salvador	81	71	89	29
Guatemala	61 [a]	31 [a]	51 [a]	15 [a]
Haiti	28	?	?	7
Honduras	30	?	?	15
Mexico	3,275	1,332	40.5	87
Nicaragua	77 [a]	9 [a]	12 [a]	48 [a]
Panama	65 [a]	?	?	57 [a]
Paraguay	29 [b]	—	—	16 [b]
Peru	778 [a]	416 [a]	53 [a]	75 [a c]
Dominican Republic	?	?	?	?
Uruguay	406 [a]	236 [a]	58 [a]	142 [a d]
Venezuela	1,277 [b]	139 [b]	12 [b]	163 [b]

SOURCE: *United Nations Statistical Yearbook*, 1962 and *United Nations Monthly Bulletin of Statistics.*

[a] Power data refer to 1960 instead of 1961.
[b] Power data refer to 1959 instead of 1961.
[c] Population data refer to 1961 instead of 1962.
[d] Population data refer to 1960 instead of 1962.

use in industrial and mining enterprises. The *per capita* figures relate to the estimated population in mid-1962.

Most of the installed power capacity shown in the table is currently used and, in general, it might be said that there is very little excess available in any one of the countries, that could be delivered to any new steel plant. In most countries, even the supply of the small amounts needed for non-integrated steel plants (rolling mills) creates a problem for the existing sources. The table presented here is rather more useful to give an indication of the degree of industrialization attained by the different countries, through the higher amounts of power installed *per capita* in those that are more industrially advanced. An exception to this general rule are Brazil and Colombia and, to a lesser extent, Peru. These countries have an industry comparable to that of the countries with the highest figures of power supply in Latin America but the average is brought down by large masses of population in the less-developed areas, living very closely to subsistance agriculture.

Most Latin American countries possess hydroelectric potential far above their present power needs and existing installations, and there are several reasons which may explain in each individual case why this has not been developed. Among these, the most frequent are the following: (*a*) capital being scarce in Latin America, preference is mostly given to thermo-electric plants because they represent a much smaller investment than a hydro project (probably some 300 dollars per kVA against 1,000 dollars for a project, including transmission lines and transformers); (*b*) in many cases, the hydro-electric potential is too far away from the populated consumer centres; for example, the extraordinary power potential in southern Chile where large rivers flow very steeply through barren land into the Pacific south of parallel 46, and where a population of less than 200,000 inhabitants lives mostly on sheep-farming. Similar situations occur in most of the South American countries bordering the Amazon basin; (*c*) the size of a possible hydroelectric project may be too large when compared with present consumption and expected rate of growth, thus making the project uneconomical for many years through under-utilization of the investment. In some of these cases, the Governments have proceeded to build a power plant but have had to finance the installation of industries to use the power. This happened at the 200,000 kilowatt plant at Huallancas in Peru, where the Chimbote steel plant was based on the available power for which there was hardly any other use, and also in Venezuela at the Caroni plant which in its first stage has a potential of 300,000 kW, for which an expansion to the complete utilization of the water power to a total of some 14 million kW, is now proposed. In the case of Venezuela, it has been necessary for the Government to plan, in addition to the steel plant, the complete infra-

Table 13. Latin America: economies of scale in two hypothetical steel plants

(Dollars per ton of finished products)

Capacity (tons per year)	Flat products a d: Cost per ton c	Flat products: Cost of imported steel e	Flat products: Savings in foreign exchange c	Merchant bars and wire b: Cost per ton c	Merchant bars and wire: Cost of imported steel f	Merchant bars and wire: Savings in foreign exchange a
100	192.09	182.00	112.88	101.50	141.00	96.26
200	173.84	182.00	123.81	91.20	141.00	97.37
300	—	—	—	84.40	141.00	98.35
400	139.17	182.00	133.30			
500	131.35	182.00	135.98			
800	115.85	182.00	141.91			
1,000	108.12	182.00	144.45			
1,500	103.44	182.00	145.29			

SOURCE: Studies made by ECLA using up-to-date technology.

a Structure of the plant: conventional blast furnace, open-hearth furnaces and rolling mills.

b Structure of the plant: conventional blast furnace, L.D. converter, continuous casting.

c Importing iron ore from Latin America and coking coal from United States.

d 30 per cent hot rolled sheet and plate, 70 per cent cold rolled including tinplate.

e f Price of steel in the internal market of the United States plus transport costs and other charges to average Latin American port.

structure for a town of some 250,000 inhabitants. Incidentally, as the data referring to Venezuela in table 12 relate to 1959 figures, the Caroni plant is not included.

For the above reasons, on enumeration of the available hydroelectric potential in Latin America has limited meaning. Some of the possibilities will however be discussed in the country review which follows in later sections of this report.

Size of the present market of a country as a resource for making steel production economical

The economies of scale in the steel industry have such an important influence that a country having a large demand but no natural resources for steel mining, may be economically justified in erecting a steel plant. On the other end of the scale, countries with too small a market may find it uneconomical to start such an industry, even if they have all the necessary natural resources. Therefore, before reviewing the raw materials situation of the individual Latin American countries, it is useful to devote a few words to this problem.

Table 13 shows some of the features of the economies of scale in two hypothetical steel plants in Latin America: one producing flat products and the other wire, merchant bars and small profiles.

ECLA is currently planning to extend these studies to a broader technical framework and into the smaller capacity range. Until these new figures are available, those presented here can be of help in reaching some interim conclusions. First, there is no doubt that splitting the 100,000 tons a year capacity into manufacture of some 50,000 tons each of flat products as well as wire bars and light profiles will result in higher production costs for each of the two groups, and that the savings in foreign exchange will also be smaller owing to the higher capital charges per unit of output. Secondly, when planning a small plant for two products, as mentioned above, no changes are involved in the blast furnace and steel shop, so that a cost increase occurs only for the roughing and rolling mills. In the case of flat products, the rise in cost would nevertheless be considerable. Thirdly, as the size of the operation increases, cost decreases and savings of foreign exchange rises rapidly, which suggests that it is better that new ventures should, where possible, be built to serve several of the Latin America markets, as can be done through the General Treaty on Central American Economic Integration and the Latin American Free-Trade Area. The reductions in cost which result from enlarging the size of operations are such that the savings will, in most cases, absorb increased transport costs.

The decision to be taken in any individual country with a small market, as to whether it is better to build the plant or import the steel will depend mostly on economic factors: whether it is preferable to have somewhat more expensive steel and save foreign exchange, or whether economic development is best served through initially low steel prices until demand grows sufficiently to make the industry economically more sound.

For the sake of comparison and in order to estimate the amount of foreign exchange saved per ton, United States internal steel prices plus transport and other expenses to have them cleared of duties in Latin American have been used in table 13, in spite of the fact that currently it is easy to import cheaper steel from Europe at prices far below the internal prices of the home country. The advantages for local steel production shown in the table have, therefore, to be taken with caution as such extremely low prices do not prevail all the time.

On the other hand, the foreign exchange savings figures are those which would correspond to a country importing all the necessary iron ore and coking coal. Replacing such imports, by local production might affect the cost of production adversely only a little because of the small scale of the mining operations, but would increase savings in foreign exchange by some 12 to 15 per cent over the figures shown in table 13.

As a limit for economic small scale operations has to be drawn somewhere to be able to include this factor in a summary table (No. 14) for the purpose of this evaluation of the Latin American resources available for iron and steel making, a total apparent steel consumption of 100,000 tons will be considered as the minimum required for a country to build the industry, unless there are definite possibilities of export to other countries or any other very special factor exists. If this criterion is applied, of the countries listed in table 14, the following might be excluded from a listing of the countries in which the current size of the market is an asset for the construction and operation of a steel mill. The apparent steel consumption (expressed in ingot tons) will appear in parentheses together with the name of the country: Bolivia (23), Costa Rica (47), Ecuador (57), El Salvador (32), Guatemala (48), Haiti (4), Honduras (10), Nicaragua (15), Panama (14), Paraguay (12), Dominican Republic (31).

Of the above countries, Bolivia should be further considered in combination with Argentina, Paraguay and Uruguay if possible, in view of the existence of the iron, manganese ore and forest reserves at Mutun; the five Central American countries: Costa Rica, El Salvador, Guatemala, Honduras and Nicaragua have a joint market of 142,000 tons of ingot steel, and will be considered and treated as a single region in table 14 in addition to their individual analyses.

Summary of the resources for steel-making available in Latin America

In table 14 an attempt has been made to summarize the raw materials availability in Latin America which has been described in the preceding tables and pages. Table 14 shows the situation in the twenty Latin American republics plus the consolidated data for the Central American Economic Integration Treaty. In order to point out the salient factors of interest from the aspect of the internal markets, the contents of the various columns are necessarily heterogeneous, and the following comments may be helpful.

Column A shows the current apparent steel market, expressed in ingot tons. As already noted, a current market smaller than 100,000 tons a year would be an obstacle to the construction of a steel plant and even a

Table 14. Latin America: summary of the resources for steel-making in the individual countries

Country	*Current apparent steel consumption (100,000 ingot tons) (A)*	*Years that known iron ore will last at current rate of steel demand (B)*	*Coking coal that can be locally produced (per cent) (C)*	*Manganese ore that can be supplied to steel industry (per cent) (D)*	*Dolomite which can be supplied locally to steel industry (per cent) (E)*	*Petroleum currently imported (per cent) (F)*
Argentina	23.71	82	—	100	—	100
Bolivia	0.23	180,000 [a]	—	100	—	100
Brazil	27.01	4,360	40	100	100	30
Chile	5.06	520	80	100		70
Colombia	4.05	332	100	—	—	100
Costa Rica	0.48	—	—	100	—	—
Cuba	2.77	[b]	—	100	?	5
Ecuador	0.58	—	—	—	—	100
El Salvador	0.32	—	—	—	—	—
Guatemala	0.48	50	—	—	100	—
Haiti	0.04	—	—	—	—	—
Honduras	0.10	630	—	—	—	—
Mexico	18.40	244	100	100	100	100
Nicaragua	0.14	450	—	—	—	—
Panama	0.14	—	—	—	—	—
Paraguay	0.12	—	—	—	—	—
Peru	2.46	2,420	—	—	?	100
Dominican Republic	0.31	1,000	—	—	—	—
Uruguay	1.20	254	—	—	100	—
Venezuela	4.48	5,600	50	50	—	100
Integrated Central American Market	1.42	120	—	100	100	—

[a] Although the Mutun iron ore reserves of Bolivia can only be considered as a potential source of supply for the country, they have been included in this table because of current studies and negotiations to export some of them to Argentina. If this project materializes it might well be that at least some charcoal blast furnaces are installed at Mutun to make pig iron.

[b] The huge iron ore reserves of Cuba can only be considered a potential resource until a process is found to separate the nickel and chrome which usually are included in them.

market in the neighbourhood of this figure might be a dubious proposition unless very special circumstances prevail. On the other hand, if one considers that the markets are growing as a result of the economic development which is taking place or planned to take place in the region, advances occurring during the time needed to prepare the blueprints for a plant may carry a country over the limit which has been arbitrarily set here. In addition, experience in Latin America has shown that even in countries in which there is no major scarcity of foreign exchange, the beginning of operations of a local steel plant is a potent stimulus for the expansion of the steel market.

Column B shows the number of years that the presently known iron ore reserves would be able to cover the countries' needs of iron ore at the current consumption rate of finished steel products. In addition to the countries shown in the table there are several of the smaller ones in which there are indications of the existence of iron ore deposits which have not been investigated. This is particularly true of Ecuador, Guatemala and Paraguay. Several of the countries are exporting jointly a tonnage exceeding more than five times the present total iron ore consumption of Latin America in its present steel industry. A survey of the scrap situation has not been made and is very difficult to make at the currently prevailing prices and in view of the dealers organization in almost all of the countries. For the present tabulation it has been assumed without further enquiry that the Latin American steel industry would almost invariably use about 30 per cent scrap in the steelshops, including circulating and purchased scrap.

Column C indicates the position for coking coal. As has been said in the text, this is the weakest point in the resources available for steelmaking in the region. The percentages in the column show the proportion of native coal which can be added to imported coking coal, if such native coal is not straight coking, but needs blending. In practice, the amounts contributed by local coal in Brazil, Chile and Venezuela are less than what are shown in the table due to lack of capacity of the mining industry to supply the corresponding quantities of adequate national coal. In the case of Argentina and Peru, where local coal exists and can easily be supplied to the steel plants, no contribution is anticipated from local sources because there is need, before deciding what amount of local coal may be used, for considerable research to develop suitable processes for converting Argentine sub-bituminous coal and Peruvian anthracite in blends into good quality coke.

Column D shows the percentage of the manganese ore needs of the steel industry which can be supplied from local sources. The data need no further explanation except in the case of Venezuela, where the manganese ore discovered so far, is low yield material which can be used for certain operations of the steel plant but which would have to be supplemented by high grade ore for additions to the steel furnace.

Column E refers to dolomite, which again has been expressed in terms of the possibility of the known mining resources to supply the present or future needs of the steel industry of the country. Although in the table this item seems to be as critical as coking coal, the small amounts needed and the low price commanded by this commodity, reduce the importance of any bottleneck which might arise from its general scarcity On the other hand, it might well be that there are additional possible sources of supply of dolomite in Latin America which have, so far, not been studied or developed. In the text the limestone situation has been examined under the same heading as dolomite. It has not been included in table 14 because it is so abundant that, generally, there is no problem in obtaining good quality limestone almost anywhere. The known exceptions in Latin America are Chili, which has to ship its limestone over 850 nautical miles by sea to the plant, and Argentina and Bolivia, where good limestone has not been found on the Paraguay-Panama river basin, so that limestone has to be taken in barges from Paraguay to San Nicolas and Mutun.

Column F shows the availability of crude oil. The data have been expressed as percentages of the total present fuel consumption which can be supplied by the national oil fields. Although petroleum consumption for all uses in the countries is rapidly increasing, there is no fear of a possible deterioration of the supply conditions for some time to come, as shown in table 14. The reason is that exploration of reserves in known fields and for new deposits is progressing faster than the growth of demand.

ANNEX I

Argentina: iron ore resources and reserves

(In metric tons)

Ore bodies	Location	Type	Mineral	Percentages				Production 1962	Reserves				Potential reserves
				Fe	SiO_2	P	S		Proven	Indicated	Calculated	Total	
Sierra Grande	30 km from the coast	Minette	Magnetite (oolythe)	56	6	1.5	0.5	—	20,000,000	60,000,000	65,000,000	145,000,000	
Zapla	Near Injuy	Lake Superior	Hematite and Limonite	40	35	0.3	0.1	134,000	6,000,000	50,000,000	50,000,000	106,000,000	
Ferriferous sands	Coast		Magnetite and Limonite	4		0.5 de TiO_2			—	—	—	—	500,000,000
		Total estimated ore in 1961 [a]						134,000	26,000,000	110,000,000	115,000,000	251,000,000	500,000,000
		Imports of ore in 1962						515,000					

[a] Several other ore bodies are known, but with reserves of less than 1 million tons which would add up to about 4 million.

ANNEX II

Iron ore resources and reserves

(In metric tons)

Ore bodies	Location	Type	Mineral	Percentages				Production 1962	Reserves				Potential resources
				Fe	SiO_2	P	S		Proven	Indicated	Calculated	Total	
Uruguay													
Valentines	260 km N. of Montevideo	Lake Superior	Itabirite	40	20.00	0.01	0.03	—	28,000,000	—	72,000,000	100,000,000	—
Ecuador													
Pascuales	25 km N.E. of Guayaquil	Stratified	Magnetite	66	10.00	0.01	0.08	—	200,000	300,000	500,000	1,000,000	—
Bolivia													
Mutum	E. frontier	Stratified	Hematite	60	17.00	0.01	0.01	—	—	—	—	—	500,000,000
Veneros	E. frontier												
Mutum		Lode bed	Hematite	62	15.00	0.01	0.01	—	—	—	—	—	40,000,000
													540,000,000
Central America													
Guatemala													
Various deposits	Ghiquimula	Magnitnaya	Hematite	60				—	500,000	—	3,000,000	3,500,000	—
Honduras													
Agalteca	35 km N. of Tegucigalpa	Magnitnaya	Hematite	53	10.00	0.04	0.02	—	—	3,000,000	5,000,000	8,000,000	—
Nicaragua													
Monte Carmelo	35 km N.E. Managua	Magnitnaya	Hematite	60	7.00	0.02	0.02	—	—	—	8,500,000	8,500,000	
												20,000,000	
West Indies													
Cuba													
Mayari	20 km south	Latherite	Limonite [a]	45	4.00	0.02	0.03	—	—	—	530,000,000	530,000,000	
Moa	N.E. region	Latherite	Limonite [a]	45	4.00	0.02	0.06	—	—	—	1,570,000,000	1,570,000,000	
Camagüey	Caribbean	Latherite	Limonite [a]	46	5.5	0.03	0.06	—	—	—	400,000,000,	400,000,000	
												2,500,000,000	
Dominican Rep.													
Duarte Hatillo		Bilbao	Magnetite	67	1.5	0.03	0.06	—	—	8,500,000	41,500,000	50,000,000	

[a] Contains 1.7 per cent Cr and 2.0 per cent Ni.

ANNEX III

Chile: iron ore resources and reserves

(In metric tons)

Ore bodies	Location	Type	Mineral	Percentages Fe	SiO$_2$	P	S	Production 1962	Reserves Proven	Indicated	Calculated	Total	Potential resources
El Laco Cia. Minera Santa Fe	300 km E. of Antofagusta	Kiruna	Magnetite and Hematite	63	1.50	0.35	0.10	—	-	-	-	—	250,000,000
Cerro Inán Soc. Minera Cerro Inán	79 km E. of Caldera	Kiruna	Hematite and Magnetite	62	3.50	0.01	0.01	740,000	630,000	2,500,000	2,500,000	5,630,000	—
Carmen Cia. Minera Santa Fe	50 km E. of Chañaral	Kiruna	Magnetite	63	3.50	0.30	0.10	1,000,000	3,000,000	2,000,000	5,000,000	10,000,000	—
Las Adriantas Cia. Minera de Atacama	50 km E. of Caldera	Magnitnaya	Magnetite and Hematite	64	4.00	0.01	0.04	300,000	2,000,000	5,000,000	3,000,000	10,000,000	—
Los Colorados — etc. Cia. de Pierre de Atacama	52 km E. of Carrinal	Kiruna	Hematite	62	9.00	0.06	0.05	180,000	1,000,000	2,500,000	3,500,000	7,000,000	—
Huantané Cia. Minera Santa Bárbara	48 km E. of Huasco	Magnitnaya	Hematite and Magnetite	64	8.00	0.02	0.01	500,000	1,000,000	2,000,000	1,500,000	4,500,000	—
El Algarrobo Cia. Acero del Pacífico	38 km E. of Guacolda	Kiruna	Magnetite and Hematite	64	5.50	0.15	0.05	1,200,000	50,000,000	30,000,000	40,000,000	120,000,000	—
Cristales	69 km N. of Cruz Grande	Kiruna	Hematite and Magnetite	64	4.00	0.02	0.40	—	5,000,000	5,000,000	5,000,000	15,000,000	—
Bandurria and others La Suerte, Hematita Cerro Negro	60 km E. of tide-water	Kiruna	Hematite	60	6.00	0.02	0.01	1,120,000	5,000,000	20,000,000	25,000,000	50,000,000	—
El Cheñar I.I.G. (Government-owned)	60 km N. of Vallemar	Magnitnaya	Magnetite and Hematite	60	6.00	0.01		—		-	—	-	200,000,000
El Pleita	30 km N.E. of Cruz Grande	Kiruna	Hematite and Magnetite	60	3.50	0.17	0.02	—	2,00,0000	3,000,000	5,000,000	10,000,000	—
El Tofo Bethlehem Chile Iron Mines	29 km E. of Cruz Grande	Kiruna	Hematite and Magnetite	60	10.00	0.06	0.06	250,000	4.000,000	-	—	4.000,000	—
El Remoral Bethlehem Chile Iron Mines	36 km N. of Guayadan	Kiruna	Magnetite and Hematite	63	7.00	0.25	0.12	1,260,000	40,000,000	20,000,000	20,000,000	80,000,000	—

ANNEX III (*continued*)

Ore bodies	*Location*	*Type*	*Mineral*	*Percentages* Fe	SiO$_2$	P	S	*Production 1962*	*Reserves* Proven	Indicated	Calculated	Total	*Potential resources*
El Dorado													
Cia. Minera Santa Fe . .	110 km S.E. of Coquimbo	Kiruna	Hematite and Magnetite	64	4.00	0.05	0.20	550,000	2,000,000	2,500,000	—	4,500,000	—
Infieraille (several)	110 km S.E. of Coquimbo	Kiruna	Hematite and Magnetite	62	4.00	0.30	0.20	—	2,000,000	2,500,000	—	4,500,000	—
Various small ore bodies . .	90 km E. of tide-water	Kiruna	Hematite	60	4.50	0.01	0.02	1,000,000	3,000,000	2,000,000	2,000,000	7,000,000	—
Fortuna													
Development Corporation	120 km E. of Talca	Kiruna	Magnetite	60	8.00	0.01	0.80	—	—	1,400,000	3,600,000	5,000,000	—
Bahia													
Cia. Mahuelbuta	80 km S. of Labu	Lake Superior	Taconite	40	35.00	0.02	0.03	—	—	—	—	—	500,000,000
Free ferriferous sands	San Antonio Chilco coast	Stratified	Magnetite	25	70.00	0.02	0.15	—	—	—	—	—	300,000,000
	TOTAL ESTIMATED ORE IN 1962							8,100,000	120,630,000	100,400,000	116,000,000	337,130,000	1,250,000,000

ANNEX IV

Colombia: iron ore resources and reserves

(*In metric tons*)

Ore bodies	*Location*	*Type*	*Mineral*	*Percentages* Fe	SiO$_2$	P	S	*Production 1962*	*Reserves* Proven	Indicated	Calculated	Total	*Potential resources*
Pas del Río	Chicamocha River Valley	Minette	Hematite (oolythe)	48	10	1.00	0.07	420,000	50,000,000	50,000,000	30,000,000	130,000,000	—
Medellín	Aburrá River Valley	Latherite	Limonite	45	15	0.00	0.07	—		2,000,000		2,000,000	—
Medellín	Aburrá River Valley	Latherite	Limonite	25	20	0.10	0.07	—					380,000,000
Cerro Matoso	Uré River Valley	Latherite	Hematite and Magnetite	50	6	0.30	0.20	—	10,000,000	10,000,000	20,000,000	40,000,000	—
	TOTAL ESTIMATED ORE IN 1961							420,000	60,000,000	62,000,000	50,000,000	172,000,000	380,000,000

ANNEX V

Mexico: iron ore resources and reserves

(In metric tons)

Ore bodies	Location	Type	Mineral	Percentages: Fe	SiO$_2$	P	S	Production 1962	Reserves: Proven	Indicated	Calculated	Total	Potential resources
Cerro de Mercado	3 km N. of Durango	Kiruna	Hematite and Limonite	62	3.90	0.70	0.25	1,000,000	50,000,000	10,000,000,	10,000,000	70,000,000	—
La Perla	1 km S. of Tacubaya	Magnitnaya	Hematite	60	7.00	0.11	0.30	200,000	25,000,000	20,000,000	5,000,000	50,000,000	—
Santa Ursula	N.S. Fernando	—	Hematite	62	3.70	0.10	0.20	—	10,000,000	3,000,000	17,000,000	30,000,000	—
Various: Volcan, La Negra and Golondrina	Northern zone	—	Hematite	60	4.00	0.12	0.25	100,000	2,000,000	55,000,000	55,000,000	112,000,000	—
El Maney and others . . .	Central zone	Magnitnaya	Hematite	65	12.60	0.10	0.20	—	62,000,000	35,000,000	34,000,000	131,000,000	—
Flutén	50 km from La Union	Magnitnaya	Hematite	63	3.50	0.05	0.08	—	400,000	50,000	—	450,000	—
Pihuano	40 km N. E. of Colina	Magnitnaya	Hematite	61	3.00	0.20	0.10	—	680,000	—	280,000	960,000	—
El Encino	18 km S. of Pihuano	Magnitnaya	Hematite	60	4.50	0.32	0.13	—	6,500,000	5,000,000	5,000,000	16,500,000	—
Las Truchas group	9 km from Playa Asul	Magnitnaya	Hematite	59	7.50	0.04	1.14	—	66 000,000	7,000,000	—	73,000,000	—
Senitua	30 km N.W. of Sola de vega	Magnitnaya	Hematite	65	1.70	0.03	0.37	—	12,000,000	8,000,000	10,000,000	30,000,000	—
Various: Sol y Luna, Aquita and Chulla	Central zone	Magnitnaya	Hematite	60	4.00	0.12	0.20	—	5,000,000	5,000,000	50,000,000	60,000,000	—
		TOTAL ESTIMATED ORE IN 1961						1,300,000	239,580,000	148,050,000	186,280,000	573,910,000	—

ANNEX VI

Peru: iron ore resources and reserves

(In metric tons)

Ore bodies	Location	Type	Mineral	Percentages: Fe	SiO$_2$	P	S	Production 1962	Reserves: Proven	Indicated	Calculated	Total	Potential resources
Marcona	23 km from San Juan	Magnitnaya	Hematite and Limonite	60	4	0.18	0.40[a]	5,230,000	40,000,000	170,000,000	460,000,000	670,000,000	—
Jaurilla	14 km S. E. of Ica	Magnitnaya	Hematite and Magnetite	50	6	0.50	0.10		—	—	1,000,000	1,000,000	—
Huaoravilca	50 km from Huancayo	Bilbao	Hematite	60	4	0.10	0.60		—	32,000,000	32,000,000	64,000,000	—
Tambo Grande	45 km from Piura	Bilbao	Hematite	46	8	0.20	0.40		—	12,000,000	20,000,000	32,000,000	—
		TOTAL ESTIMATED ORE IN 1961						5,230,000	40,000,000	214,000,000	513,000,000	767,000,000	—

[a] Also contains 1.5 per cent copper.

ANNEX VII

Venezuela: Iron ore resources and reserves

(In metric tons)

Ore bodies	*Location*	*Type*	*Mineral*	*Percentages*				*Production 1962*	*Reserves*				*Potential resources*
				Fe	*SiO_2*	*P*	*S*		*Proven*	*Indicated*	*Calculated*	*Total*	
Cerro Bolivar	85 km S. of Bolivar	Lake Superior	Hematite	62	0.70	0.15	0.01	11,060,000	653,000,000	533,000,000	500,000,000	1,686,000,000	—
El Pao	48 km S. of Palda	Lake Superior	Hematite	64	0.30	0.03	0.03	2,140,000	92,000,000	150,000,000	—	242,000,000	—
Cund. San Isidro (various)	90 km S. E. of Bolivar	Lake Superior	Hematite	60	3.00	0.15	0.01	—	563,000,000	267,000,000	—	830,000,000 [a]	780,000,000
Maria Luisa	65 km S. E. of Bolivar	Lake Superior	Hematite	64	0.90	0.15	0.01	—	—	150,000,000	—	150,000,000	—
Piacca	30 km S. of Los Castillos	Lake Superior	Itabirite	45	53.00	—	—	—	—	—	—	—	225,000,000
El Trueno	140 km S. of Bolivar	Lake Superior	Hematite	55	0.90	0.15	0.01	—	—	—	—	—	150,000,000
Las Grullas	40 km E. of El Pao	Lake Superior	Hematite	55	0.90	0.15	0.01	—	—	—	—	—	50,000,000
Los Castillos	30 km N. of Piacca	Lake Superior	Itabirite	45	50.00	—	—	—	—	—	—	—	20,000,000
TOTAL ESTIMATED ORE IN 1961								13,200,000	1,308,000,000	1,000,000,000	500,000,000	2,908,000,000	1,225,000,000

[a] Contains 45 per cent Fe and 18 per cent SiO_2.

ANNEX VIII

Brazil: iron ore resources and reserves

(In metric tons)

Ore bodies	Location	Type	Mineral	Percentages Fe	SiO_2	P	S	Production 1962	Reserves: Proven	Indicated	Calculated	Total	Potential resources
Minas Geraes (several)	320 km N.W. of Rio de Janeiro	Lake Superior	Hematite	66	0.52	0.03	0.01	10,242,000	1,146,000,000	—	950,000,000	2,096,000,000	
Minas Geraes (several)	320 km N.W. of Rio de Janeiro	Lake Superior	Hematite	50	6.00	0.14	0.01	—	500,000,000	1,500,000,000	1,000,000,000	3,000,000,000	
Minas Geraes (several)	320 km N.W. of Rio de Janeiro	Lake Superior	Itabirite	35	2.00	?	?	—	5,000,000,000	—	5,000,000,000	10,000,000,000	18,000,000,000
Urucum	Bolivian frontier	Lake Superior	Itabirite [a]	55	10.00	0.11	0.01	24,000 [a]	300,000,000	—	—	300,000,000	10,000,000,000
Amapa	Mouth of the Amazon	Lake Superior	Itabirite	66	4.00	?	?		—	—	—	—	9,000,000
Bahia (several)	Santa Fe	Lake Superior	Itabirite	60	6.00	0.03	0.01	6,000	—	—	—	—	50,000,000
Sao Paulo (several)	Joquia-Registro	Massive	Magnetite	60	0.15	0.01	0.01	2,000	500,000	3,000,000	—	3,500,000	—
Parana	Rio Branco	Massive	Magnetite	60	0.20	0.02	0.01	172,000	11,600,000	—	10,000,000	21,600,000	—
TOTAL ESTIMATED ORE IN 1961								10,446,000	6,958,100,000	1,503,000,000	6,960,000,000	15,421,100,000	28,059,000,000

[a] Includes reserves of 62 per cent Fe, 4.5 per cent SiO_2 and 0.16 per cent P, plus 0.04 per cent S; and resources containing 50 per cent Fe, 15 per cent SiO_2 and 0.02 per cent P, plus 0.04 per cent S, and 45 per cent manganese beds, in production.

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THE IRON AND STEEL INDUSTRY IN AFRICA

(DOCUMENT ECA.2)[1]

The market

Since the demand for steel depends on the size of the National Product which is very low in most African countries, the consumption of steel per head is also very low, averaging only about 6 kg per head over East and West Africa and corresponding to a figure of $90 G.D.P. per head. Higher levels of consumption obtain in the more developed areas where income per head is higher, e.g. in Algeria where it reaches $220 steel consumption is 36 kg per head, in the United Arab Republic 15½ kg corresponding to $120 and in the Republic of South Africa 140 kg corresponding to $385 per head.

The low level of the National Product is a direct result of the negligible capital stock and limited technical skills available to the inhabitants and it follows that only a small investment in absolute terms makes a great difference to the capital stock and therefore to income per head and to steel consumption. In West Africa, accordingly, steel consumption has increased by over 11 per cent annually over the last twelve years while in other regions, e.g. in East Africa and in Rhodesia still higher rates of increase were achieved in the years preceding political difficulties. The general pattern in Africa is therefore one of current low levels of steel consumption per head but with the prospect of a continuation of the previous high rates of growth, given stable political conditions and investment.

The current demand for steel in Africa is very largely for use in building and construction followed by general maintenance and repair work. The other component of capital formation, namely machinery and transport equipment, is necessarily very largely imported. In the more advanced countries, e.g. Southern Rhodesia, the engineering industries have developed to the extent that about one-quarter of these requirements are manufactured and a further substantial proportion assembled but in East, Central and West Africa the proportion manufactured at present probably does not exceed 10 per cent.

The above pattern of demand determines the type of steel required of which, more than one-third consists of reinforcing bars and sections for building and construction work in all regions. In the case of West and East Africa an additional one-fifth consists of galvanized sheet also for roofing and general construction purposes. Railway material and tubes, the latter especially important in North Africa, usually account for a further quarter and the balance of about one-fifth consists of wire and wire rod and flat products such as plain sheet, plate, tin-plate and strip. The consumption of these latter products is very largely dependent on the expansion of the engineering industries. In so far as these industries expand and substitute imported manufactures, the consumption of flat products and wire will expand more rapidly than that of other steel products. Examples of expanding industries are the manufacture of consumer goods such as hollow ware and metal furniture and the cases of electric appliances, the building of bodies on to imported chassis and the manufacture of accessories such as nuts and bolts, nails and springs.

The available market in Africa tends to be limited by the low density of population which over most of the continent is under 25 per square mile. The higher density areas are limited to the coastal areas of North Africa and part of West Africa and to certain interior areas; for example, the copper belt, the northern shores of Lakes Victoria and Tanganyika and the immediate vicinity of some of the large towns or capital cities. It follows that distribution must be conducted over a wide area to provide a large enough outlet and that distribution costs are very high.

In particular none of the national areas of the African continent, with the exception of Egypt and Algeria, can at the present time offer a large enough market to fully justify the erection of a modern integrated iron and steel unit with an annual output of at the very least 250,000 tons of finished steel.

Raw materials and fuel

Since the African continent has been developed hitherto mainly as a source of raw materials for the industrial areas of the world, it follows that prospecting has been more intense in the coastal areas and that the mineral resources of the interior are less well known. This is especially so in the case of the relatively low valued minerals required in iron production, i.e., iron ore and, to a lesser extent, coal which cannot bear the heavy transport charges to the coast or limestone which is a fairly widespread mineral and normally available for local use when required.

The iron ore resources of Africa are very extensive and those of West Africa in particular are among the largest and richest and purest deposits in the world. At least fifteen of these are large enough (over 50 million tons) and rich enough to provide the basis of an iron and steel industry, and some are over 500 million tons. An extensive export trade is conducted from them and from the North African coastal region, which also includes two or more large (over 50 million tons) and rich deposits. Two rich deposits each at least over 200 million

[1] Paper prepared by the secretariat of the Economic Commission for Africa.

tons in the Republic of South Africa provide the basis for the expanding steel industry there and one of 50 million tons exists in Swaziland, two in Southern Rhodesia, and on present information one in Northern Rhodesia, three or four in the Congo, one in Somaliland and one in the Sudan. In most of these areas there are also very large reserves amounting in the case of Rhodesia and South Africa to thousands of millions of tons of lower grade ore of 30 to 50 per cent iron content. In Mozambique, Tanganyika and Uganda there are substantial deposits of titaniferous iron ore which would normally be regarded as useless but in view of the possibilities of electric reduction which the hydroelectric resources of the area allow now, come into the category of potentially useful ores.

Extensive coal reserves exist in the southern part of Africa with about 90 per cent of these located in the Republic so that particular importance attaches to the limited coal reserves available outside this area. The only reserves of coking coal are in Southern Rhodesia (Wankie) amounting to some 500 million tons together with some 300 million tons of non-coking varieties. Other major (over 100 million tons) deposits of non-coking coal occur in Bechuanaland, Katanga, Tanganyika, Nigeria and Morocco, which may have their coking properties improved by blending with coking coal or in other ways, or be used directly in electric reduction furnaces.

For various reasons therefore interest attaches to the development of the unparalleled hydroelectric resources of the African continent. The major source is the Congo river and its tributaries which by reason of constant rainfall, sharp falls and the absence of competing claims for irrigation can supply "run of the river" stations at minimum cost. In view of the virtual absence of industrial development throughout the Congo basin, however, these resources are not utilized except in the South Katanga copper belt where a scheme is based on a tributary. The large existing stations are on the Zambesi (Kariba, 600 MW) on the Nile (Owen Falls, 120 MW), and on smaller rivers as in Morocco (El Abid, 100 MW) and Cameroon (Edea, 160 MW). There are also numerous smaller stations supplying local needs and based on small rivers or tributaries. The large stations serve a larger area and have therefore much higher transmission costs but the economies of scale in generating electricity in relation to the cost of transmitting it are such that with the extension of transmission lines across national frontiers the small stations will eventually disappear.

Transport

The current trading pattern in Africa is reflected in the transport systems where railway and rivers are used to carry raw materials to the coast for shipment to Europe and manufactured goods are returned in exchange. There is little trading between African countries themselves or between regions so that the various railway systems are in general not connected.

Exceptions to this pattern occur in the more developed and more densely populated areas of the extreme north and south. A lateral railway connects Morocco, Algeria and Tunisia but does not extend yet to Libya. In southern Africa generally, in consequence of the exploitation of the mineral wealth of the interior, railway development has been relatively more extensive and relatively integrated, leading to a link between the mining areas of the Rand, Southern Rhodesia, Northern Rhodesia and Katanga and their connections to the coast. In this way a railway system connects Lobito on the west coast to the ports of South Africa and of Mozambique on the east coast, across Lake Tanganyika through the railways of the East African system to Mombassa and northwards to link with the main river ports on the Congo. There is, however, no communication except by road with the Sudan railway system and none with Ethiopia.

The low density of population and the great distances consequently involved in the distribution of finished goods and, on the other hand, the long hauls and heavy load associated with traffic in mineral and raw materials are such that ocean, river and rail transport must continue to be the basis of an African transport system. Road transport except over short distances is too costly; for distances over 500 miles and excluding the cost of constructing the road (which is normally itself comparable with actual running costs) the charges per ton mile are nearly twice the railway costs and perhaps three of four times the cost of sea or river transport where available.

The main gaps in the African transport system are accordingly those associated with ocean and railway development. With regard to the former the practice has been that with trade being mainly overseas there are virtually no facilities for ocean traffic between African ports on a tramping basis. This is a serious gap in view of the current relatively heavy density of coastal population and the cheapness of ocean transport. The main gap in the railway system is that of inter-regional links. The East and West link would not be difficult since Sudan railways and Nigeria railways are already only 800 miles apart. It would be a major operation to create a North-South trans-Saharan link although similar undertakings, e.g., in Australia, have been commercially justified and have served to unite a continent.

The iron and steel industry

Steel production in most African countries today is based on the melting of locally available scrap. This is a natural development making use of a local material which would otherwise either not be collected at all or would have to be shipped to Europe. It makes a useful contribution to the steel requirements of the country and provides useful instruction in steel making and rolling techniques. Plants making steel in this way and rolling it into bars and rods and sections for building and construction exist in Nigeria, Algeria, Ghana, Senegal, Uganda, Ethiopia, Katanga province in Congo (Leopoldville); one is in the course of erection in the Sudan and an additional one in Nigeria.

A steel industry based only on local scrap, however, although expanding as scrap supplies expand, can only in the long run provide a steadily decreasing proportion of the steel requirements of an expanding economy.

This follows from the fact that its major source of raw material is the scrapping of obsolete buildings, machines, vehicles and equipment after an average life of some twenty years. While therefore the demand for steel relates to the current level of investment and industrial activity the supply of scrap relates to the position twenty years previously and in a rapidly expanding economy can therefore never form more than a fraction of the former. Moreover, scrap is required for the important iron and steel foundry industry which because of its relatively small scale of operation and relative indifference in regard to scrap qualities is likely to be able to pre-empt a substantial proportion of available supplies. In the circumstances developing countries have sooner or later to turn to iron production and the more so when, as in Africa, large and rich deposits of iron ore are available. Integrated works of this kind exist in the Republic of South Africa, in Egypt and in Southern Rhodesia and are currently under construction in Algeria and Tunisia.

The main difficulty in establishing such a works is that normally the minimum scale for producing iron economically is too high for a country in the early stages of development and able therefore to offer only a very limited market.

Some methods of producing iron (e.g. electric reduction) can be used relatively economically on a smaller scale than others provided cheap energy is available; where there is no alternative this method may be adopted with advantage in which case the problem of dealing with economies of scale is transferred to steel making and steel rolling sections where the problem is generally less acute.

Nevertheless economies of scale in iron and steel production are so great that it is desirable to achieve them if at all possible, and this has led to the idea of overcoming market limitations in Africa by the erection of one or more integrated iron and steel works on a sub-regional basis. Such works would be able to produce iron and steel from the rich ores in Africa using the latest techniques and on a scale which would achieve most of the economies of large scale production. Many problems of financing, of commercial policy, of co-ordination of industrial and transport development, and of international policy are involved in such a venture, which in fact is equivalent, in its own sphere, to the creation of a sub-regional common market on the lines of the European coal and steel community and might, in due course, necessitate similar supra-national institutions.

At the iron and steel level problems arise relating to plant site size and location, the availability of raw materials, the size of market necessary to achieve economies of scale and the transport facilities within the area. In the case of West Africa it is clear that a coastal works based on one of the rich ore deposits near the coast and with the facility of importing other essential materials, such as coal, by cheap sea transport, and in part using the same means for distributing the finished products is the desirable unit. In Central and East Africa it is equally clear that an interior works is the desirable unit. The number of such units corresponding to the number of natural areas within which economies of scale can be achieved before transport costs become too great is obviously limited at the current levels of consumption obtaining in Africa, but with the rapid annual rates of increase expected in consumption, possibilities will increase so that a long-term programme of development is at least as important as plans designed for the immediate situation. Such a programme must provide for sub-regional specialization within steel works facilitating the achievement of full economies of scale. In this connexion, one of its first objectives will be to integrate with any existing steel melting works so as to assist as a source of their requirements of semi-finished steel for re-rolling within a co-ordinated schedule of finished steel products.

REVIEW OF THE IRON AND STEEL INDUSTRY IN THE ECAFE REGION

(DOCUMENT ECAFE.2) [1]

General

Crude steel production in the ECAFE countries increased from approximately 9 million tons in 1953 to about 33 million tons in 1962 or an increase of about 267 per cent during this period. The share of these countries in the total world production of 369 million tons in 1962 was about 9 per cent. The comparative shares of some other countries and regions in the total world production were approximately as follows:

	Per cent
Australia	1.1
India	1.3
Japan	7.4
Latin America	1.5
Union of Soviet Socialist Republics	20.7
United States of America	24.6
Western Europe (including United Kingdom)	28.2

The rate of increase in crude steel production in the ECAFE countries having started from a low base was relatively much higher than that of the other industrialized countries of the world. This is indicated by the significant strides in steel production registered by some of the less developed countries in the region. The most noteworthy increases were made by India and Japan during the last decade.

Countries of the region

AFGHANISTAN

Afghanistan has just started its plans of industrialization. There is at present no steel production facility in the country. The emphasis of industrial development during the past few years was geared to the improvement and expansion of the mining industry. Foreign experts were engaged in geological study and exploration of the mineral resources of the country and consideration of the feasibility of establishing an iron smelting and steel plant which was included in both the first and second five-year plans (1958-1966).

The results of the geological studies and explorations at that stage indicated substantial deposits of iron ore and metallurgical coal in the country. The foreign experts recommended further exploration and analysis of the ores and coals, before a firm decision is taken on the proposed steel plant.

[1] Paper prepared by the secretariat of the Economic Commission for Asia and the Far East. See page 122 for discussion.

BURMA

The first steel plant in Burma was completed in 1958-1959. It consists of a merchant bar and sheet mill with a combined production capacity of approximately 20,000 tons per annum. The products are reinforced steel bars and plain black sheets. Ingot production is dependent on a 100 per cent scrap-charge. 10-ton electric arc furnace. The shortage of local scrap has posed a problem. To provide continuity of operation, billets are being imported to supplement ingot production in the electric furnace.

There was a plan to establish a medium-sized integrated steel complex in the country using indigenous iron ores, located in the northern states, with either electric or open hearth furnaces. The installation of this plant was to support expansion in the production of various hot-rolled steel products for use in the manufacturing and other industries.

CAMBODIA

Cambodia has no iron and steel industry at present, although its establishment has been under consideration. Hematite and magnetite ores have been found at Phnom Deck.

CEYLON

Ceylon has no iron and steel production facilities. A plan to set up a basic iron and steel industry was initiated in 1951. The project slowed down because of various inherent problems. Further studies had to be made regarding sufficiency of indigenous iron ores, fuel and power availability, location of plant site and the capital investment required for the project.

The discovery of local iron ores in the south-west and in the Chilaw district to support the project for about 25 years or more strengthened the decision to establish the steel project. An agreement was signed in 1958 with the USSR to assist in the construction of the project in stages, *viz.*:

(*a*) *First stage*. The installation of a merchant and wire rod mill for the manufacture of rounds, flats, squares, small angles, tees channels and wire rods. During this stage, wire drawing machinery will be installed. Production will be 25,000 tons of rolled steel (bars, shapes, etc.) and 10,000 tons of wire rods. The raw material for this stage will be imported billets.

(*b*) *Second stage*. This will consist of the installation of a steel-making furnace for converting local scrap iron, supplemented by imported material for the production of billets required for the rolling mill (in stage 1). Raw materials required for this stage will be imported and local scrap.

(*c*) ***Third stage.*** A blast furnace or electric furnace will be installed for the production of pig iron using local iron ore and charcoal.

The plant will be located at Oruvela, about 4 miles north of Homagama. The authorities have decided to develop the project in stages for the following reasons:

First, all material surveys have not been completed. Detailed studies of the availability of wood and its collection, transportation and conversion to charcoal have yet to be undertaken. If electric power is available at economical rates in the future, then electro-smelting can be adopted instead of the blast furnace.

Secondly, there are several new processes for both pig-iron production and steel making developed in recent years. Some of them are still in the pilot plant stage. One of these processes may be better suited to Ceylon's conditions than the blast furnace or open-hearth processes now considered for the second and third stages. In the case of the rolling mill, there are no particularly new developments.

Thirdly, the establishment of an integrated iron and steel works requires the services of scores of experts and technical, supervisory and skilled personnel, heavy capital investment, the resources of many construction firms, and an efficient organization. Any attempt to proceed with the entire project at one stage might severely strain local resources of skilled personnel, complicate co-ordination and control and lead to unavoidable delays and waste.

It was therefore considered best to proceed in stages, commencing with a rolling mill which will operate on imported billets. This will enable construction work to be phased out, operating personnel for the second and third stages trained in advance, raw material surveys completed and the most suitable metallurgical process adopted. Financing the project will also be simpler.

It is estimated that the total value of the output during stage I will be approximately Rs. 35 million. A foreign exchange saving of Rs. 10 million annually after deduction of the cost of imported billets, fuel oil, etc. is expected. The saving in foreign exchange will be more marked in the second and third stages when local materials replace imports. Employment after the three stages is estimated to be more than 1,000 at the technical, supervisory and management levels.

China (Taiwan)

The emphasis in Taiwan's steel industry since the beginning of the first five-year plan in 1953 was on the production of hot rolled steel products, particularly sheet, bars and wire rods. There was relatively fast growth in the past decade. The increases in output are shown below:

Output of selected industrial products

(*Metric tons*)

Year	*Pig iron*	*Wire rods*	*Tin plate*	*Pipe castings*
1953	8,174	172	9,277	2,743
1958	33,106	16,055	27,488	2,816
1960	24,444	16,603	21,074	9,788
1962	63,381	20,450	25,847	16,709

Industry of Free China, vol. XIX, No. 3, 1963.

Bars, wire rods and tin plate exceeded the production targets for the period 1957-1960. The planned production for crude steel for 1962-1963 is 290,000 metric tons and the planned capacity for rolling mills is 250,000 metric tons.

The iron and steel production facilities in the country consist mainly of 1-35 ton blast furnace, several electric arc furnaces from ½ ton to 10 ton capacity and a number of high frequency induction furnaces with a capacity of ½ to 1 ton. A new by-product coke oven installed a few years ago increased coke production in the country. The rolling mills are generally of pre-war types except for a few which have been modernized and improved to step up production.

A plan to establish an integrated iron and steel plant was conceived in 1955 but because of the lack of indigenous iron ore and foreign exchange, implementation of the project was delayed. The project will be built in stages. The first stage will consist of rolling mills which will produce approximately 160,000 tons of steel bars, wire rods and sheets. The second stage will include additional iron and steel facilities making for producing plates and pipes. The total output of the mill when completed will be approximately 378,000 tons. The products are as follows:

Production targets [a]

	Unit	*1963*	*1964*
Pig iron and castings	Metric tons	40,000	45,000
Bars, shapes and rail	Metric tons	230 000	250,000
Steel wires	Metric tons	26,000	27,000
Sheets	Metric tons	25,000	42,000
Plates	Metric tons	18,000	35,500
Pipes/fittings	Metric tons	14,400	16,000
Miscellaneous steel products	Metric tons	7,000	7,500
Total		320,400	423,000

[a] ***The Industrial and Mining Programme,*** Third Four-Year Plan, Dec. 1961.

Local coke will be used for metallurgical purposes and iron ore and scrap will be imported from outside sources. Power will be supplied by the expansion of the power programme (Taiwan Power Company). Engineering design and layout will be made with the assistance of foreign experts. Foreign technical supervisory personnel and skilled operators will assist in the initial stages of operation.

India

The crude steel production of India continued to grow steadily since the first five-year plan. It increased from 1.4 million tons in 1950-1951 to 4.9 million tons in 1961-1962. This represents an increase of about 250 per cent in a decade. The target for the third five-year plan (1961-1966) is 10.2 million tons.

The development of the iron and steel industry in the country was achieved by the joint efforts of the Government and the private sector. Three large integrated steel plants were completed during the second five-year plan, one at Bhilai (USSR assistance), another at Rourkela (Federal German assistance) and the third at Durgapur (United Kingdom assistance). The installed capacity of these steel plants is about 3 million tons. During the period, expansion programmes were also undertaken by the Tata Iron and Steel Works, the Indian Iron and Steel Works and the Mysore Iron and Steel Works.

The target set of 10.2 million tons for crude steel production under the third plan is expected to be achieved by (*a*) expansion of the facilities of the Rourkela, Bhilai and Durgapur plants, (*b*) increased production of the Tata, Mysore and Indian Steel plants, and (*c*) expansion and modernization of existing plants of the secondary steel producers, and the establishment of new but smaller steel works in various parts in the country. Further plans to increase steel production have been projected in the fourth planned period with a production goal of 18 million tons in 1972. It is forecast that a 50 million ton annual production will be needed in 1981 to maintain industrial growth and sustain economic development.

In addition to the projected expansion programmes of existing plants, a new steel complex will be built at Bokaro with a capacity of from 2.50 to 3.5 million tons annually. Other areas for the installation of medium-sized steel works are being contemplated in Neyvely (south India), Goa-Hospet region (west coast), Bilegali (Madya Pradesh) and Visakhapatnam on the east coast. Production will be approximately from 300,000 to 500,000 tons annually.

There are also about 143 plants producing structural shapes and other merchant products amounting to about 400,000 tons yearly. These establishments are being given assistance by the central Government to expand their facilities in order to increase production to about 900,000 tons per annum. One of the major problems in this programme of expansion will be the shortage of skilled labour and qualified supervisory and managerial staff.

Indonesia

There is no iron and steel plant of any significance in Indonesia today. Most of the steel requirements of the country are imported. A few small sheet mills and hot dip tin plating plants are in operation in Java. Of significance, however, is the installation of a new steel plant with modern roughing and finishing mills now under construction in Java. The mill is being financed with the assistance of the USSR. The steel plant will be built in stages: [2]

(i) *First stage*. This initial phase will be a steel-making unit consisting of 3 open-hearth furnaces with an annual capacity of about 100,000 tons of crude steel ingots. The raw materials will be 50% scrap from domestic sources and 50% pig iron, which will be imported in the initial stages of operation until the completion of the second stage of the project. The roughing mill will be of the universal type which will produce billets and slabs for processing by the finishing mills. The products will be merchant bars, shapes, wire rods, sheets, rails and other miscellaneous steel products.

(ii) *Second stage*. This will consist of the construction of a small blast furnace with a capacity of 50,000 tons of pig iron yearly. This plant will be erected in Lampung, south Sumatra, where good grade iron ore is available for blast furnace operation. The pig iron produced will be used in the Java installation described under stage 1.

(iii) *Third stage*. This last phase will be the construction in Kalimantan of a blast furnace with a yearly production of 250,000 tons supplied with coke from the Bukit Assam area. The pig iron produced is expected to replace the present imports. The completion of the project is scheduled for 1965.

Iran [3]

A plan to establish an integrated steel plant in the country has been the subject of studies by the Government with the assistance of foreign experts. Some of the basic problems are: (i) whether to construct the steel project in stages, i.e., to start with the installation of a rolling mill section using imported ingots or billets, and to add iron and steel-making facilities later; or to construct an integrated steel plant in one stage; (ii) the selection of a suitable location for the plant: two possible sites have been suggested, Karaj (Tehran) which is a market and communication centre, and Azna, a raw material centre.

The National Steel Corporation, a Government agency, created to implement this project, has emphasized the urgent need to establish this steel project as envisaged in the third plan. The proposed capacity of the steel plant will be about 240,000 to 300,000 tons annually.

Japan

The remarkable increase in the pig iron and crude steel production in Japan during the last decade (1951-1962) has made it the fourth biggest steel producer in the world today. Japan is largely dependent on foreign sources for iron ore and metallurgical coal. While the

[2] *Iron and Steel Review, India*, November 1962.

[3] *Kayhan International Excerpts*, August 1962.

other countries of the ECAFE region have geared their economies to produce steel to meet only domestic consumption, the industrial structure of Japan is designed also to supply the requirements of other ECAFE countries and even those of Europe and the United States. Japan's iron and steel may be seen in the following table:

Iron and steel production [a]
(1951-1962)

Previous record	Pig iron	Crude steel	Rolled products: Ordinary steel	Rolled products: Special steel
1951	3,127	6,502	4,739	159
1952	3,474	6,988	4,825	226
1953	4,518	7,662	5,338	306
1954	4,608	7,750	5,472	293
1955	5,217	9,408	6,810	319
1956	5,987	11,106	8,121	495
1957	6,815	12,570	9,265	626
1958	7,394	12,118	8,972	507
1959	9,446	16,629	11,871	828
1960	11,896	22,138	15,675	1,169
1961	15,821	28,268	19,944	1,468
1962	17,972	27,546	20,234	1,530

[a] Japan Iron and Steel Federation, *The Steel Industry of Japan, 1963.*

This illustrates an increase in pig iron production of about 417 per cent from the 3,474,000 tons in 1952 to 17,972,000 tons in 1962. In crude steel output, the increase for the same period was about 300 per cent. The average domestic steel consumption in Japan was approximately 85 to 90 per cent of the total production and the balance of 10 to 15 per cent represented the production for export (ships and capital goods not included). On the other hand, Japan also imported steel products (pig iron, slabs, billets, ordinary and special steels) totalling about 1.67 million tons (1961) from the United States and Europe.

The first and second modernization and rationalization programmes of the iron and steel industry (1951-1960) and the adoption and application of modern techniques placed the iron and steel production facilities of Japan on a level comparable with the highly industrialized countries of the world. This programme, in addition to the expansion and modernization of existing facilities, included the construction of new blast furnaces of bigger capacities, the use of the oxygen steel making process (LD converters), the installation of high production strip mills and the integration of the iron and steel facilities with the petro-chemical industry.

Steel industry facilities in Japan, 1962 [a]

	Number o companies	Pig iron	Crude steel	Ordinary rolled steel	Special rolled steel
Production (1,000 unit/tons)		17.972	27.546	20.234	1.530
Blast furnace	10	97%	76%	75%	22%
Open hearth furnace	11	1%	8%	8%	13%
Electric furnace	60	—	12%	9%	63%
Others (rolling, casting, forging, etc.)	599	2%	4%	8%	2%
TOTAL	680	100	100	100	100

[a] *The Steel Industry of Japan*, Japan Iron and Steel Federation, 1963.

Growth of production capacity of the iron and steel industry in Japan, 1956-1963 [a]

	1956 Beginning of year: Annual capacity (1,000 t)	1956 Beginning of year: Number of furnaces of mills	1963 Beginning of year: Annual capacity (1,000 t)	1963 Beginning of year: Number of furnaces of mills
Pig iron	*6,344*	*110*	*16,219*	*141*
Blast furnaces	6,056	23	15,227	39
Others	288	87	992	102
Steel	*10,110*	*654*	*36,072*	*908*
Open hearth furnaces	6,402	134	14,926	145
Converters	486	7	10,984 [b]	24
Electric furnaces	3,222	513	10,162	739
Blooming and slabbing mills	*7,584*	*13*	*22,542*	*21*
Rolled steel:				
Small and medium section mills	7,793	285	15,045	386
Large section mills	2,569	19	4,140	20
Wire rod mills	1,346	14	4,111	25
Plate mills	2,365	25	6,397	39
Hot strip mills	1,476	3	8,676	9
Cold strip mills	1,218	7	6,164	37
Pipe and tube mills	1,747	118	3,864	195

[a] *Japan Industries, 1961*, The Industrial Bank of Japan, Ltd., Tokyo, Japan, April 1962.
[b] LD converters.

The third modernization programme is now in progress and the targets are the installation of additional integrated steel complexes and "combinations" with petro-chemical industries to maximize utilization of by-product gases from the steel mills. Intensive and co-operative technological research and the adoption of modern methods in management and operation are other objectives envisaged in the programme.

The iron and steel producers in Japan consist of 10 big companies which operate blast furnaces and rolling mills, 11 companies with open hearth furnaces, 60 companies with electric furnaces, and 599 small enterprises engaged in rolling, casting and other processes of steel production. The percentage shares of iron and steel production based on processes may be seen in the two above tables.

The comparative increases in production capacity from 1956 to 1963 were as follows: (*a*) pig iron, 156 per cent; (*b*) crude steel, 256 per cent; (*c*) rolling mill capacity, blooming-slabbing, 197 per cent; sections and flats, etc., 85 per cent; (*d*) flat products, 320 per cent and (*e*) wire rods, 200 per cent. The production targets for 1963 are as follows:

	Million tons
Pig iron (blast furnaces)	20.36
Other sources	21.38
Crude steel	32.50
Hot rolled ordinary steel	22.50
Hot rolled special steel	1.78
Pig iron foundry	3.24

Crude steel production for 1970 is estimated at approximately 48 million tons. This future target may require construction of new large blast furnace capacities and high production rolling mills as well as additional oxygen steel converters. It is estimated that about 49 million tons of iron ore and about 25 million tons of coal will be imported. It has also been proposed that to facilitate handling of materials and provision of a safe anchorage for huge ore carriers, the new iron and steel facilities may be built in deep harbour or reclaimed areas near harbours and ports. Additional power generation sources are being planned to meet future requirements.

Republic of Korea [4]

The iron and steel-production facilities in the Republic of Korea consist of about 138 plants ranging in sizes from small to medium: 17 iron making plants, 16 rolling mills, 68 foundries and the remainder, small metal manufacturing shops. The current iron and steel production is about 200,000 tons yearly, consisting of pig iron, crude steel, wire rods, sheets and small merchant bars and shapes. About 60,000 tons of steel products were imported in 1960.

The first five-year plan (1962-1966) estimates a production of 48,000 tons of pig iron and 162,000 tons of crude steel from the existing plants. The plan also includes the establishment of an integrated iron and steel plant with a capacity of 220,000 tons of ingots and 250,000 tons of steel wire products. To provide the necessary raw materials for this project which is now under construction, the accent in the plan is on increasing production of both iron ore and coal. The yearly increase in production of the mining industry is expected to meet the raw material requirements of this new enterprise.

Federation of Malaya

There is no plant in the country producing iron and steel. Plans are under consideration for the establishment of a small iron and steel plant.

Pakistan [5]

There is no integrated iron and steel industry in Pakistan. There are several electric arc furnaces which produce about 20,000 tons yearly of crude steel from scrap. There are also about 115 re-rolling mills in the country with a total rolling capacity of approximately 115,500 tons annually. Because of the shortage of scrap, billets and ingots, most of those small mills do not operate at full capacity. A programme of modernization is in progress to increase operational efficiency in the existing small mills. A new mill is under construction in Karachi (west Pakistan) to produce about 10,000 tons of wire rods and 6,000 tons of hoops yearly. In east Pakistan, there are two wire rod mills with a total annual capacity of about 15,000 tons.

The establishment of an integrated iron and steel plant has been included in the current five-year plan. The country imports about 500,000 tons of steel products yearly. The basic plan is to establish an iron and steel industry using indigenous iron ore and coal. The quality of indigenous iron ore however is not suitable for reduction by conventional methods. Because of the urgency of the need to produce steel, two proposals have been made: (*a*) the establishment of a pilot plant to produce 16,000 tons of "luppens" from the ore at Kalabagh in west Pakistan, as a large scale test of a new process for the utilization of local ores. Should this be successful, then the establishment of the proposed integrated steel plant will be pursued vigorously; (*b*) the immediate establishment of a steel plant in Karachi, west Pakistan, using imported pig iron and scrap with a capacity of about 250,000 tons annually and a similar plant of 100,000 tons annual capacity in Chittagong, east Pakistan, or a combined annual production of 350,000 tons. This production is expected to meet about 70 per cent of the country's requirements of steel products. Both projects are part of the over-all plan for the establishment of an integrated iron and steel complex in both west and east Pakistan.

The discovery of natural gas in great quantities in some parts of the country has created the possibility of utilizing this source for the production of iron by some of the new iron and steel making processes (direct reduction). Power resources are also progressively being expanded to meet the future requirements of industry.

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[4] *The Status, Progress of Industrialization and Problems Incident Thereto, 1963*, Ministry of Commerce and Industry, Republic of Korea.

[5] *The Second Five-Year Plan, Pakistan*, 1960-1965.

Philippines

Annual crude steel production in the Philippines is approximately 150,000 tons. Raw materials are domestic scrap and imported pig iron. Three steel producers use electric arc furnaces of capacities ranging from 5 to 25 tons and one producer has an oil-fired 35-ton cold charged open-hearth furnace for ingot production. The first pig iron smelting furnace (low shaft furnace) plant, using indigenous ores and coal, will be in operation in early 1964. This new plant will produce initially 12,000 tons of foundry pig for local foundries and cast iron pipe manufacturing plants. In addition to these major producers, there are three re-rolling mills but these do not have melting facilities. The rolling mill capacity, including re-rollers, is approximately 200,000 tons yearly. Steel production consists mainly of bars and small shapes and flats. A wire rod mill with a capacity of about 40,000 tons has recently been placed in operation. A pipe mill producing welded steel pipes of ½" to 3" diameter has also been established. It has a capacity of about 30,000 tons yearly. The raw material (skelp) for this mill is imported.

During the last few years, 4 sheet galvanizing plants, 2 cold rolling mills with hot dip tin plating lines, 2 welding electrodes factories, and 2 steel wire rope plants were established. All these plants import sheets and steel wires for their operations. A large integrated steel plant is now being established under the National Shipyards and Steel Corporation (NASSCO). The plant will be located at Iligan, in northern Mindanao. The area for this installation has been cleared and graded. Soil foundation tests have been completed and found satisfactory. The engineering designs and plant layout have been completed and financial assistance for the foreign exchange required has been granted by the Export and Import Bank of Washington, D.C., for the purchase of the rolling mills from the United States. The smelting and steel making equipment will be obtained from western Europe. The local peso expenditures will be subscribed by Philippine private groups.

The whole integrated plant will be built in one phase of construction, from the iron and steel making facilities to the rolling mills. The products are as follows:

	Metric tons/yr
Skelp	40,000
Hot rolled coils	30,000
Hot rolled sheets	15,000
Cold rolled sheets	85,000
Tin plate (electrolytic)	40,000
Plates up to 96" width for shipbuilding	15,000
Merchant shapes, not produced locally	30,000
Pig iron	15,000
TOTAL	270,000

This steel project is designed primarily as a flat products plant to meet the urgent requirements of existing metal and food processing industries in the country. The facilities consist of electric smelters for iron production, LD converters for steel making and various rolling mills including a universal roughing mill, a hot reversing mill, a cold mill and a temper mill.

Power will be supplied by the Maria Cristina hydro-electric installation which is only about 4 miles from the mill site. Power cost is estimated at $0.0015 per kW. During the initial stages of the project, highly technical and supervisory personnel will be provided by foreign consultants. Operating personnel will be trained abroad before the commencement of operations. The present small force of skilled steel workers in the NASSCO steel plant will serve as the nucleus of the operating force.

Another integrated medium size plant is planned to be established on Luzon Island to produce billets, forged steel and castings. Negotiations are under way for Federal German financial assistance for the supply of machinery and equipment for the plant. A new plant for special steel products with a capacity of about 6,000 tons annually, to produce small size rolled shaftings, leaf springs and grinding balls, will be completed in 1966. The plant will be located in the suburbs of Manila.

Another interesting development is the installation of a 40-ton low shaft furnace at Panganiban, Camarine Norte, which will produce pig iron from indigenous ores and coals mined in neighbouring areas. The main equipment consists of the low shaft furnace proper, dust and tar separators, pre-coolers, pre-heaters, air blowers and other accessory units. Power will be supplied by a thermal unit which will utilize the waste gases.

Singapore

The feasibility of setting up an iron and steel mill has been under Government study for some time. The groundwork was laid by an application to the United Nations Technical Assistance Board, which sent a study mission in early 1961. The Mission's report showed how Singapore could profitably set up in the steel making Industry from modest beginnings, first by establishing a mill for melting scrap, rolling steel ingots, and re-rolling ship scrap, with a capacity of 30,000 to 50,000 tons output a year. The mill's production target is 40,000 tons in the first year going up gradually to 60,000 tons, as requirements may dictate.

As a second stage, the Mission recommended an integrated steel mill, which would include equipment for smelting iron ore to pig iron, and converting this to steel. The third and final stage of development would produce 500,000 tons or more of pig iron a year. The Mission suggested that this development should be considered in collaboration with a large established foreign steel company. With this report in hand, the Government held discussions with local entrepreneurs and then brought all interested parties together in a company named the National Iron and Steel Mills Ltd. The Economic Development Board has taken up 20 per cent of the share capital, leaving the remainder to be subscribed by local residents, bankers, merchants and businessmen.

Thailand

Steel production in the country is very small at present. A small quantity of bars is produced in a small charcoal blast furnace, open hearth steel furnace and rolling mill plant owned by the Thai Cement Company at Tha

Luang. The plant is being expanded to meet increased local demand for steel bars for construction. Imported scrap will supplement the limited domestic scrap supply. Recently, the Government has planned to engage foreign experts to prepare a feasibility report for the establishment of a primary basic steel industry using indigenous ores. A large new ore deposit of high grade quality has recently been discovered in the north-eastern part of the country.

Republic of Viet-Nam

No steel-producing facilities exist in the country. Plans for a small rolling mill have been under consideration, as a joint venture with a Japanese group.

D03919

PRESENT AND FUTURE TRENDS OF PRODUCTION AND CONSUMPTION OF PIG-IRON AND CRUDE STEEL IN EUROPE AND IN THE UNITED STATES

(DOCUMENT ECE.2) [1]

Summary

This paper shows the present situation of pig-iron, ferro-alloys and crude steel production in Europe and the United States, and gives some indications on the medium-term developments. Output of pig-iron and ferro-alloys is at present adequate to meet the requirements of crude steel production and it appears that resources both in the countries concerned and overseas are sufficient to allow for further expansion of crude steel output. The paper shows also the advances that have been made during the past ten years by oxygen-using steel-making processes.

Some disturbances in the equilibrium between steel demand and general economic growth have made themselves felt during recent years in some countries, to be ascribed to a number of factors of both short- and long-term character; among the latter, changes in the structure of demand, as they occur when economies reach higher levels of development, hold a prominent place. The steel industry it taking measures to adapt its pattern of output and its rate of expansion to the changed situation.

Introduction

Europe and the United States are not only the most important producers of pig-iron and crude steel, but also their main consumers. The share held by this group of countries has, however, been declining during the last twenty-five years as the steel industries and steel consumption in the Far East, in Latin America and in Africa expanded. While Europe and the United States together accounted on an average in 1936-1938 for over 86 per cent of world crude steel consumption, this share had fallen to 83 per cent in 1957 and was at 78 per cent in 1962; the situation is much the same for pig-iron.

Table 1 gives data on the trend of apparent consumption of steel in selected regions and countries. It will be seen that European countries and the United States figure among those with the highest *per capita* consumption rates in the world; mention should be made of Czechoslovakia (549 kg in 1962); Sweden (530 kg); the United States and Federal Republic of Germany (488 kg each). Countries not reaching 200 kg *per capita* are Greece (62 kg); Ireland (78 kg); Portugal (49 kg); Spain (91 kg); Turkey (16 kg); Yugoslavia (96 kg); Bulgaria (110 kg); and Romania (171 kg). Although these levels may appear to be low in comparison with other European countries, they are still well above the standards prevailing in many countries of Africa, Latin America and the Far East.

Pig-Iron and ferro-alloys

Together with scrap, pig-iron is the main raw material for production of crude steel in Europe and in the United States; since in many European countries, especially in Belgium, France, Luxembourg and the Federal Republic of Germany, a sizable share of total crude steel is produced in conventional converters (Thomas and Bessemer) which allow for relatively little flexibility in the choice of raw materials, pig-iron is the predominant steel-making raw material in those countries. This trend is further accentuated for all countries by the expansion of steel production in oxygen-blown vessels which, although it is technically feasible to use up to 50 per cent scrap in certain types, are mainly charged with pig-iron.

Table 2 gives data on output and trade in pig-iron. It will be seen that most of the countries shown are almost self-sufficient in pig-iron supply, or are even net-exporters the only notable exception being Italy, which imported about 18 per cent of total requirements in 1962. Almost all countries shown import some pig-iron, to meet demand for special qualities or to cover temporary deficits. The principal exporters are the USSR (1.8 million tons in 1961) and the Federal Republic of Germany (900,000 tons in 1962); in relation to its domestic output Spain exports sizable quantities, in 1960 as much as 23 per cent of production. Since integration of iron and steel production is constantly growing, international trade in pig-iron is tending to decrease in volume in Europe, and may be assumed to consist finally only of exchanges of special qualities and the covering of short-term deficits.

The main outlet for pig-iron is, of course, steel making. Iron foundries rank next in importance, especially in the United Kingdom, the United States, the Federal Republic of Germany, Italy and Poland; although data are not available, it may be assumed that noticeable tonnages are also used for this purpose in the USSR. Other industries and uses are normally insignificant consumers of pig-iron. Data in table 3 confirm this point.

Production and trade in ferro-alloys is illustrated by data in table 4. It will be seen that only some European countries are able to cover their requirements in this field from domestic production, *viz.* France, Norway, Spain, Sweden, Yugoslavia, Poland and the USSR. Other important steel-producing countries rely on foreign

[1] Paper prepared by the secretariat of the Economic Commission for Europe. See page 122 for discussion.

Table 1. Trend of apparent consumption of steel in selected regions and countries, in 1938 and 1957 to 1962

(Thousands of tons of crude steel equivalent and kilogrammes per capita)

Region and country	1938 [a] 1,000 t	1938 [a] kg/capita	1957 1,000 t	1957 kg/capita	1958 1,000 t	1958 kg/capita	1959 1,000 t	1959 kg/capita	1960 1,000 t	1960 kg/capita	1961 1,000 t	1961 kg/capita	1962 1,000 t	1962 kg/capita	Increase or decrease of apparent consumption per inhabitant (%): 1962 over 1938	Increase or decrease of apparent consumption per inhabitant (%): 1962 over 1957
Oceania [b]	1,674	195	3,491	294	2,885	238	3,478	281	4,552	360	4,553	352	4,031	306	157	104
Australia	1,424	206	3,125	324	2,437	248	3,087	307	4,070	396	3,996	380	3,557	332	161	102
New Zealand	250	156	366	164	448	196	391	168	482	203	537	222	474	191	122	116
Far East	11,306	10.4	25,590	18	26,243	17	35,546	23	46,742	29	53,256	32	..	..		..
China (mainland)	1,267	2.8	5,544	8.8	8,000	12	14,197	20	19,205	27	18,289	25	..	..	.	..
India	1,237	3.5	3 619	8.9	3,637	8.8	3,525	8.3	4,643	11	5,154	12	..	.	..	..
Japan	5,929	84	12,627	139	10,278	112	15,103	163	19,476	209	25,763	274	23,012	242	288	124
Middle East	409	8.0	1,459	20	1,837	25	1,745	23	2,019	26	1,803	23	..	.	..	..
Africa	1,378	9.6	3,870	20	4,152	19	3,731	17	4,343	19	4,517	19	..	..	..	..
South Africa	919	82	2,222	137	2,312	138	1,971	115	2,164	123	2,380	132	2,213	133	162	97
Latin America	2,006	16	8,051	41	7,943	38	8,051	39	8,437	39	9,599	44	..	..	..	..
Argentina	695	50	1,409	71	2,051	101	1,996	97	1,585	76	2,379	113			..	.
Brazil	328	8.3	1,876	31	1,924	31	2,400	37	2,668	41	2,701	37	..	.	..	..
Chile	138	29	498	70	490	67	441	59	531	70	506	65	.	..		..
Colombia	89	10.3	275	21	148	11	256	19	387	27	405	28				
Mexico	205	11	1,351	43	1,329	41	1,241	37	1,735	50	1,840	51	.	.	.	.
Venezuela	129	37	1,556	254	799	126	684	105	510	76	448	59		.	.	..
North America [b]	41,899	..	103,867	553	80,915	423	93,367	478	95,370	480	95,575	473	97,475	475	.	86
United States	40,456	314	97,178	568	75,529	433	87,180	491	89,876	497	89,694	488	91 058	488	155	86
Canada	1 443	127	6 689	403	5,386	316	6,187	355	5,494	308	5,881	322	6,417	345	272	86
EUROPE — GRAND TOTAL	..	..	145,887	227	146,124	225	158,931	242	184,265	277	189,654	282	..	..	..	..
Western Europe	44,081	..	78,698	230	73,639	213	79,176	227	96,209	272	95,051	267	95,914	266	..	116
Austria	465	69	1,444	206	1,418	203	1,464	208	1,897	268	1,888	267	1,684	238	345	116
Belgium-Luxembourg	1,555	180	2,929	315	2,318	249	2,643	280	2,604	275	3,257	343	2,937	306	170	97
Denmark	553	147	912	203	844	188	1,078	237	1,185	259	1,233	267	1,261	271	184	133
Fed. Rep. of Germany [c]	..	..	21,097	400	20,136	377	24,216	444	29,211	527	27,571	490	27,804	488	..	122
Finland	339	93	923	213	595	136	830	188	1,022	230	1,100	244	1,043	232	249	109
France [d]	5,457	132	13,594	301	13,895	305	11,551	253	13,919	306	14,167	308	14,923	319	242	106
Greece	170	24	271	33	300	37	276	33	410	49	405	48	525	62	258	188
Ireland	102	35	106	37	149	52	152	53	160	56	178	63	219	78	223	211
Italy	2,280	52	6,733	139	6,250	129	7,016	143	9,226	187	10,901	220	11,938	240	462	173
Netherlands	1,167	136	2,876	261	2,324	208	2,701	238	3,186	278	3,180	273	3,132	265	195	102
Norway	398	136	907	260	806	231	888	250	987	275	1,049	291	1,092	300	221	115
Portugal	172	23	392	44	366	41	368	42	393	43	539	61	434	49	213	111
Spain	377	15	1,614	55	1,820	61	2,082	70	1,817	60	2,242	73	2,809	91	607	165
Sweden	1,367	218	3,096	420	2,897	391	3,380	453	4,077	545	4,087	544	4,005	530	243	126
Switzerland	436	104	1 360	266	983	190	1 331	254	1 554	290	1 968	358	2 112	376	362	141
Turkey	164	10	298	12	275	11	479	14	602	22	549	20	464*	16	160	133
United Kingdom [c]	10,921	227	19,022	370	17,034	330	17,284	332	22,243	425	18,838	357	17,731	332	146	90
Yugoslavia	261	17	1,124	62	1,229	67	1,437	78	1,716	92	1,881	101	1,801	96	565	155

Table 1 *(continued)*

Region and country	1938 a 1,000 t	1938 a kg/capita	1957 1,000 t	1957 kg/capita	1958 1,000 t	1958 kg/capita	1959 1,000 t	1959 kg/capita	1960 1,000 t	1960 kg/capita	1916 1,000 t	1916 kg/capita	1962 1,000 t	1962 kg/capita	Increase or decrease of apparent consumption per inhabitant (%) 1962 over 1938	1962 over 1957
Eastern Europe	20,971	..	67,189	224	72.485	239	79 755	259	88 056	281	94 603	298	..	..	..	..
Bulgaria	..	..	517	67	530	68	589	75	866	110	871	110	..	..	..	..
Czechoslovakia	1,452	95	4,814	361	5,102	379	5,935	498	6,501	476	6,791	493	7,605	549	578	152
Eastern Germany	..	..	4,545	259	5,036	290	5,549	321	5,979	347	6,346	371	..	..	..	..
Hungary	459	50	1,514	154	1,585	161	1,726	174	2,088	209	2,103	210	2,237	222	444	144
Poland	1,040	30	4,932	174	5,451	193	5,694	195	6,282	211	6,931	231	7,197	237	790	136
Romania	427	22	1,530	86	1,661	92	2,292	126	2,827	154	3,179	171	..	..	..	..
USSR	17,523	103	49,337	243	53,120	258	58,070	276	63,513	296	68,382	314	..	..	..	..

SOURCES: *Quarterly Bulletin of Steel Statistics for Europe*, ECE, Geneva; *Statistics of World Trade in Steel*, ECE, Geneva.

Note: Owing to the economic integration of the Saar with federal Republic of Germany as from July 1959, the 1959 figures shown for France and federal Republic of Germany are not strictly comparable with those of previous years. The presentation adopted in this table has been chosen in order to ensure comparability of total data.

a For Europe and the United States, 1936-1938 averages.
b Countries listed only.
c Including the Saar as from July 1959.
d Including the Saar until June 1959.
e The year 1958 covers 53 weeks.
* Secretariat estimate.

Table 2. Production, imports and exports of pig-iron, for selected countries, 1959 to 1962

(Thousands of tons)

Country	Production 1959	1960	1961	1962	Imports 1959	1960	1961	1962	Exports 1959	1960	1961	1962	Apparent consumption 1959	1960	1961	1962
Belgium-Luxembourg	9,354	10,245	10,196	10,318	341	324	351	429	46	60	43	55	9,649	10,509	10,504	10,692
Fed. Rep. of Germany a	19,768	25,461	25,159	23,975	322	390	333	602	371	658	841	899	19,719	25,193	24,651	23,678
France b	13,731	13,758	14,160	13,551	115	143	182	165	162	230	258	222	13,684	13,671	14,084	13,494
Italy	2,098	2,683	3,056	3,556	378	680	887	799	3	2	—	—	2,473	3,361	3,943	4,355
Netherlands	1,140	1,346	1,456	1,571	20	25	15	15	142	162	166	204	1,018	1,209	1,305	1,382
TOTAL ECSC	46,091	53,493	54,027	52,971	1,176	1,562	1,768	1,991	724	1,112	1,308	1,369	46,543	53,943	54,487	53,593
Austria	1,824	2,219	2,256	2,118	8	160	68	75	75	37	10	2	1,757	2,342	2,314	2,153
Spain	1,651	1,888	2,152	2,089	1	1	3	5	208	429	288	145	1,444	1,460	1,867	1,949
Sweden	1,408	1,518	1,756	1,812	148	217	138	185	63	74	104	69	1,493	1,661	1,790	1,928
United Kingdom	12,634	15,807	14,823	13,714	103	232	39	145	160	148	148	222	12,577	15,891	14,714	13,635
Yugoslavia	863	972	997	1,050	53	65	85	115	9	—	4	1	907	1,037	1,078	1,164
Czechoslovakia	4,192	4,629	4,971 c	5,100	165	186	156	254	2	34	21	10	4,355	4,781	5,106	5,344
Poland	4,020	4,176	4,337	4,836	86	13	84	1	1	2	—	28	4,105	4,187	4,421	4,809
USSR	41,808	45,433	49,448	53,650	138	208	134	..	1,443	1,801	1,814	..	40,503	43,840	47,768	..
United States	54,608	60,310	58,632	59,548	644	305	346	457	10	102	377	142	55,242	60,513	58,601	59,869

SOURCE: *Quarterly Bulletin of Steel Statistics for Europe*, ECE, Geneva.
a Including the Saar as from July 1959.
b Including the Saar until July 1959.
c Including blast-furnace ferro-alloys.

Table 3. Consumption of pig-iron in different sectors, in selected countries, 1959 to 1962

(Thousands of tons)

Country	Steel making 1959	Steel making 1960	Steel making 1961	Steel making 1962	Iron foundries 1959	Iron foundries 1960	Iron foundries 1961	Iron foundries 1962	Other industries and uses 1959	Other industries and uses 1960	Other industries and uses 1961	Other industries and uses 1962	Total 1959	Total 1960	Total 1961	Total 1962
Belgium	5,864	6,477	6,330	6,705	..	..	..	..	5	4	4	4	..	..	..	..
Luxembourg	3,536	3,891	3,940	3,717	18	25	19	16	—	—	—	—	3,554	3,916	3,959	3,733
France	11,047	12,494	12,683	12,421	..	..	..	..	..	..	..	..	..	..	..	..
Italy	2,232	2,828	3 320	3,655	339	385	400	600	—	—	—	—	2,571	3,213	3,720	4,255
Netherlands	923	1,107	1,178	1,222	96	118	123	127	—	—	—	—	1,019	1,225	1,301	1,349
Fed. Rep. of Germany [a]	19,835	23,147	22,532	21,734	1,535	1,935	1,866	1,783	—	—	—	—	18,234	25,082	24.398	23,517
TOTAL, ECSC	43,437	49,944	49,983	49,454	..	..	..	..	..	..	..	..	..	..	..	..
Austria	1,720	2,260	2,209	2,136	59	88	102	97	—	—	—	—	1,779	2,348	2,311	2,233
Spain	1,059	1,126	1,435	1,392	..	129	..	57	—	—	—	—	..	1,255	..	1.449
Sweden	1,295 [b]	1,406 [b]	1,612 [b]	1,717 [b]	..	..	..	..	..	..	..	..	..	..	..	..
United Kingdom	11,285	14,129	12,858	12,301	17,724	1,926	1,759	1,561	26	25	21	17	13,035	16,080	14,638	13,879
Yugoslavia	724	785	937	981	92	119	129	128	—	—	—	—	816	904	1,066	1,109
Czechoslovakia	3,749	4,146	4,331	4,719	569	622	..	..	—	—	—	—	4,318	4,768	..	..
Poland	3,325	3,569	3,809	4,064	604	661	700	741	—	—	—	—	3,929	4,230	4,509	4,805
USSR	28,933 [c]	31,302 [c]	34,514 [c]	37,526 [c]	..	..	..	..	..	..	..	..	..	..	..	..
United States	49,601	54,304	53,882	..	4,700	4,193	3,845	..	1,739	1,945	1,964	..	56,040	60,442	59,691	..

SOURCE: *Quarterly Bulletin of Steel Statistics for Europe*, ECE, Geneva.

[a] Including the Saar as from 1959.

[b] Excluding consumption of sponge iron.

[c] For open-hearth steel only.

[d] Included under iron foundries.

Table 4. Production and trade in ferro-alloys, for selected countries, 1959 to 1962

(Thousands of tons)

Country	Production 1959	Production 1960	Production 1961	Production 1962	Imports 1959	Imports 1960	Imports 1961	Imports 1962	Exports 1959	Exports 1960	Exports 1961	Exports 1962	Apparent consumption 1959	Apparent consumption 1960	Apparent consumption 1961	Apparent consumption 1962
Belgium-Luxembourg	22	21	24	15	86	97	101	105	19	25	29	44	89	93	96	76
France [a]	528	585	654	618	26	28	32	24	152	195	224	211	402	418	462	431
Italy	94	144	144	122	36	57	64	79	22	17	19	8	108	184	189	193
Netherlands	—	—	—	—	16	25	23	16	—	5	1	—	16	20	22	16
Fed. Rep. of Germany [b]	357	429	419	387	176	240	262	224	57	41	52	61	476	628	629	550
TOTAL, ECSC	1,001	1,179	1,241	1,142	340	447	482	448	250	283	325	324	1,091	1,343	1,398	1,266
Austria	16	19	13	4	31	41	35	33	4	4	3	2	43	56	45	35
Norway	277 [c]	340 [c]	377 [c]	328 [c]	—	—	—	1	290	335	323	275	..	..	..	..
Spain	51	26 *	52	52	2	1	3	4	—	13	18	16	53	40	37	40
Sweden	99	116	136	125	20	35	32	25	20	21	29	28	99	130	139	122
United Kingdom [d]	150	209	161	198	152	217	204	178	11	13	6	6	291	413	259	370
Yugoslavia	40	47	56	53	—	1	1	1	27	31	28	26	13	17	29	28
Czechoslovakia	95	118	..	125	7	8	..	..	—	—	—	—	102	126	..	..
Poland	127	139	158	167	—	3	1	1	7	6	4	4	129	136	155	164
USSR	1,164 [e]	1,324 [e]	1,445 [e]	1,615 [e]	2	13	3	..	131	155	155	..	1,035	1,182	1,293	..
United States	1,800	1,892	1,755	1,773	186	171	240	151	62	67	72	23	1,924	1,996	1,923	1,901

SOURCE: *Quarterly Bulletin of Steel Statistics for Europe*, ECE, Geneva.

Note: Wherever possible, all blast-furnace and electric-furnace ferro-alloys are included.

[a] Including the Saar until July 1959. Data on production of electric-furnace ferro-alloys for the Saar are not available.

[b] Including the Saar as from July 1959.

[c] Electric furnace ferro-alloys only.

[d] Production figures include blast-furnace ferro-alloys only, while trade data concern all alloys.

[e] Blast furnace ferro-alloys only.

* Secretariat estimate.

Table 5. Crude steel production in 1950 to 1962 and estimated capacity in 1963 and 1965 in selected countries

(Thousands of tons)

Country	1950	1959	1960	1961	1962	Estimated capacity [a] 1963	Estimated capacity [a] 1965	1965 over 1963 (%)
Austria	947	2,511	3,163	3,103	2,969	3,200	4,000	25.0
Belgium	3,789	6,433	7,179	7,000	7,343	8,800 [b]	10,800	22.7
Denmark	122	292	317	323	367	380	400	5.3
Federal Republic of Germany [c]	12,121	29,436	34,100	33,458	32,563	39,300 [b]	43,500	10.7
Finland	104	249	273	298	331	400	600	50.0
France	10,550	15,219	17,279	17,572	17,240	20,820 [b]	22,400	7.6
Greece	23	65 •	65 •	65 •	65 •	65	150	130.8
Ireland	16	40 •	40 •	40 •	40 •	40	40	—
Italy	2,362	6,762	8,229	9,125	9,488	20,710 [b]	14,500	35.4
Luxembourg	2,451	3,665	4,084	4,113	4,010	4,355 [b]	4,700	7.9
Netherlands	490	1,672	1,942	1,971	2,087	2.900 [b]	3,200	10.3
Norway	81	416	478	486	489	550	800	45.5
Portugal	2	—	—	—	174	250	400	60.0
Spain	815	1,838	1,920	2,327	2,199	3,426 [d]	3,990	16.5
Sweden	1,456	2,862	3,218	3,556	3,610	3,700	4 500	21.6
Switzerland	137	250	275	297	318	350	400	14.3
Turkey	91	228	280	304	244 •	350	900	157.1
United Kingdom	16,554	20,511	24,695	22,441	20,820	29,500	32,500	10.2
Yugoslavia	428	1,299	1,442	1,532	1,595	1,750	2,300	31.4
TOTAL, WESTERN EUROPE	52,539	93,748	108,979	108,011	105,952	130,846	150,080	14.7
Bulgaria	—	230	250	330	422	550 [d]	900 [e]	63.6
Czechoslovakia	3,122	6,136	6 768	7,041	7,639	8,100 [d]	10,500 [e]	29.6
Eastern Germany	995	3,647	3,787	3,914	4,095 •	4,200 [d]	4,600 [e]	9.5
Hungary	1,022	1,757	1,886	2,053	2,333	2,500 [d]	3,000 [e]	20.0
Poland	2,515	6,160	6,680	7,233	7,683	7,956 [d]	9,300 [e]	16.9
Romania	558	1,418	1,806	2,127	2,451	2,700 [d]	3,300 [e]	22.2
USSR	27,329	59,950	65,292	70,751	76,306	81,500 [d]	97,000 [e]	19.0
TOTAL, EASTERN EUROPE AND USSR	35,541	79,298	86,469	93,449	100,292	107,506 [d]	128,600 [e]	19.6
GRAND TOTAL	88,080	173,046	195,448	201,460	206,881	238,352	278,680	16.9
United States	89,959	84,773	90,068	88,920	89,202	140,000	145,000	3.6

Note: Unless otherwise specified, estimated capacity figures are based on official statements and Secretariat estimates.

[a] At the beginning of the year.

[b] Expected capacity — source: *Les investissements dans les Industries du Charbon et de l'Acier de la Communauté*, ECSC, Luxembourg, 1963.

[c] Including the Saar as from 1959.

[d] At the end of the year.

[e] Expected production.

• Secretariat estimate.

sources for a considerable part of their total needs; the following proportions of total consumption were imported in 1962 (percentages): Netherlands, 100.0; Austria, 88.6; Belgium-Luxembourg, 80.3; United Kingdom, 46.5; Italy, 36.8; and Federal Republic of Germany, 29.7. The role of France, Norway and the USSR as the principal European exporters should be emphasized. Norway has to some extent specialized in the production of electric-furnace ferro-alloys; with exports of around 300,000 tons per year (80 to 90 per cent of total output) Norway is now the world's chief exporter of these products, mainly to western Europe.

Crude steel

More than 80 per cent of world crude steel output in 1963 stemmed from the steel industries in Europe and in the United States; their combined total production has increased by over 66 per cent since 1950. This is mainly due, as will also be seen from data in tables 5 and 6, to the growth of output in the USSR and the countries of eastern Europe (by 184 per cent), and to the doubling of output in the countries of western Europe; crude steel production in the United States has changed little during the last few years, after having reached a record level of about 102 million tons in 1957.

Almost the whole period covered by data in table 5 was one of sustained economic growth, accentuated by reconstruction and the back-log of demand that had arisen during the war and the immediate post-war period. At the end of the past decade a trend was discernible where the equilibrium between economic development and demand for steel was disturbed in many western European countries and in the United States. Expansion of capacity followed for some years the general trend of economic growth until a point where the discrepancy in the development of steel demand, and the economy in general, became apparent. This led, first, to a considerable surplus capacity for the production of steel, then to increased competition on the world market for steel and on the domestic markets of the main producing countries, with a consequent fall in export prices; and finally, to restrictions in steel output and also to restrictions in investment for further expansion of capacity.

In enumerating the factors which have had an adverse effect on the rate of increase of steel demand in western Europe and in the United States during recent years, a distinction may conveniently be made between those which are of short-term character and may be described as disturbances in the mechanism of supply and demand, and those which are of a long-term nature, i.e., which can be assumed to continue influencing the pattern of growth of steel demand and, hence, of the steel industry in many countries.

The first category comprises mainly two factors:

(*a*) The existence of excess steel production capacity, ensuring future steel supplies within shorter delivery delays, and giving rise to an anticipation of lower prices, to de-stocking on the part of the consumers and to hesitation in the placing of orders;

Table 6. Rates of increase of crude steel production and estimated rates of increase of capacity in selected periods, 1939 to 1965

(Percentages)

Region or country	*1958 over 1939*	*1959 over 1958*	*1960 over 1959*	*1961 over 1960*	*1962 over 1961*	*1965 over 1963*
Total Africa	385.1	3.4	11.7	16.0	6.5	48.3
South Africa	370.8	3.3	11.4	17.0	6.8	28.6
Middle East	—	9.4	30.3	0.9	—	260.0
Far East	204.2	29.6	34.9	14.5	2.4	
China (Mainland)	1,933.0	20.5	38.2	−2.4	5.6	..
India	72.6	34.3	33.0	23.7	20.1	81.8
Japan	80.9	37.3	33.1	27.7	−2.3	6.3
Oceania	170.0	7.1	8.7	5.1	7.3	11.1
Latin America	1,384.4	5.6	43.8	11.1	9.7	25.5
Argentina	1,120.0	−12.3	29.4	59.2	46.0	25.0
Brazil	1,093.0	8.5	54.7	7.1	4.6	34.4
Chile	—	19.3	8.7	−13.3	35.0	27.3
Mexico	1,184.4	2.6	45.2	14.1	1.8	5.0
North America	64.9	10.9	5.7	−0.6	1.0	4.8
United States	61.5	9.6	6.2	−1.3	0.3	3.6
USSR	212.0	9.2	8.9	8.4	7.9	19.0
Europe (excluding USSR)	76.5	8.7	15.1	0.4	−0.1	15.8
ECSC countries	60.8	9.0	15.3	0.6	−0.7	14.1
United Kingdom	48.0 [a]	3.2	20.4	−9.1	−7.2	10.2
Other western Europe	199.8	13.9	14.1	7.5	0.6	27.8
Eastern Europe	166.5	11.3	9.4	7.2	8.4	21.5
TOTAL, world	101.6	11.3	13.5	3.8	2.4	..

[a] 1958 was a 53-week year.

(*b*) In certain important steel-consuming sectors, the last years brought to some countries a reduction in business activity, or comparatively low rates of expansion with a corresponding fall in investments. This had repercussions on the over-all level of demand for finished steel, which was further accentuated by the fact that in times of recession there is a tendency among consumers to reduce their rate of investment in stocks of component part and work-in-progress.

The influence of these short-term factors may well be offset once the level of steel demand coincides with that of iron- and steel-making capacity, through producers restricting the expansion of capacity and through a genuine growth of steel demand in line with economic development, up to the level of available capacity.

The long-term factors appear to be as follows:

(*a*) The improvement of the mechanical properties of steel products and the standardization of these products result in a considerable economy of steel tonnages through lowered specific consumption;

(*b*) The trend of industrial design and of construction is towards ever lighter products (e.g. motor cars, structures, electrical appliances, tools, office machinery, etc.), resulting in the use not only of lighter steel products of improved mechanical properties, but also of other materials whose chief advantage over steel is their lower specific weight;

(*c*) Measures taken by industrial engineers throughout the world for rationalization, automation and higher productivity entail an economy in industrial materials, including finished steel products;

(*d*) These measures are in some countries contributing to a slowing-down in the rate of industrial investment, since output can be raised partly through a more rational use of existing plant and equipment. This change in investment may also affect demand for finished steel products through a relatively reduced demand for and output of plant and machinery, and through diminished construction activities;

(*e*) In many steel-consuming sectors of western European countries and the United States there is noticeable competition from such other materials as aluminium, plastics, asbestos-cement, glass, timber and cardboard, and from new and improved techniques — e.g. reinforced and pre-stressed concrete construction, deep-freezing (instead of canning), etc. During the last decade the quality of these materials and techniques has improved substantially and their fields of application have widened, mostly to the detriment of steel demand. The industries producing these substitutes have in many countries applied efficient and relentless marketing techniques;

(*f*) As economic development reaches higher levels, shifts occur in the industrial structure, not only affecting the product pattern of demand for finished steel, but also its level. Such changes in structure involve the familiar trend towards greater expenditure on services which do not of necessity belong to the category of steel-intensive sectors of the economy, and they also contribute to the increased complexity of industrial output, which in turn tends to reduce steel intensity.

Although it is not possible to quantify the impact these factors — both long-term and short-term — may have had individually or as a group on the level of steel demand during the past few years, it appears that they all have contributed to the fluctuations which have been observed, and the last-mentioned group of factors may be assumed to continue to exert its influence. The steel industry has taken and is taking measures to counteract some of these factors — in particular, competition from other materials — and already new steel products, increased research activity and efficient measures to reduce production costs have resulted. For other factors, especially those affecting the structure of steel markets, the steel industry will have to adapt its level and pattern of output further to the exigencies of the market. This process may in the short run involve a slower growth of steel output in the principal producing countries of western Europe and in the United States than in the past; seen, however, in a long-term perspective, such fluctuations of steel demand and output have been overcome in the past rather rapidly, and the original trend of growth of steel demand was resumed after measures of adaptation to the new situation had been taken by the steel industry.

The foregoing problems concern mainly the market economies, although some of those listed in the second group, affecting the technical and structural developments in the economy, have also an influence on steel requirements and output in the socialist countries of Europe. In most of these steel is still in short supply and the further expansion of steel output has always been one of the principal tasks of national planning authorities. Since, however, despite a rapid growth of production facilities, requirements cannot always fully be satisfied, other industrial sectors have been obliged to increase their efforts to develop new materials and techniques in order to overcome the scarcity of finished steel products for certain uses. Moreover, as economic development progresses, shifts in industrial structure similar to those in other countries have to be planned, and will affect the steel industry of socialist countries in much the same way. Thus, albeit for different reasons and under different circumstances, steel producers in both types of economic systems are facing rather similar situations.

Reverting now to crude steel production in Europe and in the United States, data in table 7 provide a picture on the pattern of output by individual steel-making processes. Apart from the fact that in Western Europe the Thomas converter (and, to a lesser extent, the Bessemer converter) is widely used for crude steel production, it is brought out that the "Other steels" group (mainly produced in oxygen-blown vessels) is making rapid progress. For western Europe as a whole "Other steels" constituted in 1962 6 per cent of total output (compared to 2.7 per cent in 1959). In Austria almost 62 per cent of total output is LD-steel, in the Netherlands over 51 per cent, and in the USSR over 2.7 million tons of steel (or 2.7 per cent of total output) were produced in converters blown with pure oxygen; the United States, the world's most important producer of LD-steel, made more than 5 million tons (5.6 per cent of total output) in 1962. Corresponding to the advance made by oxygen-steels is a fall in the share of other processes in total

Table 7. Output of pig-iron and crude steel, 1959 to 1962

(Thousands of tons and percentages)

Country and year		Pig-iron	Crude steel: Total	Thomas	Bessemer	Open-hearth	Electric	Other steel: Total	Other steel: LD steel
Austria	1959	1,836	2,511 (100)	— (—)	— (—)	868 (34.6)	350 (13.9)	1,293 (51.5)	1,293 (51.5)
	1960	2,232	3,163 (100)	— (—)	— (—)	990 (31.3)	400 (12.6)	1,773 (56.1)	1,773 (56.1)
	1961	2,263	3,103 (100)	— (—)	— (—)	862 (27.8)	423 (13.6)	1,818 (58.6)	1,818 (58.6)
	1962	2,118	2,969 (100)	— (—)	— (—)	814 (27.4)	326 (11.0)	1,829 (61.6)	1,829 (61.6)
Belgium	1959	5,965	6,433 (100)	5,519 (85.8)	17 (0.3)	595 (9.2)	302 (4.7)	— (—)	— (—)
	1960	6,553	7,179 (100)	6,104 (85.0)	23 (0.3)	611 (8.5)	441 (6.2)	— (—)	— (—)
	1961	6,445	7,000 (100)	5,967 (85.2)	33 (0.5)	539 (7.7)	461 (6.6)	— (—)	— (—)
	1962	6,749	7,343 (100)	6,370 (86.8)	30 (0.4)	507 (6.9)	436 (5.9)	— (—)	— (—)
Denmark	1959	58	292 (100)	— (—)	— (—)	278 (95.2)	14 (4.8)	— (—)	— (—)
	1960	69	317 (100)	— (—)	— (—)	298 (94.0)	19 (6.0)	— (—)	— (—)
	1961	64	323 (100)	— (—)	— (—)	301 (93.2)	22 (6.8)	— (—)	— (—)
	1962	67	367 (100)	— (—)	— (—)	344 (93.7)	23 (6,3)	— (—)	— (—)
France	1959	12,472	15,219 (100)	9,262 (60.9)	111 (0.7)	4,555 (29.9)	1,291 (8.5)	— (—)	..
	1960	14,144	17,279 (100)	10,466 (60.6)	106 (0.6)	5,130 (29,7)	1,493 (8.6)	84 (0.5)	..
	1961	14,656	17,572 (100)	10,405 (59.2)	113 (0.7)	5,064 (28.8)	1 567 (8.9)	423 (2.4)	..
	1962	13,959	17,240 (100)	10,024 (58.1)	105 (0.6)	4,928 (28.6)	1,525 (8.9)	658 (3.8)	..
Federal Republic of Germany	1959	21,602	29,436 (100)	13,458 (45.7)	68 (0.2)	13,485 (45.8)	1,876 (6.4)	549 (1.9)	..
	1960	25,739	34,100 (100)	14,906 (43.7)	71 (0.2)	16,087 (47.2)	2,173 (6.4)	863 (2.5)	..
	1961	25,430	33,458 (100)	14,368 (42.9)	67 (0.2)	15,457 (46.2)	2,365 (7.1)	1,201 (3.6)	..
	1962	24,250	32 563 (100)	13.211 (40.5)	52 (0.2)	15,048 (46.2)	2,567 (7.9)	1,685 (5.2)	..
Italy	1959	2,121	6,762 (100)	399 (5.9)	— (—)	3,752 (55.5)	2,611 (38.6)	— (—)	— (—)
	1960	2,715	8,229 (100)	449 (5.5)	— (—)	4,601 (55.9)	3,179 (38.6)	— (—)	— (—)
	1961	3,092	9,125 (100)	632 (6.9)	— (—)	4,986 (54.7)	3,507 (38.4)	— (—)	— (—)
	1962	3,583	9,488 (100)	637 (6.7)	— (—)	5,160 (54.4)	3,691 (38.9)	— (—)	— (—)
Luxembourg	1959	3,411	3,665 (100)	3,576 (97.6)	— (—)	— (—)	89 (2.4)	— (—)	— (—)
	1960	3,713	4,084 (100)	4,003 (98.0)	— (—)	— (—)	81 (2.0)	— (—)	— (—)
	1961	3,775	4,113 (100)	4,038 (98.2)	— (—)	— (—)	75 (1.8)	— (—)	— (—)
	1962	3,585	4,010 (100)	3,881 (96.8)	— (—)	— (—)	64 (1.6)	65 (1.6)	65 (1.6)
Netherlands	1959	1,140	1,672 (100)	— (—)	— (—)	1,039 (62.1)	193 (11.6)	440 (26.3)	440 (26.3)
	1960	1,346	1,942 (100)	— (—)	— (—)	1,103 (56.8)	204 (10.5)	635 (32.7)	635 (32.7)
	1961	1,456	1,971 (100)	— (—)	— (—)	1,025 (52.0)	198 (10.0)	748 (38.0)	748 (38.0)
	1962	1,571	2,086 (100)	— (—)	— (—)	805 (38.6)	208 (10.0)	1.073 (51.4)	1,073 (51.4)
Spain	1959	1.651	1,838 (100)	.. a	244 (13.3)	1,217 (66.2)	377 (20.5)	— (—)	— (—)
	1960	1,888	1,920 (100)	.. a	266 (13.9)	1,360 (70.8)	294 (15.3)	— (—)	— (—)
	1961	2,152	2,327 (100)	.. a	274 (11.8)	1,694 (72.8)	359 (15.4)	— (—)	— (—)
	1962	2,089	2,199 (100)	.. a	255 (11.6)	1.599 (72.7)	345 (15.7)	— (—)	— (—)

Table 7 *(continued)*

Country and year		Pig-iron	Crude steel: Total	Crude steel: Thomas	Crude steel: Bessemer	Crude steel: Open-hearth	Crude steel: Electric	Other steel: Total	Other steel: LD steel
Sweden	1959	1,408	2,862 (100)	400 (14.0)	35 (1.2)	934 (32.6)	1,383 (48.3)	110 (3.9)	..
	1960	1,518	3,218 (100)	406 (12.6)	34 (1.1)	1,091 (33.9)	1,561 (48.5)	126 (3.9)	..
	1961	1,756	3,558 (100)	486 (13.7)	26 (0.7)	1,222 (34.3)	1,620 (45.6)	204 (5.7)	..
	1962	1,812	3.610 (100)	447 (12.4)	— (—)	1,151 (31.9)	1,578 (43.7)	434 (12.0)	..
United Kingdom	1959	12,784	20,511 (100)	1,216 (5.9)	218 (1.1)	17,602 (85.8)	1,370 (6.7)	105 (0.5)	..
	1960	16.016	24.695 (100)	1,708 (6.9)	299 (1.2)	20.862 (84.5)	1,713 (6.9)	113 (0.5)	..
	1961	14,984	22,441 (100)	1,656 (7.4)	258 (1.1)	18,674 (83.2)	1,674 (7.5)	179 (0.8)	..
	1962	13,912	20,820 (100)	1,609 (7.7)	196 (1.0)	16,989 (81.6)	1,504 (7.2)	522 (2.5)	..
Yugoslavia	1959	863	1,299 (100)	— (—)	1 (—)	1,196 (92.1)	102 (7.9)	— (—)	— (—)
	1960	972	1,442 (100)	— (—)	— (—)	1,322 (91.7)	120 (8.3)	— (—)	— (—)
	1961	997	1,532 (100)	— (—)	— (—)	1,393 (90.9)	139 (9.1)	— (—)	— (—)
	1962	1,050	1,595 (100)	— (—)	— (—)	1,435 (90.0)	160 (10.0)	— (—)	— (—)
TOTAL, WESTERN EUROPE [b]	1959	65,311	92,500 (100)	33,830 (36.6)	694 (0.8)	45,521 (49.2)	9,958 (10.7)	2,497 (2.7)	..
	1960	76,905	107,568 (100)	38,042 (35.4)	799 (0.7)	53,455 (49.7)	11,678 (10.9)	3,594 (3.3)	..
	1961	76,980	106,523 (100)	37,551 (35.3)	772 (0.7)	51,217 (48.1)	12,410 (11.6)	4,573 (4.3)	..
	1962	74,745	104,290 (100)	36,179 (34.7)	638 (0.6)	48,780 (46.8)	12,427 (11.9)	6,266 (6.0)	..
Bulgaria	1959	172	230 (100)	— (—)	— (—)	207 (90.0)	23 (10.0)	— (—)	— (—)
	1960	192	250 (100)	— (—)	— (—)	225 (90.0)	25 (10.0)	— (—)	— (—)
	1961	206	330 (100)	..	..	..	..	..	..
	1962	219	422 (100)	..	..	..	..	..	..
Czechoslovakia	1959	4,245	6,136 (100)	241 (3.9)	— (—)	5,149 (83.9)	746 (12.2)	— (—)	— (—)
	1960	4,695	6,768 (100)	247 (3.6)	— (—)	5,716 (84.5)	805 (11.9)	— (—)	— (—)
	1961	4,971	7,041 (100)	234 (3.3)	— (—)	5,879 (83.5)	928 (13.2)	— (—)	— (—)
	1962	5.177	7,639 (100)	230 (3.0)	— (—)	6,368 (83.4)	1,041 (13.6)	— (—)	— (—)
Eastern Germany	1959	1,899	3,647 (100)	355 (9.7)	70 (1.9)	2,750 (75,4)	472 (13.0)	— (—)	— (—)
	1960	1,996	3,787 (100)	380 (10.0)	72 (1.9)	2,837 (74.9)	498 (13.2)	— (—)	— (—)
	1961	2,031	3,914 (100)	375 (9.6)	75 (1.9)	2,944 (75.2)	520 (13.3)	— (—)	— (—)
	1962	2,076	4,100 (100)	..	..	..	..	— (—)	— (—)
Hungary	1959	1,116	1,757 (100)	— (—)	— (—)	1,588 (90.4)	169 (9.6)	— (—)	— (—)
	1960	1,257	1,886 (100)	— (—)	— (—)	1.700 (90.1)	186 (9.9)	— (—)	— (—)
	1961	1,315	2,053 (100)	— (—)	— (—)	1,856 (90.4)	197 (9.6)	— (—)	— (—)
	1962	1,393	2.333 (100)	— (—)	— (—)	2,136 (91.6)	197 (8.4)	— (—)	— (—)
Poland	1959	4,088	6,160 (100)	— (—)	— (—)	5,648 (91.7)	494 (8.0)	18 (0.3)	..
	1960	4,253	6,680 (100)	— (—)	— (—)	6,144 (92.0)	513 (7.7)	23 (0.3)	..
	1961	4,427	7,233 (100)	— (—)	— (—)	6.661 (92.1)	541 (7.5)	31 (0.4)	..
	1962	4,933	7,683 (100)	— (—)	— (—)	7,062 (91.9)	580 (7.6)	41 (0.5)	..

Table 7 *(continued)*

Country and year		Pig-iron	Crude steel: Total	Thomas	Bessemer	Open-hearth	Electric	Other steel: Total	LD steel
Romania	1959	846	1,418 (100)	— (—)	— (—)	1,250 (88.2)	168 (11.8)	— (—)	— (—)
	1960	1,014	1,806 (100)	— (—)	— (—)	1,609 (89.1)	197 (10.9)	— (—)	— (—)
	1961	1,099	2,127 (100)	— (—)	— (—)	1,911 (89.9)	216 (10.2)	— (—)	— (—)
	1962	1,511	2,451 (100)	— (—)	— (—)	2,223 (90.7)	228 (9.3)	— (—)	— (—)
USSR	1959	42,972	59,950 (100)	— (—)	1,795 (3.0)	51,118 (85.3)	5,147 (8.7)	1,890 (3.1)	..
	1960	46,757	65,292 (100)	— (—)	1,867 (2.9)	55,109 (84.4)	5,820 (8.9)	2,496 (3.8)	..
	1961	50,893	70,751 (100)	— (—)	1,895 (2.7)	60,049 (84.9)	6,301 (8.9)	2,506 (3.5)	..
	1962	55,265	76,306 (100)	— (—)	1,909 (2.5)	64,924 (85.1)	6,818 (8.9)	2,655 (3.5)	..
TOTAL, EASTERN EUROPE	1959	55,338	79,298 (100)	596 (0.8)	1,865 (2.3)	67,710 (85.4)	7,219 (9.1)	1,908 (2.4)	..
	1960	60,164	86,468 (100)	627 (0.7)	1,939 (2.3)	73,339 (84.8)	8,044 (9.3)	2,519 (2.9)	..
	1961	64,942	93,449 (100)	609 (0.7)	1,970 (2.1)	79,597 (85.2)	8,736 (9.3)	2,537 (2.7)	..
	1962	70,574	100,934 (100)	624 (0.6)	1,987 (2.0)	86,176 (85.4)	9,451 (9.3)	2,696 (2.7)	..
TOTAL, EUROPE [b]	1959	120,649	171,798 (100)	34,426 (20.0)	2,559 (1.5)	113,231 (65.9)	17,177 (10.0)	4,405 (2.6)	..
	1960	137,069	194,036 (100)	38,669 (19.9)	2,738 (1.4)	126.794 (65.3)	19,722 (10.2)	6,113 (3.2)	..
	1961	141,922	199,972 (100)	38,160 (19.1)	2,742 (1.4)	130,814 (65.4)	21,146 (10.6)	7,110 (3.5)	..
	1962	145,319	205,224 (100)	36,803 (17.9)	2,625 (1.3)	134,956 (65.8)	21,878 (10.7)	8,962 (4.3)	..
United States	1959	55,184	84,773 [c] (100)	— (—)	1,252 (1.5)	74,090 (87.4)	7,740 (9.1)	1,691 (2.0)	1 691 (2.0)
	1960	61,072	90,068 [c] (100)	— (—)	1,079 (1.2)	78,353 (87.0)	7,601 (8.4)	3,035 (3.4)	3,035 (3.4)
	1961	59,235	88,918 [c] (100)	— (—)	799 (0.9)	76,660 (86.2)	7,860 (8.8)	3,599 (4.1)	3,599 (4.1)
	1962	60,139	89,202 [c] (100)	— (—)	730 (0.8)	75,258 (84.4)	8,176 (9.2)	5,038 (5.6)	5,038 (5.6)

SOURCE: *Quarterly Bulletin of Steel Statistics for Europe*, ECE, Geneva.
Note: The figures in parentheses are percentages of crude steel production.

[a] Included under open-hearth steel.
[b] Excluding small producers.
[c] Including steel for castings made by ingot makers only.

output, mainly of conventional converters and open-hearth steel. It should be mentioned that the latter process contributes increasing tonnages to total output, mainly as a result of increased use of oxygen and other measures to improve operations and the quality of output.

As far as future development of crude steel output is concerned, table 5 gives also data on estimated capacity in 1965. Total capacity in Europe and the United States is expected to reach about 424 million tons, or approximately 78 per cent of the world total (150 million tons in western Europe; 145 million tons in the United States; 97 million tons in the USSR, and about 32 million tons in eastern European countries). Should production in 1965 reach estimated capacity, this would imply an increase over 1962 of 42 per cent in western Europe, and of 27.4 per cent in eastern European countries and the USSR taken together. The corresponding increase in demand for iron- and steel-making raw materials would be considerable; it appears, however, that steel producers have made adequate provision for an increase in demand for the principal raw materials, i.e., iron ore, coke and pig-iron. Scrap is in a special category since its availability depends not only on the degree of activity of the steel industry itself, but also on that of steel transforming industries and on arisings of capital scrap.

Conclusions

It has been shown that Europe and the United States are at present the world's main steel producers and consumers, and that they may be expected to keep this position for some time into the future. The production of pig-iron and ferro-alloys is adequate to meet present requirements and it appears that resources, both in the countries concerned and overseas, are sufficient to allow for further expansion of crude steel output. Some disturbances in the equilibrium between steel demand and general economic growth have made themselves felt during recent years in some countries, to be ascribed to a number of factors of both short- and long-term character; among the latter, changes in the structure of demand, as they occur when economies reach higher levels of development, hold a prominent place. The steel industry is taking measures to adapt its pattern of output and its rate of expansion to the changed situation.

Between 1950 and 1960 output of crude steel in Europe and the United States grew by over 60 per cent, while world production increased by 80 per cent. This difference in growth rates reflects the spectacular progress made in other regions, especially in the Far East (Japan and India) and in Latin America, in setting up new steel production facilities. The volume of world trade in steel has, however, hardly been affected by new steel industries in other regions: world trade in steel increased during the period between 1950 and 1960 by about 148 per cent (compared to growth in output of 80 per cent). Although many factors work in the direction of an expansion of international trade in steel (growing integration between groups of countries, exchange of specialities among the advanced steel-producing countries, etc.) one of them appears to have been that the increase of demand for steel in countries establishing domestic steel production was even higher than the growth of their own output. In other words, the deficits tend to shrink in size only for certain products which can — given the state of technical know-how and investment funds — be home-produced; for other products, mostly of a more advanced technical stage of finishing, new demand appears to be created as economic development gathers momentum. The over-all effect was an increase in imports into the regions mainly concerned, as can be seen from the following data on increase of production and of imports (percentages: 1950 = 100):

	Production	*Imports*
Far East	+418	+124
Africa	+211	+52
Latin America	+342	+42

Cases of individual countries appear to confirm this argument: while India's crude steel output increased between 1950 and 1960 by 234 per cent (from 1.5 million tons to 4.9 million tons), steel imports increased by 351 per cent (from 260,000 tons to 1.2 million tons). The same is true for Brazil, where increase in output was 223 per cent, while imports grew by 51 per cent in the same period.

THE IRON AND STEEL INDUSTRY OF LATIN AMERICA: PLANS AND PERSPECTIVES

(DOCUMENT ECLA.2)[1]

Introduction

In 1961, the nine Latin American countries which are now producing steel[2] had a total output of about 5.3 million tons of ingot. Thirty years before, in 1930, only two countries[3] were steel producers and their total output was 153,000 tons. The balance of the consumption has been supplied by imports from other areas, and it is a striking fact that annual import tonnages have remained fairly constant, with a slight tendency to increase. It would thus appear that notwithstanding the merit of planned steel-works as a means of replacing imports, Latin American steel production has in fact served the purpose of fostering economic development.

Table 1 substantiates this deduction. It shows production, import and apparent consumption figures annually from 1939 through 1961 for Brazil, the largest single market for steel products in the region and producer of about 47 per cent of the total Latin American output. While local production rose from 134,000 tons in 1939 to 2,282,000 in 1961, imports rose slightly, from 329,000 tons in 1939 to 439,000 in 1961, having been considerably higher during 1959 and 1960. If the column of imports is examined, one finds immediately that they have been limited by the availability of foreign exchange and reflect mostly the changes in the quantum and terms of trade of Brazilian exports. For instance, the drop of coffee prices in the world market in the mid-fifties brought steel imports down from 856,000 tons in 1954 to 347,000 in 1956.

Table 1. Production, imports and apparent consumption of steel in Brazil

(Thousands of metric tons of equivalent ingot steel) [a]

Year	Production	Imports	Apparent consumption [b]
1939	134.3	427.1	561.4
1940	180.9	381.9	550.6
1941	203.1	327.2	501.6
1942	210.5	161.0	363.5
1943	214.5	236.1	436.0
1944	221.4	427.6	635.1
1945	220.5	405.6	603.2
1946	306.2	590.3	892.0
1947	358.3	649.8	1,004.8
1948	507.4	312.5	777.2
1949	618.6	345.9	939.0
1950	761.4	376.1	1,131.9
1951	906.8	524.9	1,430.9
1952	935.1	525.6	1,457.1
1953	1,056.6	340.5	1,397.9
1954	1,109.3	897.7	2,006.9
1955	1,239.9	519.4	1,743.5
1956	1,428.0	347.8	1,767.5
1957	1,503.2	525.5	2,015.9
1958	1,733.8	290.0	2,021.9
1959	1,984.4	678.1	2,662.1
1960	2,224.0	577.6	2,785.2
1961	2,497.0	447.2	2,943.0

SOURCE: Grupo Executivo da Industria Metalurgica · Servi os do Planejamento. Paper presented by Americo Barbosa de Oliveira to the XVII Annual Congress of the Associaçao Brasileira de Metais.

[a] In all of this paper, finished steel has been converted to the equivalent in ingot steel multiplying by 1.33.

[b] Local production plus imports minus a small volume of exports.

With only two or three exceptions, Latin American countries have considerable shortages of foreign exchange, at least if their propensity to import is considered. In all of them, in addition, capital is scarce, especially the huge amounts necessary for construction of iron and steel making facilities. Given the close tie between availability of steel and economic development, it is relevant to consider whether in preparing development plans it is wiser to build the steel plants after consumption has developed through imports, or to invest the funds which otherwise would have to be spent in buying steel abroad for erecting a plant at the beginning of the cycle.

To a large extent, the answer to the above question is related to the economies of scale of steel plants of various sizes. Some data about this, under conditions prevailing in Latin America, will be given in this paper. It also depends, of course, on the availability of raw materials and other facilities. This problem has been discussed in paper ECLA.1 dealing with the natural resources available for steel making (see page 121). On the other hand, the problem of financing construction of a steel plant is a very difficult one for almost all countries, once the decision has been adopted to build a plant or to expand existing facilities. There are many projects of this kind in Latin America and most of them are falling behind schedule owing to financial difficulties. Given what has been said before on market growth and production, it is easy to see that the reality will differ from the best possible projections if the local production component of the supply of steel cannot materialize because of lack of funds to build the plant. There is no way for total Latin American exports to grow sufficiently for the amounts of steel which appear as probable needs in the various existing projections to be purchased. In other

[1] Paper prepared by the secretariat of the Economic Commission for Latin America. See page 122 for discussion.

[2] Argentina, Brazil, Chile, Colombia, Cuba, Mexico, Peru, Uruguay and Venezuela.

[3] Brazil and Mexico.

words, these projections are made on the assumption that steel production will continue to grow and are implicitly linked to the development of the Latin American iron and steel industries.

Fortunately, most of the technological progress which has taken place in the iron and steel industries during the last fifteen years or so, and the improvements which are being made at present, have the effect of reducing the investment necessary for steel production. Many of these new technologies can be adapted, with slight changes or additions, to existing facilities for what are known as the "classical" steel-making processes. The tables showing hypothetical costs and economies of scale in Latin America have been prepared on the assumption that most of these improvements are being used. Unfortunately, this is not generally being done in Latin America. Although a few plants have incorporated into their processes all the improvements that can reasonably be applied, many are lagging behind and the possibility of increasing production in a number of plants with only a little additional investment is one of the means of increasing local production capacity which should be drawn about to its fullest extent.

Another effect of the so-called new technologies for steel-making is that they influence the economies of scale permitting the construction of smaller plants that are still economical and might be useful for countries with a small market or to serve isolated regions in large countries. ECLA is exploring this possibility for the size category of under 100,000 tons a year, but unfortunately this has not yet been completed. The lower limit of the analysis, for plants making either flat products or bars and profiles, has therefore been set at a minimum tonnage of 100,000 per year.

Present and anticipated demand for the next ten to fifteen years

PRESENT SITUATION OF THE STEEL MARKET

The current situation of iron and steel production and consumption in Latin America can best be conveyed by a set of tables giving the corresponding figures. Of these, table 2 shows the total production and imports of the six Latin American countries which were producing steel in 1930, 1940 and 1950. Table 3 gives the same data for the nine countries producing iron and steel in 1960/61. Peru, Uruguay and Venezuela have been added to the six appearing in table 2, as they became producers during the 1950-1960 decade. Table 4 shows the volume of steel products imported in 1960 and 1961 by the countries which are still not producing steel and cover their whole demand with steel purchases from abroad.

Tables 2 and 3 together confirm what has been said in the introduction with respect to the fact that local production has not yet replaced imports, although these have also increased considerably. To take only the six countries in table 2, production has risen 31 times between 1930 to 1960, from 152 thousand tons of ingot to 4.70 million tons. At the same time, imports have also risen, but more slowly, from 2.03 million to 2.90 million tons; i.e., they increased by 40 per cent. Finally, in 1930 local production covered about 7 per cent of apparent consumption as against 55 per cent in 1960. If the countries are considered individually, Chile is the only one of the six in which local production has, to some extent, replaced imports and reduced their volume. The reason is that of all the plants listed in table 2, the Huachipato, in Chile is the only one that was planned and built on a larger scale than the internal market warranted, with the intention of taking more advantage of economies of scale by exporting any available surplus, as has been done consistently. Moreover, during the years 1929-31, Chile experienced a period of extraordinary economic growth, which has not been surpassed since. The nitrate industry was operating at full capacity and many foreign loans were invested to build roads and otherwise improve the infrastructure of the country. It may well be that, of the new plants, the Orinoco in Venezuela will follow a similar line of development. The tube section of it has been made larger than necessary for the Venezuelan market, so that substantial amounts can be exported. The similarity with the case of Chile in the past is enhanced in view of the irregularity with which important development work is usually carried out by the petroleum industry.

Table 4 shows the imports in 1960 and 1961 of the twelve Latin American countries with no steel production in those years. As the five Central American countries

Table 2. Steel production and apparent consumption in the countries producing steel in 1930, 1940 and 1950

(Thousands of metric tons of ingot steel)

Country	1930			1940			1950		
	Production	*Imports*	*Apparent consumption*	*Production*	*Imports*	*Apparent consumption*	*Production*	*Imports*	*Apparent consumption*
Argentina		1,112.8	1,112.8	24.0	736.2	760.2	130.0	892.4	1,022.4
Brazil	34.4	329.8	364.2	180.0	387.0	567.0	761.4	351.5	1,112.9
Chile		326.7	326.7	30.6	149.6	180.2	70.5	148.3	218.8
Colombia		60.4	60.4	—	107.1	107.1	a	202.4	202.4
Cuba		93.1	93.1	—	86.5	86.5	a	180.9	180.9
Mexico	118.1	105.2	223.3	173.0	122.4	295.4	463.1	301.6	764.5
TOTALS	152.6	2,027.8	2,180.4	407.6	1,588.7	1,996.3	1,425.0	2,077.2	3,502.2

SOURCE: Foreign trade reports of the Governments and figures published by the Latin American Iron and Steel Institute (ILAFA) in several of its monthly publications.

a There may have been a small volume of production in non-integrated plants in Colombia and Cuba, but production figures, if they exist, are not available.

Table 3. Steel production, imports and apparent consumption of the Latin American steel-producing countries in 1960-1961

(Thousands of metric tons in ingot steel)

Country	1960 Production	1960 Imports	1960 Apparent consumption	1961 Production	1961 Imports	1961 Apparent consumption
Argentina	277.0	1,551.6	1,828.7	442.0	1,987.1	2,469.1
Brazil	2,282.2	571.9	2,854.1	2,569.3	439.6	2,998.3
Chile	422.6	91.8	514.4	393.0	126.7	436.7
Colombia	172.3	214.1	386.5	188.9	212.8	401.6
Cuba	?	141.0	141.0	?	266.0	266.0
Mexico	1,539.5	318.7	1,858.2	1,682.1	216.2	1,898.3
Peru	59.9	125.4	185.3	74.9	171.9	246.8
Uruguay	9.7	193.7	203.4	8.8	100.3	109.1
Venezuela	46.7	537.8	584.5	70.7	459.8	530.5
TOTALS	4,809.9	3,746.0	8,556.1	5,429.7	3,974.4	9,356.5

SOURCES: Yearbooks on Foreign Trade of the Governments and information from the Latin American Iron and Steel Institute (ILAFA).

Table 4. Steel imports of the Latin American countries not currently producing steel in 1960 and 1961

(Thousands of metric tons of ingot steel)

Country	1960	1961
Bolivia	19.7	25.1
British West Indies	141.0	141.0
Costa Rica	54.5	50.9
Dominican Republic	31.3	31.0
Ecuador	51.4	58.3
El Salvador	34.4	34.9
Guatemala	47.8	50.0
Haiti	8.1	10.0
Honduras	10.1	15.5
Nicaragua	37.0	39.9
Panama	28.3	37.7
Paraguay	7.2	10.6
TOTALS	470.8	504.9
Imports of the Central American integration treaty countries	183.8 [a]	191.2 [a]
Balance	287.0	313.7

SOURCE: Foreign Trade Yearbooks of the Governments.

[a] Costa Rica, El Salvador, Guatemala, Honduras and Nicaragua.

which have signed the economic integration treaty can be considered as a single market, their imports have also been grouped together at the foot of the table. If the lower limit for economic steel production is set, for the time being,[3] at a minimum of 100,000 tons a year, half flat products and the other half bars and profiles, it is apparent that the only possible Latin American candidate to become a steel producer in the near future, apart from Central America, is the British West Indies, provided that their market is not split as a result of political considerations. The other possibility for anyone of these countries is, of course, to export part of their products to other Latin American countries. Countries that might do this are Bolivia and Ecuador.

As regards the present market situation faced by the Latin American steel industry, another important consideration is the division of finished steel products between flat products on one hand and bars and profiles on the other. A breakdown of apparent consumption of finished steel in 1961 is given in table 5.

Table 5 shows that all the seven countries with integrated steel industries, i.e., Argentina, Brazil, Chile, Colombia, Mexico, Peru and Venezuela, have an apparent consumption of flat products, that is over 100,000 tons a year, but only three — Argentina, Mexico and Brazil — have enough demand for flat products to permit them to take advantage of the economies of scale when producing for their internal market only. The other four countries, Chile, Colombia, Peru and Venezuela, would have to operate on a rather unfavourable sector of the cost curve. Of the countries with non-integrated plants or those which plan to instali integrated plants in the near future, Central America, Cuba, Uruguay, and pessibly the British West Indies are reasonably well placed as regards demand for bars and profiles but less so for production of flat products. In spite of the fact that flat products production in these countries will be costly, the Governments might consider that, within steel production as a whole, the availability of flat products has the greatest effect on industrial growth and therefore undertake to sponsor construction of a plant for this purpose, in spite of the recognized disadvantage of high production costs.

If the percentage distribution of flat products is compared among the different Latin American countries, it is evident that the more industrialized countries generally have a higher percentage of flats except for Bolivia with an unduly high relative consumption of flat products and Venezuela with too low a level. The Latin American ceiling, from 39.1 per cent in Chile to 46.4 per cent in Mexico is unusually high if the distribution in

[3] Until a study is carried out on economies of scale in the capacity range of under 100,000 tons a year, possibly using the so-called new processes for iron ore reduction and steel making.

industrialized countries in other regions is considered. One possible explanation is that heavy profiles are hardly used at all in Latin America for construction work, because of the scarcity of foreign exchange to import them, steel structures are therefore very uncommon, being mostly replaced by reinforced concrete.

Table 5. Breakdown of the apparent consumption of finished steel in Latin America in 1961

(Percentages and thousands of metric tons of ingot steel)

Country	Percentage of flat products	Tonnage of bars and profiles	Tonnage of flat products
Argentina	42.5	1,419.7	1,049.4
Bolivia	48.7	12.9	12.2
Brazil	43.2	1,703.0	1,295.2
British West Indies	35.0	97.5	52.5
Chile	39.7	263.3	173.4
Colombia	42.9	229.3	172.3
Costa Rica	44.8	28.1	22.8
Cuba [a]	35.0 [a]	173.0 [a]	93.0 [a]
Ecuador	31.3	40.0	18.3
El Salvador	31.1	24.1	10.9
Guatemala	30.0	35.0	15.0
Haiti	30.0	7.0	3.0
Honduras	23.3	11.8	3.6
Mexico	46.4	1,017.5	880.8
Nicaragua	30.0	28.0	11.9
Panama	27.4	27.4	10.3
Paraguay	30.0	7.4	3.2
Peru	43.1	140.4	106.4
Dominican Republic	25.8	23.0	8.0
Uruguay	33.1	67.1	33.2
Venezuela	33.6	352.3	178.3
TOTAL	42.0	5,737.9	4,155.0
Of the total, Central American economic integration treaty area	33.6	126.9	62.4

SOURCE: Foreign Trade Yearbooks of the Governments.

[a] Estimated.

DATA ON THE STRUCTURE OF EXISTING INDUSTRY

In spite of the fact that the Latin American iron and Steel industry is fairly new and has been built up at about the same time in the different countries, it is far from being homogeneous. It seems advisable to include here a few tables showing some of the main groups in the aggregate. Differences are due to variations in the availability of raw materials, special characteristics of the consumer market and in some cases in which several alternatives were more or less equivalent, just to personal preferences.

Table 6 shows total pig iron and sponge iron production in 1961, by end-uses and reduction processes. The figures, as indicated at the foot of the table, have been taken from ILAFA's publications, but the totals, based on direct information obtained by ECLA, are lower by some 200,000 tons a year, i.e., about 5 per cent. In spite of the difference, ILAFA's figures will be used throughout this paper so as to facilitate cross-comparison between the various tables. It should be noted that by far the major part of the foundry pig has been made in non-integrated blast furnaces, using in most cases charcoal as fuel and reducing agent and that several important integrated plants in Brazil produce steel from charcoal pig-iron. In fact, foundry pig-iron production is low in the region and most of the countries have, and will continue to have, difficulty in producing it. This should open up a possibility for interregional trade in this particular field.

As may be seen from table 6, only about 58 per cent of the pig-iron and sponge produced in Latin America is reduced in coke blast furnaces. The reason is the scarcity of good coking coal in almost all countries, with the exception of Colombia and Mexico. The figure for electric iron ore reduction in the Latin American steel industry is low in table 6 because the Orinoco Plant in Venezuela, which has a planned capacity of about one million tons of ingot steel, operated only on an experimental basis in 1961, the year to which these figures refer, and started to increase production gradually from the beginning of 1962.

Table 6. Pig iron and sponge iron produced in Latin America by end uses and processes in 1961

(Thousands of metric tons)

Country	Total 1961	By end uses: Foundry	By end uses: Steel making	By process: Coke blast furnace	By process: Charcoal blast furnace	By process: Electric reduction	By process: Sponge
Argentina	398.5	136.0	262.5	335.8	62.7	—	—
Brazil	1,977.1	300.0 [a]	1,677.1 [a]	862.5	1,042.4	72.2	—
Chile	296.1	13.8	282.3	296.1	—	—	—
Colombia	188.6	—	188.6	188.6	—	—	—
Mexico	931.3	82.7	848.7	757.8	—	—	173.6
Peru	51.4	—	51.4	—	—	51.4	—
Venezuela	5.2	—	5.2	—	—	5.2	—
TOTAL	3,848.3	532.4	3,315.8	2,440.8	1,105.2	128.8	173.6

SOURCE: Latin American Iron and Steel Institute (ILAFA), *Repertorio de las Empresas Siderúrgicas Latinoamericanas*, 1962-1963.

[a] Estimated.

Table 7. Steel ingot production by countries and processes in Latin America in 1961

(Thousands of metric tons)

Country	Total ingot production	Distribution by processes: Thomas	Bessemer	Open hearth	Electric	L D
Argentina	441.5	—	—	441.0	0.5	—
Brazil	2,443.2	—	0.7	1,624.5	559.8	258.2
Chile	391.1	—	—	362.9	28.2	—
Colombia	192.1	153.3	—	—	38.7	—
Mexico	1.682.1	—	—	1,046.9	635.2	—
Peru	74.9	—	—	—	74.9	—
Uruguay	9.2	—	—	9.2	—	—
Venezuela	70.8	—	—	—	70.8	—
TOTAL	5,304.9	153.3	0.7	3,484.4	1,408.1	258.2

SOURCE: Latin American Iron and Steel Institute (ILAFA), *Repertorio de las Empresas Siderúrgicas Latinoamericanas*, 1962-1963.

The structure of steel making in Latin America is shown in table 7 for the countries producing steel, except Cuba, for which no information is available.

There is a notably high percentage of electrically refined steel in the region; it is, in fact, much higher than is customary in the more industrialized countries. It should be noted that Brazil and Mexico's share of the electric steel-making in the region is high and to a large extent responsible for the final figures. In the case of Mexico, the tonnage coming from non-integrated plants is increased by the HyL sponge produced at Hojalata y Lamina in Monterrey.

Table 8 shows ingot steel production in integrated and semi-integrated steel mills in Latin America in 1961.

If the results of tables 6 and 7 are combined, and it is assumed that there was no difference in stocks at the end of the year, it would appear that about 63 per cent of the total steel poured during 1961 in the region came from molten pig-iron and the rest from scrap plus iron ore. If the 729,000 tons of ingot produced in semi-integrated plants are deducted, the integrated plants used about 73 per cent hot metal in their charges.

Table 8. Production on steel ingots in integrated and semi-integrated plants in Latin America in 1961

(Thousands of metric tons of ingot steel)

Country	Total steel production	Integrated plants	Semi-integrated plants
Argentina	441.5	171.5	270.0
Brazil	2,504.0	2,174.1	330.0
Chile	388.8	363.8	25.0
Colombia	198.0	176.7	22.0
Mexico	1,736.0	1,490.9	245.1
Peru	73.9	73.9	—
Uruguay	9.2	—	9.2
Venezuela	70.7	—	70.7
	5,422.1	4,450.9	972.0

SOURCE: Data assembled by ECLA directly from the plants. The figures are 2 per cent higher than total steel ingot production given in table 7, based on ILAFA data. All possible care has been exercized to avoid double-counting.

PROJECTIONS OF DEMAND UNTIL 1975

ECLA is currently working, in co-operation with the Latin American Iron and Steel Institute, on the preparation of projections of Latin American steel demand for the next ten to fifteen years. These will be based on careful research into present consumption and the probable development of various industrial sectors. Until they are ready, the question of good projections remains relatively open. In table 9 a series of projections for the years 1970 to 1975 are shown.

Until the ECLA-ILAFA study clarifies the probable future position a little more, we can see from table 9 that projections for 1975 vary between Mr. Martijena's minimum figure of 25.8 million tons to ECLA's estimate of 37.5 million for implementing the objectives of the Punta del Este Charter. The ECE projection, and the ECLA projection extending the trend of the last decade, are close together and fall within the limits of the two aforementioned. Mr. J. R. Miller's projection has not been extended to the extreme because the author states that it was mainly based on the ECE projection. On the other hand, if extended to 1975 it would fall very close to those of Mr. Martijena's. For the year 1970 we have again a considerable spread, with the ECLA series showing the maximum and Mr. Martijena's the minimum figures.

If global projections, such as those shown in table 9, have to be viewed with considerable reserve, the uncertainty increases considerably if an attempt is made to estimate future consumption by countries. In the hope that the new projections currently being prepared by ECLA will soon be ready, the secretariat has made no attempt to obtain country figures so far. As a breakdown by countries is much more important than the aggregate figures given before, an endeavour is made here to produce country figures of a very preliminary nature. In table 10 two series of figures are shown: one is the ECE country breakdown for 1972 and the other the Martijena projection for 1975. The increase of both over apparent consumption in 1961 is also shown.

The events which have taken place since the ECE study was prepared, using 1957 as the last real figure,

Table 9. Projections of total steel demand in Latin America for 1970 and 1975

(Thousands of metric tons)

Source of projection	Estimated demand 1970	1972	1975
Economic Commission for Europe [a]	19,100 [g]	22,300	28,100 [g]
J. R. Miller [b]		21,600 [f]	
ECLA, past trend with increase of 8.1 per cent annually [c]	20,100		29,700
ECLA, past trend with increase of 9.8 annually [d]	23,500		37,500
Armando P. Martijena [e]	17,500 [g]		25,800 [f]

[a] ECE, *Long Term Trends and Problems of the European Steel Industry*. The figures refer to 1972 but are ascribed to 1972-1975.

[b] J. R. Miller, "El Acero en la América Latina" (O.A.S. Magazine *Americas*, April 1961).

[c] Consumption during the decade 1950-1960 showed a cumulative increase of 8.1 per cent per year in spite of the deterioration in the terms of trade for most of the Latin American export products. Maintenance of the same rate of growth during the next one and a half decades would give the results shown in the table.

[d] The Punta del Este Charter envisages a growth rate for the gross national product of 5.5 per cent annually, compared with 4.75 per cent in the last decade. If the same correlation is maintained between the growth of steel demand and the growth of the gross national product, the former would be 9.8 per cent annually.

[e] This projection has been elaborated by Mr. Armando P. Martijena, a consultant who works occasionally for ECLA and are presented here on the author's own responsibility. They are based partly on ECE's projection and partly on the conviction that in order to increase steel consumption in Latin America it is necessary to build more steel plants. Hence the figures are, in a way, influenced by the author's opinion as to the probability of expansions and the creation of new facilities in certain Latin American countries.

[f] Provision has been made for demand in Cuba and other countries not considered in the original projections in order to make them comparable.

[g] Although the ECE projection refers to the period 1972-1975, it is assumed here that it is certain 1972, and the probable figure for the end years in the table has been obtained by assuming an 8.1 per cent annual increase in steel demand.

have proved most of the assumptions to be true. One exception is Venezuela, where a decline in petroleum development activities considerably reduced steel consumption. It is true that the Government is promoting an industrialization plan in which steel transforming industries will play an important role but even so, it appears at the moment that the ECE figure for this country should be lowered to an apparent consumption of 3 million tons in 1972 at the maximum. With this correction, there seems to be no reason why the distribution assumed by ECE should not be used for estimating the possible distribution of demand in 1970.

Table 11 gives a projection of the possible breakdown of steel consumption by countries in 1970, in line with ECE's breakdown, with the aforementioned correction for Venezuela, on the basis of two assumptions: the ECE 1972 figure projected to 1970 and the ECLA figure using the Punta del Este rate of increase for the Latin American gross national product. The following has been added in the appropriate columns: (*a*) 1961 real consumption, and (*b*) all expansion and new development plans for steel industries in the different countries, which will be discussed in the following sections.

The purpose of this table within the context of the present section, is merely to test the feasibility of the two projections considered, in view of the relationship which exists between apparent consumption and local production. Provided that the economic development of the region stays within the ECLA projection (even the most optimistic), and that the individual countries develop on the lines implicitly assumed in the preparation of the ECE projection, it emerges that if most of the expansions and new plans are carried out Latin America's apparent consumption may well reach 23.5 million tons by 1970. This would mean a *per capita* consumption of only 86 kilos per year. This applies even if two countries, namely, Brazil and Mexico, fall behind in their expansion schedules, i.e., Brazil by 2 million tons and Mexico by

Table 10. Breakdown of projections of steel demand by Latin American countries

(Thousands of metric tons and percentages)

Country	1961 Apparent consumption	1972 ECE projection: Tonnage	Percentage increase over 1961	1975 Martijena projection: Tonnage	Percentage increase over 1961
Argentina	2,469	3,500	42	5,000	103
Brazil	2,998	6,500	117	6,650	121
Chile	436	1,000	119	1,024	135
Colombia	401	1,200	200	1,596	298
Mexico	1,898	3,600	90	4,788	153
Peru	247	600	135	625	153
Uruguay	109	300	175	—	—
Venezuela	530	4,000	650	4,123	680
Cuba	266	125	..	—	—
Central America	191				
British West Indies	141 } 505	1,000	98	—	—
Others	172				
	9,858	22,300	127	—	—

SOURCES: ECE, *Long Term Trends and Problems of the European Steel Industry*; Latin American Iron and Steel Institute and preliminary study by Armando Martijena for the ECLA secretariat.

1.5 million tons annually. To a lesser extent this is also probably true of Argentina, except that the backlog in plant construction is not likely to be as large as in the first two countries.

The great difference existing in economies of scale in rolling flat products or bars and profiles suggested the desirability of working out the possible distribution of the two series of country projections in table 11 according to types of finished steel product. The results are shown in table 12.

The above distribution has, of course, no pretentions to being a precise forecast of future consumption but it may be useful for studying, on the one hand, the soundness of the expansion plans and, on the other, the possibilities of regional complementarity. These two points will be discussed later in this paper.

Expansion plans and projects of new facilities

Almost every steel plant in Latin America has expansion plans and there are plenty of new projects in various stages of implementation. Many of these plans and projects are just ideas which have been discussed among the managers of the plants or small groups of the respective communities; others are more detailed studies

Table 11. Steel consumption by countries in 1961, projections of demand for 1970 and current expansion plans for the industry

(Thousands of metric tons)

Country	(A) 1961 Apparent consumption	(B) Modified ECE projection for 1970	(C) ECLA maximum projection for 1970	(D) Expansion plans for the industry in 1970	Difference D-C
Argentina	2,469	3,350	3,840	3,852	12
Brazil	2,998	5,750	7,350	9,082	+1,732
Chile	436	990	1,100	1,165	+65
Colombia	401	1,050	1,320	639	681
Mexico	1,898	3,130	3,930	4,982	+1,052
Peru	247	530	650	250	400
Uruguay	109	260	320	121	209
Venezuela	530	2,570	3,240	1,294	1,946
Cuba	266	530	650	? [a]	? [a]
Central America	191				
British West Indies	141	950	1,100	100	1,000
Others	172				
TOTAL	9,858	19,110	23,500	21,485 [a]	1,399

[a] Excluding Cuba, as recent information is not available.

Table 12. Possible distribution of projections of steel demand in 1970 between flat products and bars and profiles

(Thousands of metric tons and percentages)

Country	Percentage of flats in 1961	Assumed percentage of flats in 1970	Consumption of flat products: Minimum ECE projection [a]	Consumption of flat products: Maximum ECLA projection	Consumption of bars and profiles: Minimum ECE projection [a]	Consumption of bars and profiles: Maximum ECLA projection
Argentina	42.5	43.0	1,440	1,650	1,910	2,190
Brazil	43.2	43.0	470	3,160	3,280	4,190
Chile	39.7	43.0	425	470	565	630
Colombia	42.9	43.0	450	570	600	750
Mexico	46.4	43.0	1,350	1,690	1,780	2,240
Peru	43.1	43.0	227	280	303	370
Uruguay	33.1	38.0	99	138	161	182
Venezuela	33.6 [b]	38.0	975	1,380	1,590	1,860
Cuba	35.0	38.0	210	297	320	353
Central America	33.6	38.0				
British West Indies	35.0	38.0	360	470	590	630
Others	32.0	38.0				
		42.7	8,000	10,105	11,000	13,395

[a] Amended to reduce the projection for Venezuela and to fall within 1970

[b] The relatively small consumption of flat products is due to the large proportion of tubes entering into mix.

including blueprints or they are at the stage where blueprints should be prepared; still others are ready in every respect except for financial arrangements with the promotors actively trying to obtain the necessary funds; finally there are projects that are completely financed but the managers of the respective plants must still choose between different alternatives. If, to all the above, one adds that this is a continually changing picture, it can easily be understood that a table such as annex I can have no claim to presenting a completely true picture of the situation. It has been prepared with all the information that seemed reliable, and if it is unrealistic the bias is probably in the direction of including some projects that will never be implemented. Most of the new important "possible" projects are included in annex I, as are the expansion plans of certain plants that accounted for 71 per cent of ingot production of 1961. The remaining 29 per cent consists of a large number of small integrated and semi-integrated plants which, considered individually, do not warrant discussion although jointly they are an important factor in Latin American steel production and will be so in the future. They have been added together, countrywise, and an average annual increase of 3 per cent in capacity has been assumed for them. The percentage is probably on the low side, but it is hoped that this shortfall will be compensated by the great enthusiasm of the promoters of expansion plans for the larger plants mentioned in annex I. The annual results per country have been summarized in table 13.

As may be seen from table 13, the rate of growth of Latin American steel production will be impressive if a substantial number of the projects considered in the table materialize. In subsequent sections of this paper some of the more important features of the above plans will be discussed. Concerning the breakdown of probable production as given in table 13, into flat products, bars and profiles, it is fairly difficult to work out definite figures since some of the important plants such as Volta Redonda and Belgo Mineira in Brazil, produce either type interchangeably, within limits. Nevertheless, as most of the plants have facilities that incline to one or the other, an estimated breakdown by types of products is given in table 14.

At first sight, it appears that too much capacity for rolling of flat products has been envisaged and that a careful revision of existing plans would therefore be justified. On the other hand, the imbalance in favour of

Table 13. Possible annual production of steel ingot if current expansion plans and new projects are implemented [a]

(Thousands of metric tons of steel ingot)

Country	1961	1964	1965	1966	1967	1968	1969	1970
Argentina	441	1,274	1,383	2,012	2,170	3,831	3,841	3,852
Brazil	2,443	3,307	4,240	4,757	4,775	7,393	8,312	9,082
Chile	391	637	641	645	1,150	1,155	1,160	1,165
Colombia	192	202	203	204	285	287	288	639
Mexico	1,682	2,041	2,408	2,960	3,190	4,360	4,380	4,982
Peru	74	74	75	250	250	250	250	250
Uruguay	9	15	16	17	18	119	120	121
Venezuela	71	427	780	782	784	1,287	1,291	1,294
Central America	—	—	—	—	—	100	100	100
TOTALS	5,304	7,978	9,746	11,627	12,623	18,662	19,642	21,382

SOURCES: Information available at ECLA and data from the Latin American Iron and Steel Institute.

[a] No information from Cuba is available.

Table 14. Breakdown by type of products of output according to expansion plans and new projects shown in table 13 [a]

(Percentages of flat products)

Country	1961	1964	1965	1966	1967	1968	1969	1970
Argentina	—	51	54	48	35	47	47	47
Brazil	43	47	49	54	54	63	71	73
Chile	44	38	38	37	52	52	52	51
Colombia	—	10	10	10	14	14	14	47
Mexico	44	56	53	66	63	62	61	54
Peru	20	20	20	40	40	40	40	40
Uruguay	—	—	—	—	—	—	—	—
Venezuela	—	—	—	—	—	47	47	47
Central America	[b]	[b]	[b]	[b]	[b]	—	—	—
Average regional production	36	47	45	48	48	56	59	59

[a] Information about Cuba is not available.

[b] No steel production in these countries at present.

Table 15. Comparison of the breakdown between types of products of the projections for 1970 of demand on one side, and production on the other

(Thousands of metric tons of ingot steel)

Country	*Flot products*			*Bars, profiles and tubes*		
	Projected demand [a] *(A)*	*Projected production* [b] *(B)*	*Difference B − A (C)*	*Projected demond* [a] *(D)*	*Projected production* [b] *(E)*	*Difference E − D (F)*
Argentina	1,650	1,800	+ 150	2,190	1,552	− 638
Brazil	3,160	6,620	+ 3,460	4,190	2,462	− 1,728
Chile	470	600	+ 130	630	465	− 165
Colombia	570	300	− 270	750	339	411
Mexico	1,690	2,700	+ 1,010	2,240	1,662	576
Peru	280	100	− 180	370	150	220
Uruguay	138	—	− 138	182	120	62
Venezuela	1,380	600	780	1,860	694	− 1,166
Cuba	297	[c]	[c]	353	[c]	[c]
Central America British West Indies Others	470	—	− 470	630	100	530
TOTAL	10,105	12,720	+ 2,912	13,395	7,545	5,496

[a] From table 12.

[b] See annexes II and III.

[c] No data on Cuba were available at the time of writing.

flat products may tend to smooth itself out to a certain extent, in practice. This is because, the figures have been assembled with a double bias, in both cases tending to exaggerate the proportion of flat products in the final results. On one hand, it is probable that not all the projects mentioned in annex I will be executed and it is this type of plan and projects which is responsible for the whole of the planned production of flats; on the other hand, it is highly probable that the expansion of the plants not specifically listed will take place faster than has been envisaged in annex I and this is the type of plant that produces bars, profiles and tubes exclusively. It may therefore be expected that by 1970 production will be composed of a smaller amount of flats and a higher tonnage of other products than that tabulated. Nevertheless, the situation depicted warrants careful study, especially to explore the possibilities of inter-regional complementarity for the industry.

If we compare the maximum ECLA projection to 1970, as shown in table 12, with the expansion plans given in annex I, we can place together the figures shown in table 15. It shows that, even with a very optimistic hypothesis of growth, there is an over-planning of production of some 3 million tons a year of flat products and a deficit of some 5.5 million of other products. This situation warrants very careful study. To begin with, it is indispensable to obtain more information on the proportion of flat products that will eventually enter the Latin American market once the steel transforming industries are more developed. Although such considerations exceed the scope of the present paper, it may be noted that even if the percentage of flat products in the final consumption pattern should rise from the 43 per cent contemplated in table 12 to 46 or 47 per cent, the excessive planning for flat rolled production would persist.

In all probability, the reason for the general trend towards the production of large quantities of plate and sheet is the behaviour of the cost curves and the economies of scale to be gained from large annual tonnages.

Problems which arise from the expansion plans and new projects

Operating conditions of local production

As has been mentioned in the introduction to this paper, local steel production has a strong influence on a country's steel consumption and economic development, but it is evident that this function of local production is best accomplished if the steel for the internal market has a low price. The technological improvements which have taken place during the last decade in the various departments of integrated steel works have all tended to reduce the cost of steel through an increase in the output of existing installations which raises the productivity of the capital invested per unit of product, an increase in labour productivity, and a reduction in some of the inputs, as, for instance, an improvement in the coke rate in the blast furnace. A survey conducted by ECLA in some of the plants has shown that some of them, albeit very few, have introduced many possible improvements so as to operate in excellent technological conditions. Many of them are, unfortunately, lagging behind in this respect although some of the industries in this category are admittedly intending to introduce technological improvements when they carry out planned expansion schemes. In general, and with the above principle in mind, the industry should make a thorough study of the situation of each plant and introduce possible improvements at the earliest possible moment.

Another factor responsible for high steel costs in Latin America is the unduly large assortment of finished products that forms part of the production plans of most industries. This is evidently largely due to the fact that most of the plants have been planned for a restricted national or local market that is protected by high tariff or import quotas. These plants have had to try to produce the largest possible proportion of the different products, common or specialized, that make up local demand. As the first steps already taken towards the organization of a wider market within the Latin American Free-Trade Association, provide for future complementarity in steel products, the expansion plans and new ventures currently contemplated in Latin America should take into account the possibilities offered by concentrating product-mix on a few more marketable lines of production and, as far as possible, maintain them to establish specialization within the industry in general.

In addition to these factors which are open to direct action by the industry itself, there are in most Latin American countries several factors that pertain to the realm of the Government and other public institutions, which increase the cost of steel production, such as distorted transport costs, port charges and electric power rates; inadequate fiscal, tariff and labour policies; etc. In present circumstances, industry in Latin America, even in those cases where it has no need to prepare itself to meet competition resulting from freer intra-regional trade, should revise all those items carefully in order to attain its main objective; i.e., to earn a profit through the sale of as much steel as possible to its respective community at the lowest possible price.

Of all the factors pertaining to the operations of an integrated steel works, once the assembly costs are given, those on which the largest increases in cost will in all probability depend, are (*a*) the processes applied at each stage of the transformation of iron, from ore to the finished product, and (*b*) the product-mix.

The selection of the production processes depends, to a very large extent, on local conditions: availability of raw materials and their characteristics, fuel and power supplies, proximity to tide water and to the markets, etc. A discussion of all the possible technologies and their economic implications is, of course, outside the scope of this paper, in which one can only draw attention to the problem and strongly recommend that before a final decision is taken the experiences gained by others under similar conditions in Latin America, be thoroughly investigated.

On the other hand, the production processes have considerable bearing on the economies of scale and these, in their turn, on the advantages of specialization. To illustrate these points some data are given in table 16 on the costs of iron ore reduction in hypothetical steel works of various sizes under the optimum conditions that might currently prevail in Latin America. Annex II illustrates the most important basic assumptions on which each set of figures has been prepared and subsequent tables will furnish similar data on steel making and finishing. It is necessary to point out that very few plants in Latin America have production costs as low as those appearing in the tables, because in these hypothetical cases all the technological improvements that seem feasible for Latin America have been introduced, which, in fact, is the exceptional situation. It should also be noted that the series of data which have been worked out at ECLA are much more complete and include, among other processes, iron ore reduction in electric furnaces, although for the purposes of this paper only a few salient cases have been selected. Direct reduction has not been carried beyond an annual capacity of 300,000 tons since it is assumed that unless exceptional conditions prevail, larger plants based exclusively on this method will not be built in new Latin American ventures.

Table 16 shows that, when a coke blast furnace is used to reduce the ore, production costs drop by about 25 per

Table 16. Iron ore reduction costs in hypothetical Latin American steel plants

(US dollars per ton of pig iron at 1962 prices)

Reduction system and item of cost	*Capacity in thousands of tons of pig-iron or sponge per year* 100	200	300	400	500	800	1,000	1,500
Coke blast furnace								
Assembly costs	28.30	28.30	—	28.30	28.30	28.30	28.30	28.30
Salaries and wages	5.18	2.83	—	1.53	1.13	0.99	0.95	0.77
Fuel and power	1.00	1.00	—	1.00	1.00	1.00	1.00	1.00
Oxygen	0.62	0.60	—	0.58	0.57	0.53	0.51	0.45
Other supplies	5.73	3.87	—	2.72	2.48	2.38	2.18	1.79
Total direct cost	40.83	36.61	—	34.13	33.48	33.20	32.94	32.31
Capital charges [a]	8.56	7.78	—	6.78	6.24	5.20	4.75	4.35
TOTAL COST	49.39	44.39	—	40.91	39.72	38.40	37.69	36.67
Direct reduction [b]								
Assembly costs	26.27	26.27	26.27	—	—	—	—	—
Salaries and wages	1.85	1.22	0.85	—	—	—	—	—
Other conversion costs	5.32	3.56	1.88	—	—	—	—	—
Total direct cost	33.44	31.05	29.00	—	—	—	—	—
Capital charges [a]	4.16	3.41	3.16	—	—	—	—	—
TOTAL COST	37.60	34.46	32.16	—	—	—	—	—

SOURCE: Study under preparation at ECLA, "The Steel Industry in Latin America".

[a] Taken as a straight 9 per cent on the invested capital, not considering taxes, profits, etc.

[b] Theoretical data checked with Monterrey's Hojalata y Lamina.

cent for an annual capacity expanding from 100,000 to 1.5 million tons, but they decrease by only 5 per cent when capacity is increased from 800,000 to 1.5 million tons a year. On the other hand, investment costs for a small 100,000 tons a year blast furnace are about 9.5 million dollars, but as much as 17.3 million for a 200,000-ton a year furnace. Finally, for the capacities contemplated in the table, the cost of sponge-iron produced through direct reduction of the ore is about 77 per cent that of pig-iron produced in a 100,000 ton blast furnace. But as will be seen later, much of this advantage is lost when the sponge is melted in an electric furnace to make ingots.

Table 17 gives similar data for selected steel-making processes including the oxygen blown open hearth furnace, the electric steel furnace and the L.D. converter. Of the three, the L.D. is the lowest cost producer and also needs the least investment. Compared with an open hearth installation of the same capacity, capital requirements for a small, 100,000 ton a year L.D. plant are 33 per cent less, and drop to 27 per cent in the case of a 1.5 million ton plant. The data concerning steel-making starting from sponge iron are presented separately in table 18 to give details of physical inputs that may be of interest as the process is not well-known. They refer to the electric furnace which seems to be the most favored process. If the costs of steel made through melting of sponge are compared with those of blast furnace metal it will be found that for a 100,000-ton a year plant, steel from sponge-iron costs exactly the same as steel made from pig-iron in an electric steel furnace but that the costs of the former do not drop as fast when operations increase in size. In addition investment and capital charges for the steel process are also higher for the practice using sponge. The reason is that sponge is more difficult and slower to melt, and therefore needs bigger installations. Hence, the advantage of lower investment for sponge-iron in the reduction of the iron ore is almost completely offset by the required larger steel plant. On the other hand, that part of the cost equation that is below 100,000 tons a year, and has not yet been explored by ECLA, will, in all probability, be

Table 17. Cost comparisons of various steel-making processes for operations of different yearly capacity

(US dollars at 1962 prices and thousands of metric tons of ingot)

Process and cost item	*Annual ingot production* 100	200	400	500	800	1,000	1,500
Open-hearth furnace							
Molten pig-iron [a]	36.99	33.25	30.64	29.75	28.76	28.23	27.47
Scrap [a]	14.26	12.82	11.82	11.48	11.09	10.89	10.23
Iron ore [a]	0.76	0.76	0.76	0.76	0.76	0.76	0.76
Iron plus ferroalloys	55.61	50.43	46.82	45.59	44.21	43.48	42.42
Salaries and wages	8.07	6.98	4.10	3.73	3.28	3.08	2.56
Other conversion costs	14.46	14.21	13.41	13.09	12.75	12.61	12.41
Total direct costs	78.14	71.62	64.30	62.41	60.24	59.17	57.39
Capital charges [b]	6.74	6.24	5.34	4.80	3.86	3.37	2.75
TOTAL COSTS	84.88	77.86	69.67	67.21	64.10	62.54	60.14
Electric steel furnace							
Molten pig-iron [c]	35.71	32.09	29.57	28.72	27.76	27.25	26.51
Scrap [c]	13.77	12.38	11.41	11.08	10.71	10.51	10.23
Iron ore [c]	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Iron and ferroalloys	52.88	47.87	44.38	43.20	41.87	41.16	40.14
Salaries and wages	6.50	5.23	3.06	2.78	2.42	2.26	1.97
Other conversion costs	12.75	12.55	11.75	11.45	11.15	11.05	10.95
Total direct costs	71.73	65.65	59.09	57.43	55.44	54.77	53.06
Capital charges [b]	5.78	5.34	4.73	4.26	3.54	3.21	2.71
TOTAL COSTS	77.51	70.99	63.92	61.69	58.89	57.68	55.77
L.D. process							
Molten pig-iron [d]	38.92	34.98	32.24	31.29	30.25	29.70	28.90
Scrap [d]	15.11	13.26	12.51	12.49	11.75	11.53	11.22
Iron and ferroalloys [d]	57.18	51.39	47.90	46.93	45.15	44.38	43.27
Salaries and wages	5.38	4.62	2.84	2.54	2.20	2.07	1.75
Other conversion costs	8.53	8.30	7.46	7.14	6.77	6.61	6.36
Capital charges	4.52	4.10	3.44	3.12	2.58	2.26	2.00
TOTAL COSTS	75.61	68.41	61.64	59.73	56.70	55.26	53.38

[a] The charge of all open-hearth furnaces has been assumed to be: 0.749 tons of hot metal, 0.321 tons of scrap and 80 kilos of high-grade lump ore.

[b] Capital charges are estimated at 9 per cent annually on the investment in the steel shop and do not include taxes, profits, etc.

[c] The charge of all electric steel furnaces is estimated to be 0.723 tons of hot metal, 0.31 tons of scrap and 120 kilos of high-grade lump ore.

[d] The charge of the L.D. converters has been assumed to be 0.788 tons of hot metal and 0.34 tons of scrap.

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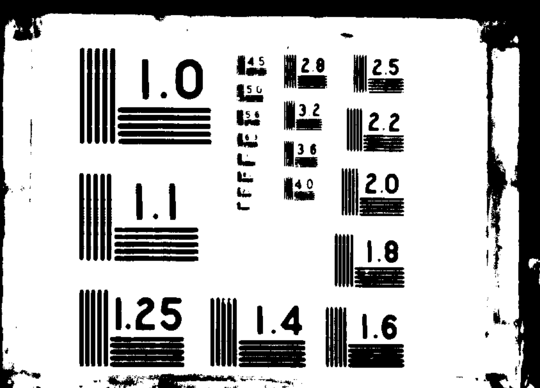


Table 18. Cost of making steel from sponge-iron in an electric steel furnace
(US dollars at 1962 prices and metric tons of ingot)

Input	Unit	100 Specific input	100 Cost	200 Specific input	200 Cost	300 Specific input	300 Cost
		Capacity of plant in thousands of tons					
Sponge-iron [a] [b]	ton	0.790	29.71	0.790	27.22	0.790	25.42
Scrap [a]	ton	0.340	11.51	0.340	10.54	0.340	9.85
Iron ore [a]	ton	0.010	0.10	0.010	0.10	0.010	0.10
Ferroalloys	kg	6.000	2.70	6.000	2.70	6.000	2.70
TOTAL, ferrous material		—	44.02	—	40.56	—	38.07
Labour (direct)	m.h.	3.20	4.80	2.80	4.20	2.60	3.90
Indirect labour			2.60		2.10		1.95
TOTAL, wages and salaries			7.40		6.30		5.85
Fuel (coal)	kg	23.0	0.41	23.0	0.41	23.0	0.41
Refractories	kg	11.0	1.10	11.0	1.10	11.0	1.10
Electric power	kWh	680.0	3.40	680.0	3.40	680.0	3.40
Lime or limestone	ton	0.078	2.34	0.078	2.34	0.078	2.34
Electrodes	kg	7.5	4.50	7.5	4.50	7.5	4.50
Overheads, sundries and general services			5.80		5.46		5.32
TOTAL, conversion costs			17.55		17.21		17.07
Capital charges [c]			8.65		8.01		7.85
TOTAL COST			77.62		72.08		68.84

[a] For a charge of 70 per cent sponge and 30 per cent scrap.
[b] Equivalent iron content of the scrap.
[c] Nine per cent annually on the capital invested in the steel shop, without considering taxes, profits, etc.

decided in favour of the sponge iron process. As the capacity of the reduction plant can easily be increased by the additional small units, without too much effect on the economies of scale, and as there seems to be no great advantage in a combination blast furnace-electric steel furnace up to a capacity of some 300,000 tons a year, it may be concluded that, in the case of markets which are not expected to grow beyond 300,000 to 400,000 tons a year, it would be economically sound to start with small direct reduction plants.

The final products of the steel plant and those which are really of interest here are finished goods. Tables 16 to 18, dealing with the preliminary steps, have been included to clarify some ideas concerning the final part. Table 19 gives the hypothetical costs, in Latin America, of a steel plant producing nothing but flat products with a capacity ranging from 100,000 to 1.5 million tons a year. Of course, different types of rolling equipment have been envisaged for the various brackets of annual capacity. They are summarized in annex III. It can be seen from the table how extraordinarily the size of the operations affects costs and investment per ton, dropping from a theoretical cost of 192.09 dollars per ton at the 100,000 tons a year plant to 103.44 dollars for the largest capacity; in other words, a drop in production cost of 46 per cent, while the investment per annual ton drops by 60 per cent.

To turn back to table 15, it may be seen that of the Latin American countries, only Argentina, Brazil, Mexico and Venezuela will have a sufficiently large demand for flat products by 1970 to enable them to take full advantage of economies of scale. In fact, Brazil's demand could be large enough to permit full operation of two 1.5 million-ton continuous strip mills. Of the other countries, Chile and Colombia would be around the 500,000-ton mark but, other conditions being equal, their flat products would cost about 27 per cent more than in the other four countries.

It should not be forgotten that of all steel products, the flat product that has the biggest impact on economic development, and it is not surprising that under present conditions and with small closed markets, all the countries have tended to manufacture flat products along with bars and profiles. In order to permit these installations, especially those that are efficient, to continue operations if the market is opened to the whole region, a partial solution may be for the smaller plants to devote themselves to the manufacture of more specialized products.

Table 20 compares the cost of producing light bars and profiles, up to a capacity of 300,000 tons a year, with two different technologies, i.e., the classical combination of blast furnace, open-hearth steel furnace,[4] blooming mill and rolling mill, on the one hand, and blast furnace,

[4] Throughout these tables it is assumed that the open-hearth uses oxygen to increase productivity.

Table 19. Cost of rolling flat products in hypothetical plants of different sizes
(US dollars at 1962 prices and tons of finished products)

Cost item	Annual capacity of plant in thousands of tons of finished products: 100	200	400	500	800	1,000	1,500
Physical imput of ingot per ton of finished products (tons) [a]	1.66	1.66	1.51	1.51	1.45	1.39	1.39
Ingot steel	140.92	129.25	105.20	101.49	92.95	86.39	83.59
Fuel (blast furnace gas or equivalent purchase)	2.01	2.01	1.48	1.48	1.67	1.54	1.54
Credit for scrap	−22.22	−19.97	−14.10	−13.69	−11.68	9.94	−9.66
Cost of ferrous material	120.71	111.39	92.58	89.28	82.94	78.53	75.47
Salaries and wages	15.52	12.60	6.22	5.62	4.51	3.92	3.30
Other conversion costs	12.30	11.25	10.67	10.60	8.60	7.75	7.30
Total direct cost	148.53	135.24	109.47	105.50	96.05	90.20	86.07
Capital charges [b]	43.46	38.60	29.70	25.85	19.80	17.92	17.37
TOTAL COST	192.09	173.84	139.17	131.35	115.85	108.12	103.44

[a] Considering the best possible yield of the equipment selected for each size of plant.

[b] Nine per cent on the capital invested in the rolling and roughing mill without considering taxes, profits, etc.

Table 20. Cost of rolling merchant bars and light profiles in plants of different size
(US dollars at 1962 prices and tons of finished merchant bars)

Cost item	Open hearth and blooming mill (capacity of plant in 1,000 tons)			L.D. and continuous casting (capacity of plant in 1,000 tons)		
	100	200	300	100	200	300
Steel ingots [a]	104.83	96.16	91.02	83.04	74.90	71.27
Fuel (blast furnace gas)	1.11	1.11	1.11	—	—	—
Credit for scrap	−7.82	−7.03	−6.74	−4.89	−4.39	−3.83
Total raw materials	98.12	90.54	85.39	78.15	70.51	67.44
Salaries and wages	6.00	4.58	3.87	7.80	5.47	4.37
Other conversion costs	8.40	7.85	7.40	7.30	6.10	5.95
Total direct cost	112.52	102.97	96.66	93.00	82.68	77.91
Capital charges [b]	12.18	11.26	10.39	8.05	7.27	6.83
TOTAL COSTS	124.70	114.23	107.05	101,05	89.95	84.79

[a] 1,235 tons of ingot per ton of finished product in the classical case and 1,145 with continuous casting.

[b] Nine per cent on the capital invested in the rolling and roughing mill without considering taxes, profits, etc.

L.D. converter and continuous casting [5] and rolling mill on the other. The importance of economies of scale in both cases can readily be seen from the table, since costs drop by 14 per cent in the case of the classical mill and 16 per cent in the combination of L.D. with continuous casting, when capacity increases from 100,000 to 300,000-tons a year. Investment is also much lower for the latter process, 34 per cent for the smaller mill and 44 per cent for the larger unit.

This would suggest that, when a new venture for the production of bars and profiles or the expansion of an existing plant are being planned, careful consideration should be given to all local factors in order to determine whether the combination of L.D. converter and continuous casting can be used or not.

Of course, a plant producing, say 100,000 tons of flat products and 100,000 tons of bars and profiles would have, for each set of products, slightly lower costs than those shown in the table for two individual specialized plants producing the same tonnage (100,000), since it would benefit from the larger blast furnace and steel shop. But its costs for flats would be higher than those of a plant producing 200,000 tons of flat products, and its bars and profiles would cost more than 89.95 dollars per ton shown for the 200,000-ton bar plant.

These data should give food for thought to all plants which have planned or are planning to diversify their production in future. The continuation of the policy adopted up to now of creating and expanding the steel industry with a view to operating in a closed market

[5] There is a semi-integrated mill of 70,000 tons annual capacity using continuous casting, and operating successfully at Rio Grande do Sul in Brazil.

under heavy protection, might be one of the factors that would compel such plants to oppose integration of the Latin American market, unless they are favoured by extremely low assembly costs.

This section would be incomplete without a review of the semi-integrated and non-integrated small steel mills existing in Latin America that furnish an important share of total production. Unfortunately, this type of activity has, so far, not been investigated by ECLA, in spite of being quite a dynamic sector in which Latin American local capital has been particularly active, and which is being continuously stimulated to expand existing facilities or create new enterprises.

As may be seen from table 17, according to the assumptions in annex II, the cost of ferrous material, not including ferro-alloys, in integrated Latin American steel mills would vary from 55 to 39 dollars per ton of ingot produced and the cost per ton of ingots from 85 to 53 dollars. If local scrap can be purchased at the price prevailing in the 25 to 35-dollar range, there is a distinct possibility of making a profit in a semi-integrated plant as the lesser cost of the raw material would make up for inefficiencies in the rolling operations. Given, in addition, the possibility of lower transport costs owing to the plant's proximity to the consuming centres, and of reduced investment through the possible use of second-hand or locally-made equipment, the profit margin increases considerably. On the other hand, a plant based on imported scrap, at a price of from 45 to 50 dollars delivered at the plant in Latin America, has much less chance of being profitable, but special cases may permit even this.

Ingots made in an integrated plant in Latin America would cost between 53 and 85 dollars; as said before, another possibility which is quite extensively followed by private business is to import billets for rolling into the required finished forms. Imported billets are usually quoted at about 80 dollars a ton c.i.f. Latin American port, but recently prices have dropped to as low as 68 dollars per ton c.i.f. Buenos Aires. Under such conditions, unless imports are forbidden or a very high tariff imposed, integrated Latin American steel plants will have difficulty in selling billets to non-integrated local mills.

If a country has either iron ore, coking coal or both, imports of scrap and, more especially, of billets by small plants would prevent full utilization of the possibilities of foreign exchange saving, which is the main justification for a Latin American steel industry. The activities of non-integrated or semi-integrated steel mills would thus run counter to any policy of sound economic development. On the other hand, the situation would become worse if the smaller plants were to take up a part of the market which could be served by an integrated steel works, thus adversely influencing either the utilization of the equipment or the economies of scale in the operations.

Benefit of local steel production for Latin American countries

In general the development of the small rolling mills and semi-integrated steel plants in Latin America has followed the same pattern of growth as most of the existing privately-owned industry. The entrepreneur's aim is to make profits and the Government's aim in granting to such activities rather high protection has been to create well-paid jobs and more important generally, to replace imports to save foreign exchange. In the case of the larger integrated steel plants which have usually been to a greater or lesser extent financed by the Government through direct participation in capitalization and management or by guaranteeing foreign credits, the purpose of the Government has generally been to build up a sufficient supply of steel with the lowest possible expenditure of foreign exchange to support the economic development of the country. In these cases, the amount of imports at the time of planning has, of course, been used as a yardstick for ascertaining the size of the projected operations. That this has only occasionally resulted in a reduction in imports has been shown at the beginning of this paper. Another purpose which many Governments have had is the creation around a steel mill of a nucleus of highly skilled workers, from whom technological progress may be expected to flow into the community.

Of all the above considerations, the possibility of having more steel for a specific expenditure of foreign exchange is the most important justification for the creation of the steel industries of the region. In order to see to what extent this purpose can be accomplished, table 21 has been prepared showing, for the same processes as those analysed in tables 19 and 20, the inputs in foreign exchange classified by items and reassembled under different operational conditions: (*a*) in the case of countries which have iron ore and coking coal, such as Colombia and Mexico; (*b*) for countries which import coal, such as Brazil, Chile, Peru and Venezuela and, finally, (*c*) in countries which import both iron ore and coking coal. Table 21 includes a column called "Capital charges" which represents 6 per cent interest annually and 3 per cent amortization on loans for covering the foreign exchange component of the investment. This, again, is estimated at 66 per cent of the total capital investment in the plants, without social overhead facilities, such as housing, schools, hospitals and recreation centres. It is supposed that the latter investments will be made in local currency, but they have not been included in the total investment considered in this paper.

The powerful influence of the scale of operations on foreign exchange expenditure, especially in the case of flat products, can readily be appreciated. For a plant importing all its raw materials, the drop is 47 per cent in passing from 100,000 to 1.5 million tons annual capacity and 67 per cent for a plant using only local raw materials for the same productive capacity range.

What is of particular interest here is the saving attainable through the reduction in foreign exchange expenditure. To determine that amount it is necessary to establish the prices of imported material. This touches upon a very delicate matter; if normal prices are taken to be those prevailing in industrialized countries plus transport and landing costs, the prices are high and the amount of savings according to the various assumptions

Table 21. Expenditure of foreign exchange in steel production in hypothetical Latin American plants

(US dollars per ton at 1962 prices and tons of finished products)

Type of plant	Annual capacity 1,000 tons (A)	Spare parts and sundries a (B)	Foreign exchange inputs: Iron ore b (C)	Coking coal c (D)	Capital charges d (E)	Total foreign exchange expenditure: Importing ore and coal (F)	Importing coal only (G)	With local ore and coal (H)
Production of flat products: coke blast furnace, L.D. convertor, rolling mill	100	22.97	23.50	14.80	41.80	103.07	80.20	64.77
	200	19.30	23.50	14.80	37.30	94.90	71.40	56.50
	400	12.32	22.40	13.50	28.70	76.92	54.52	41.02
	500	9.76	22.40	13.50	25.40	71.06	48.66	35.16
	800	6.84	20.50	13.00	19.70	60.04	39.54	25.54
	1,000	5.30	20.00	12.40	18.80	56.50	36.50	24.10
	1,500	4.59	20.00	12.40	16.90	53.89	33.89	21.49
Production of light bars and profiles: coke blast furnace, L.D. convertor continuous casting, rolling mill	100	14.00	16.30	10.60	13.80	57.40	38.40	27.80
	200	12.93	16.30	10.60	12.70	52.53	36.23	25.63
	300	11.95	16.30	10.60	11.85	50.70	34.40	23.80

a Spare parts, refractories and sundries.

b Imported ore at 14 dollars per ton at plant. Consumption varies with the yield of the rolling equipment.

c 100 per cent coal imported at 18 dollars per ton at plant. Consumption varies with the yield of the rolling equipment.

d Covers interest and amortization on two-thirds of the investment, which are assumed here to have been obtained abroad.

for the processes under study can be seen in table 22. Even in the case of a country that imports all raw materials, the savings are impressive once capacity reaches a figure consistent with the economies of scale.

Unfortunately, many steel exporting countries follow the highly disturbing policy of selling abroad at very low prices the product of their excess capacity beyond domestic consumption. Against a "normal" price of some $182 per ton of flats and $141 per ton of bars and profiles, the prices prevailing during the last few years have been around $125 and $100, respectively. Recently, these export prices have been further reduced and minimum quotations at present (Nov. 1963), are around $100 for flat products and $78 for bars and profiles. Table 23 establishes the foreign exchange savings for Latin American operations in competition with such low prices.

For a country importing its raw materials, the saving is 40 per cent with a plant capacity of 800,000 tons a year and over, and much less for merchant bars within the limits of the plants analysed in the table. For plants using local raw materials only, 40 per cent saving is already achieved with a 200.000 ton annual production of flat products and even a small 100,000 ton plant producing merchant bars exceeds this limit.

If the hypothetical production cost of steel in Latin America is compared with both the import prices shown in table 23, the pressure to which the local manufacturers of steel are currently being subjected by the price policy of the exporting countries can readily be imagined. This situation should also go some way towards discouraging expansion and the construction of new facilities. And this all the more so, because real costs in most of the

Table 22. Saving of foreign exchange resulting from local production under normal steel market conditions

(US dollars per ton at 1962 prices and tons of finished products)

Plant capacity 1,000 tons per year	Steel cost at plant	Cost of imported steel	Saving of foreign exchange: Importing ore and coal	Importing coal	With local raw materials	Two-thirds of the investment estimated to be in foreign exchange
A. Flat products						
100	182.71	182	78.93	101.80	117.23	464
200	165.35	182	85.10	110.60	125.40	414
400	134.41	182	105.08	127.48	140.98	317
500	127.23	182	110.94	133.54	146.84	290
800	113.47	182	121.96	142.64	155.46	219
1,000	106.61	182	125.50	145.50	157.90	208
1,500	102.65	182	128.11	148.11	160.51	187
B. Light profiles and bars						
100	101.05	141	83.60	102.60	113.20	168
200	98.95	141	88.47	104.77	115.37	140
300	84.79	141	90.30	106.60	117.20	130

Table 23. Saving of foreign exchange resulting from local steel production facing very low-priced outside competition

(US dollars per ton at 1962 prices and tons of finished products)

Plant capacity 1,000 tons per year	Steel cost at plant	Cost of imported steel	Saving of foreign exchange: Importing ore and coal	Importing coal	With local raw materials	Two-thirds of the investment estimated to be in foreign exchange
			A. Flat products			
100	182.71	100	—3.07	19.80	35.23	464
200	165.35	100	5.10	28.60	43.40	414
400	134.41	100	23.08	45.48	58.98	317
500	127.23	100	28.94	51.34	64.84	290
800	113.47	100	39.96	60.46	73.46	219
1,000	106.61	100	43.50	64.50	75.90	208
1,500	102.65	100	46.11	66.11	78.51	187
			B. Bars and profiles			
100	101.05	78	20.60	39.60	50.20	168
200	89.95	78	25.47	41.77	52.37	140
300	84.79	78	27.30	43.60	54.20	130

plants are probably higher than the hypothetical figures given here for the following reasons: (*a*) the combination of processes used in the calculations is very rare in integrated plants in Latin America, the existing processes being less efficient and more costly; (*b*) in few plants is the potential productivity of their installations really attained, again causing higher costs; (*c*) in some instances assembly costs are higher than those contemplated in the hypothetical calculations.

Nevertheless, for the Governments sponsoring installation of a steel plant, once there is an assured internal market, the main question of the influence of the steel plant on foreign exchange still persists even with lower prices, and the question becomes one of finding out how long it would take for the foreign exchange component of the investment to be amortized by the annual saving in foreign exchange stemming from local production.

Table 24 shows the relevant figures expressed in terms of the years necessary for the return of the foreign exchange portion of the invested capital both for imports at the normal and the lowest current price. Since international credit is usually given for a longer term than would be required by most of the situations shown in table 24, it may be concluded that the prospects for new ventures are not quite desperate. Another type of problem faces existing plants which have become accustomed to the higher prices of foreign competition, and for new ventures, there is the problem of the time available for attaining full efficiency which is shortened by any reduction in sales price, given Governmental debt servicing and agreement to subsequently pay for imports of steel to replace any not produced should the plant be late in attaining the anticipated full efficiency.

Table 24. Number of years in which the saving in foreign exchange can pay back the foreign exchange component of the investment in a steel plant

(US dollars at 1962 prices per ton of finished products)

Plant capacity 1,000 tons per year	Normal prices of steel: Price of steel (dollars per ton landed)	Years in which investment will be returned by saving in foreign exchange: Importing ore and coal	Importing coal	With local raw materials	Low prices of imported steel: Price of steel (dollars per ton landed)	Years in which investment will be returned by saving in foreign exchange: Importing ore and coal	Importing coal	With local raw materials
			A. Flat products					
100	182	5.8	4.6	4.0	100	—	23.5	13.1
200	182	4.9	3.8	3.3	100	81.0	14.5	9.6
400	182	3.0	2.5	2.2	100	13.7	7.0	5.4
500	182	2.6	2.2	1.7	100	10.0	5.6	4.5
800	182	1.8	1.5	1.4	100	5.4	3.6	3.0
1,000	182	1.7	1.4	1.3	100	4.8	3.3	2.8
1,500	182	1.5	1.3	1.2	100	4.1	2.9	2.4
			B. Bars and profiles					
100	141	2.0	1.6	1.5	75	7.3	4.2	3.4
200	141	1.6	1.3	1.2	75	5.5	3.4	2.7
300	141	1.4	1.2	1.1	75	4.7	3.0	2.4

Raw materials

The raw materials situation in Latin America and their availability may be summarized as follows: (*a*) there is plenty of high-grade iron ore available in Latin America, and all countries currently producing steel have reasonable reserves. Argentina, which at present imports ore from Brazil, Chile and Peru, could develop its Sierra Grande deposit and pelletize the ore to produce a 68 per cent to 69 per cent product, very low in sulphur and phosphorus. Several countries that consume little steel and are not producing it have also reserves; among these, Bolivia has very large reserves according to the latest information. The ore in all countries, except Colombia, is high grade: Colombia's ores are generally relatively low in iron and high in phosphorus; (*b*) only Colombia and Mexico have good direct coking coal. The other countries either have no coal at all, or none of the coking type; only in certain cases, as in Chile or Brazil, can the coal be blended with imported coals to produce a good quality coke. In Mexico, the coal mines are in the north, remote from the main steel-consuming centres; while in Brazil, they are in the south, with only 30 per cent of the coal mined usable in a 40 per cent blend with imported coals. The rest is equally divided between middlings and ash; (*c*) all countries have some type of limestone, but in Argentina and Chile it must be hauled over long distances by river or sea to the plant; (*d*) only Brazil, Mexico and Uruguay have dolomite, the other countries being obliged to import it; (*e*) only Argentina, Bolivia, Brazil, Chile and Mexico have metallurgical grade manganese ore. The rest of the countries import ferromanganese; (*f*) oil, gas and hydro-electric potential are available in the region but their availability for steel-making has to be analysed separately for each location.

The current raw material assembly costs of five important Latin American steel plants have been obtained by the ECLA secretariat. They are as follows:

Argentina: San Nicolás	41.82 dollars per ton of pig iron
Chile: Huachipato	28.29
Mexico: Monclova	23.78
Peru: Chimboto	37.43 including 13.50 dollars for electric power for reduction
Venezuela: Orinoco	22.44 including 5.26 dollars for electric power for reduction
Figure used in this paper for hypothetical plants	28.30

Although, with the exception of Argentina and Peru, of which the first imports its ore and coal at present and the second imports coke, the raw material assembly costs of Latin American plants are not high compared with the assumed hypothetical figure; there is still considerable room in most cases for reducing the assembly costs which are distorted by high freight charges or other factors. The basis of all low-cost steel production are low assembly costs and any excess paid at this stage of the process cannot be corrected even with extreme efficiency in subsequent operations. In the case of Argentina, the San Nicolás plant was planned for the manufacture of a large tonnage of flat products only in a modern continuous strip mill. It will therefore be able to absorb the high assembly costs and still produce at a reasonable price owing to the advantage of economies of scale in this type of operation. But the case of Argentina is an exception in Latin America and is unlikely to be duplicated in any other country.

Manpower problems

Some of the Latin American steel plants have been built within an industrial centre and have had no particular difficulty in obtaining labour that is already familiar with work in industry. This has been the case at Volta Redonda in Brazil, San Nicolás in Argentina, Hojalata y Lámina in Mexico, and, to a lesser extent, at Chile's Huachipato, Peru's Chimbote and Mexico's Monclova plants. In such cases, the intermediate cadres of the labour force could be drawn from existing industry, assisted by a little training in the special features related to their assignments in the steel plant. This training has generally been accomplished in special schools and completed with in-service training. Other plants, like Brazil's Acosita, Colombia's Paz de Rio and Venezuela's Orinoco, have been built far away from any activity, except agriculture, generally subsistence agriculture. Manning of the intermediate cadres in these cases had to be done by transferring mechanics and other workers with industrial habits to the plant, thereby adding to the training problem described above, the burden of adaptation of the staff to the new environment. To facilitate this adaptation, it is indispensable that in a new steel plant far from populated centres, housing and other facilities be built before work is initiated on the plant itself, if possible. This policy was followed, very successfully, by Volta Redonda, which built a town for its labour force, while Paz de Rio's failure to adopt it resulted in many difficulties for the plant. In the latter case, it was expected that private capital would build enough houses to be rented to the staff, but this did not materialize, thereby creating serious problems for the skilled workers who were transferred to the plant from other parts of the country.

The unskilled and less skilled workers have generally been recruited from the labour force engaged on the construction of the plant. In many cases where there are strong labour unions in the country or where the plant is Government-owned or depends to a considerable extent on the good will of the local or national Government, management has not been permitted to dismiss the construction workers in mass after the construction has been finished. The plants had to employ them in productive work where, through natural turnover and selection, the labour force was gradually reduced from about double the standard labour requirements for the plant to a number consistent with reasonably efficient operations.

As to engineers and technicians, all the Latin American countries in which steel plants have been put into operation have good engineering and technical schools from which such staff could be drawn, with or without previous practice in industry. Almost all the successful plants in Latin America have started operations with a management contract given to a foreign consulting or operating firm, which provided the initial technical staff for manning key posts. Local engineers and technicians

Table 25. Labour force in three Brazilian steel plants

(On the payroll on 31 December 1961)

Type of employment or function	*Volta Redonda production 1,129,000 tons of ingot steel*	*Belgo-Mineira 407,150 tons of ingot steel*	*Mannesmann 122,330 tons of ingot steel*
Clerical staff and workers at all levels	10,501	6,960 [a]	4,007
Medium-level technicians	1,202	348	36
High-level technicians	314	78	28
TOTAL	12,117	7,386	4,071

[a] The figure does not include some 5,000 labourers employed in wood-cutting, charcoal production and reforestation.

were assigned as counterparts to the foreign technicians until they had acquired sufficient knowledge and practice to take over the post, at which time the foreign technicians returned to their own country. The training of the counterpart is generally considered complete, not at the moment when he can take charge of the day-to-day operation, but when he has proved that he has acquired sufficient knowledge to be able to meet the difficulties which may arise if anything goes wrong in the particular sector of his assignment. In those countries where local technicians are scarcer or adapt themselves with more difficulty to work in a steel plant, the management contract usually provides for a proportionately larger number of foreign technicians who frequently remain for longer periods.

ECLA is trying to obtain listings of the staff and labour force at Latin American steel plants to permit the respective managements to make comparisons. If these figures are made available, they will be treated as confidential information and will not be published. By way of illustration, the number of people employed in three Brazilian steel plants are given in table 25. Unfortunately, the figures are not strictly comparable because, in some cases, they include iron ore mining and other activities in addition to the steel-making proper. Thus Belgo-Mineira includes wire drawing, and Mannesmann the manufacture of seamless steel tubes.

Also, in December 1961, Paz de Rio in Colombia with a production of 176,800 tons of ingot had the following labour force:

Technical and clerical staff and labour force at the steel plant	4,250
Personnel working in the coal and iron ore mines	2,900
Bogotá office, personnel at ports, etc.	300
	7,450

From Huachipato in Chile, with a production of 394,039 tons of ingot we obtain the following breakdown for mid-1962:

Technical and clerical Chilean staff	1,443
Foreign technical staff	19
Labour force	3,821
	5,283

The number of foreign technicians brought to Huachipato plant by the foreign managing firm in 1950-51, when operations began was 117. As may be seen from the above figures, this had dropped to 19 by 1962.

Problems of personnel training

Personnel training in Latin American steel plants is limited generally to engineers and technicians, on the one hand, and to skilled labour — mechanics, etc. — on the other. As regards engineers and technicians and some key posts for skilled labour, the simplest solution would seem to be for adequately qualified young persons to be given a fellowship for study either in a school or plant abroad, after which they serve at the sponsoring plant for a number of years. This method has been applied by nearly all the plants, but mainly with negative results. When the fellow returns and begins working on his specific assignment which usually is supervisory work within the plant, he often becomes discouraged by the long series of promotions that are necessary before he eventually reaches one of the better positions. To this one may add in the case of skilled labour, the difficulty that follows when someone returning from a fellowship in a foreign country believes that he knows more about his job than his supervisor and that he should therefore replace his superior. The following list enumerates the special fields in which personnel were sent by Colombia's Paz de Rio on fellowships before the plant started, so that it would have good technical personnel at hand for operations.

Coal and iron ore mining	11
Coking plant	6
Blast furnace	5
Thomas converters	2
Electric steel furnace	1
Roughing and rolling mill	10
Wire drawing plant	3
General metallurgical engineering	6
General mechanical engineering	15
General electrical engineering	14
General chemical engineering	2
Others	3
	78

Shortly after the start of operations most of these 78 fellowship holders left the company and at present there are only about 30 per cent of them working for Paz de Rio. General experience in Latin America indicates that a fellowship programme before a plant initiates operations may be a necessary step, but that it gives a low yield of effective staff after operations start. Its advantage is that it provides a basis for selecting from the former fellows those who can best adapt themselves to the strenuous work in the steel industry. On the other hand, if the fellowship programme is applied to staff with some practical experience in the plant, it generally has successful results as the fellow knows what to look for when abroad and is aware of the conditions under which be will have to work when he returns.

A much better scheme is to give the responsibility for operating the plant, through a management contract, to some well-known firm of consultants or a company with their own steel works in one of the industrialized countries. This firm would supply, at the beginning, a sufficient force of engineers, technicians and supervisors to man all key posts in the plant. For instance, the management contract at the Chilean steel plant in Huachipato divided the technical jobs at the plant into 90 key posts, and the contractor provided 117 foreign staff to fill them and to train Chilean counterparts. Huachipato also sent a large number of engineers and supervisors on fellowships abroad, but, as in the case of Paz de Rio, with poor results.

As regards skilled labour, one scheme which has generally met with success is to give some of the more promising workers in-service training supplemented with special courses, during the construction work. Although the Chilean steel plant at Huachipato was able to draw some of its skilled labour from industry in the neighbourhood, especially from the naval shipyards at Talcahuano, the nearby coal-mining industry and the railway repair shop, the following number of workers received some kind of special training at the plant during construction with a view to being given work at the plant, once operations started:

505 welders
172 general mechanics
164 assemblers in structural work
209 plumbers and pipe fitters
198 electricians
192 masons specialized in refractories
30 crane and tractor operators

In addition to a similar training effort for Paz de Rio, that plant found it had to give in-service training and special courses to its mining workers, especially for coal mining. Although coal mining is a traditional activity in Colombia, the scarcity of housing facilities near the steel plant's mine at La Chapa was probably responsible for the lack of any substantial migration by coal miners to the plant, and the labour force for the coal and iron ore mines had to be drawn from subsistence-level agricultural workers in the neighbourhood.

In connexion with the training of personnel, two special cases in Latin America should be mentioned: one is the Monclova plant in Mexico, where training was successfully carried one step further, as the plant was constructed during the last world war and was built almost entirely from reconverted second-hand material. In addition to the normal training problems, the management of the plant also had the task of training engineers, mechanics and labour for the reconstruction of machinery and equipment. The other case is Volta Redonda in Brazil where the problem was one of language. Brazil having had a limited steel-making tradition, a glossary of words and names to be used in the iron and steel industry had to be prepared in Portuguese at the very beginning. For this purpose, the expressions used in the small existing plants were analysed and compared with corresponding Spanish, French and English terms.

LOCATIONAL PROBLEMS

Latin American planners and promoters of steel industries are well aware of the basic principles of space and locational economy, and suggest the creation of steel industries at those points where the addition of assembly costs for the raw materials plus transport of the finished products to the respective consumer centres, will result in the lowest possible product cost. Some distortions have occurred in the past and will undoubtedly continue to occur in the future, to take into account the possible advantages, for example, from proximity to more industrially developed regions where a new venture can find basic support, or because of political considerations. The latter may be the reason for the planning of a small integrated steelworks in the north-east region of Brazil and in the State of Sonora in Mexico. To discuss in this paper the problems of assembly of raw materials in existing plants or in some of the new projects currently contemplated requires more specific data than those available at present. Hence, this subject will be covered by a short review of a few cases of existing plants whose original site selection was quite logical, but where the needs or growth of capacity beyond initial levels are creating difficulties.[6]

Argentina

The San Nicolás works seem to have been originally planned for a final capacity of 1 million tons of finished products. In that case, the site selected, between the two largest consumer centres — Buenos Aires and Rosario — with good communications with both and on a navigable river open during most of the year to carriers of the largest tonnage then known (22,000 tons), was sound in every sense. When the proposed plant was in the blueprint stage, the opportunity was offered of buying at bargain price a large continuous strip mill for flat products with an annual capacity of 2 to 2.5 million tons of finished flat products; it was decided to buy and to plan the plant for that size. In the meantime, to reduce transport costs the size of ore carriers used by most of the importing countries has been increased from the 22,000 tons pre-war figure to 60,000 tons and more. In

[6] This review is based only on data and figures available at ECLA, and has not been discussed with the management of the respective plants, who may in all probability disagree with the view expressed here.

all probability, the increase in capacity from the original 1 million to about 3 million may lead to over-congestion of the already crowded land transport facilities between Buenos Aires and Rosario, facilities which must carry almost all the traffic coming from the north of Argentina and from the Province of Córdoba in the west. As regards the delivery of imported coal and iron ore to San Nicolás, difficulties are being experienced due to the shallows in the River Plate at Martín García, which during several months of the year, do not allow passage of ships loaded with more than 10,000 tons. While overland transport of the increased tonnage of finished products has not received special attention, several solutions are being studied for water transport and there is much support in Argentina to the idea that the blast furnaces at San Nicolás should not be further expanded, but that any new pig iron production should be elsewhere and transported to San Nicolás in smaller vessels. Another idea which is being explored is to build on the island of Martín García, in the River Plate, an ore and coal unloading port from which those materials would be transferred into barges, depending on the general conditions of the river.

Brazil

The Volta Redonda plant in Brazil was originally planned for a production of 1 million tons a year of ingot steel; it has since been expanded to its present capacity of 1.25 million and will soon grow to 1.5 million. From the point of view of locational economy the place is well chosen, since it lies on the junction of the road between São Paulo and Rio de Janeiro, the two largest consumer centres, with a rail line joining the iron ore deposits at Lafayette in the interior, with the port of Rio where imported and local coal from the south are landed. The company intends to supplement their present rolling facilities by a completely new continuous strip rolling mill with an annual capacity of some 2 million tons of products, plus the needed additional blast furnaces and steel shops. It is now being asked whether such an expansion would not overload the transport facilities between Rio and São Paulo, on the one hand, and the railway from Minas Gerais that currently carries the ore from the mine to Volta Redonda on the other. Should this turn out to be the case, the company intends to build a completely new plant with a rolling mill of that kind north of Rio de Janeiro in a place called Vale de Parapoeva. This is the solution which has been incorporated among the existing expansion plans for new industry in annex I, but from the point of view of future steel availability, it really makes no difference which of the two possibilities is finally selected.

Mexico

All the known coking coal deposits in Mexico are situated in the north, and a substantial part of the iron ore mines is in the same vicinity. For this reason, the Mexican steel industry is concentrated at Monterrey and Monclova to attain the lowest possible raw material assembly costs, while the main consuming centre is Mexico City, about 1,000 kilometres to the south. All three existing plants have expansion plans, from the present level (1961) of 967,000 tons of ingots 2.85 million in 1968. The Government is concerned that further expansion may overload the transport system from the north to the capital and is contemplating the creation of a large new steel plant either on the Rio de la Truchas iron ore deposit on the Pacific coast or on the Gulf at Veracruz. The Rio de las Truchas project would make it necessary to import coking coal from abroad, and the Veracruz project to import both coking coal and iron ore, as land transport of these raw materials would be prohibitive and, in addition, would entail the use or an already overloaded transport system. If the influence of raw materials import on the balance-of-payments situation shown in table 24 is taken into consideration, it will easily be understood that the decision is a complicated one and must be carefully studied.

Venezuela

The Orinoco steel plant in Venezuelan Guiana was built in an almost completely unpopulated region of the country, to take advantage of the huge iron ore deposits there and of the Caroni-Orinoco hydroelectric system which has an ultimate potential capacity of 11 million kilowatts. The Government's industrial development and diversification plans provide for the building of a town for an initial population of some 250,000 inhabitants. The intention is that this new town should contain a substantial part of the steel transforming industries which are currently being planned to integrate the industrial development project. Although this appears to be the one case in which the location of the steel plant is determined first and the steel consuming activities are then moved into its vicinity, it may not be especially unusual for Latin America. Thus, if the development planned for the Chocón-Rio Negro hydroelectric system in Argentina takes place, it would be complemented by the installation of a steel plant, to use Sierra Grande ore, and steel-using industries would be grouped around the steel plant according to the project currently known as the North Patagonia development plan.

Estimate of the financial requirements of the expansion of the Latin American steel industry

In various ECLA studies, it has been assumed that the average investment needed to construct a new steel plant is about $500 per annual ton, without including housing and other social overheads. The figure would be much higher for a small flat products mill, in fact, it would be some $790 for a plant with a capacity of 100,000 tons a year including a blast furnace, an open-hearth steel shop with oxygen and the standard small operations rolling equipment. The amount would be only around $300 per annual ton in a plant producing 1.5 million tons of flat products per year. A plant with a capacity of some 500,000 tons of ingot, such as several currently envisioned in Latin America, would cost about $550 to $600 a year. On the other hand, plants for the production of bars and profiles require less investment, i.e., around $250 per annual ton of finished products for plants ranging from 100,000 to some 300,000 tons in annual capacity. Since the average figure of $500 per annual ton has also been extensively used by other authors, and considering that it would be a very complicated task to get more exact figures for most of the projects mentioned in annex I, the amount of $500 will be taken as an average in this paper for estimating the future financial requirements of new projects.

With respect to the cost of expansion plans, ECLA has estimated an average of some $300 per annual ton. This figure relates to cases in which it is necessary to add some major equipment, such as a blast furnace, but is high if the increase in capacity is obtained through a rise in productivity as a result of the application of some technological improvements in the blast furnace or the use of oxygen in the steel plant, etc. But, in view of the fact that the production increase that can be expected from a rise in productivity is limited in comparison with the total volume of the planned expansions, while in some cases the $300 figure may be low, it will be used as an average for estimates of future financial requirements.

The above figures do not include investments in social overheads, such as housing, hospitals, schools and recreation facilities, and provision of electric power, water and sewerage for the houses which have to be built for the staff and workers in plants that are remote from populated centres, and where housing facilities must be provided by the steel company. Nor do the estimated investment requirements include the amounts necessary for the eventual construction of ports, roads and railway sidings which vary widely from plant to plant. While no attempt can be made to provide an average estimate for the latter type of investment, housing costs and allied facilities may easily amount to $3,000 to $5,000 per family of employees or workers. On the other hand, most of the sums necessary for transport and housing would be in local currency, and although they are not included in this estimate, it is recognized that, in several cases of Government-owned plants and in countries facing continuous budget deficits, the lack of funds for these purposes may represent a bottleneck for the building of the plant.

As there is a great deal of uncertainty as to whether or not all expansion plans and new projects have been included in annex I, no plant-to-plant tabulation of investment needs is presented here, but the resulting figures have been lumped together, by countries in tables 26 and 27. Table 26 shows the investment necessary for the new plants listed in annex I, and table 27 the funds needed for the anticipated expansions.

It should be noted that the rate of expansion for the small plants (grouped in annex I under the heading of "Others" with an estimated average annual growth rate of 3 per cent), has been increased to 7 per cent annually in table 27. As this is a very dynamic sector which depends

Table 26. Financial requirements for building the new plants planned in Latin America [a]

(Millions of US dollars at 1962 prices)

Country	1964	1965	1966	1967	1968	1969	1970
Argentina	50	—	260	75	—	—	—
Brazil	310	—	250	—	500	—	—
Mexico	—	—	—	60	250	—	—
Uruguay	—	—	—	—	50	—	—
Honduras	—	—	—	—	50	—	—
Total for new plants	360	—	510	135	850	—	—

[a] The total capital expenditure has been entered in the table for the year in which the plant is expected to start operations. Or course, the investment must be spread over a number of previous years, during construction. 5 years can be estimated as the minimum. The estimate is based on an investment of $500 per annual ton.

Table 27. Financial requirements for the expansion plans of existing plants in Latin America [a]

(Millions of US dollars at 1962 prices)

Country	1964	1965	1966	1967	1968	1969	1970
Argentina	6.3	67.2	7.5	8.1	153.4	9.0	9.6
Brazil	61.8	247 5	12.9	13.5	15.0	390.0	16.5
Chile	45.8	1.2	1.2	151.5	1.5	1.5	1.5
Colombia	4.2	0.9	0.9	24.9	0.9	0.9	106.2
Mexico	124.8	117.0	141.6	42.6	210.9	17.7	18.6
Peru	—	—	52.5	—	—	—	—
Uruguay	1.8	0.3	0.3	0.3	0.3	0.3	0.3
Venezuela	109.8	107.4	1.8	2.1	152.7	2.4	2.7
Central America	—	—	—	—	—	—	—
TOTAL, expansion of existing plants	352,5	541,5	218.7	243.0	534.5	421.8	155.4

[a] The average cost of expansion has been estimated at $300 per annual ton. It has been tabulated for the year in which the new facilities start production, but in practice it has to be spread over at least three to four preceding years.

only little on Government aid for its expansions, the higher figure may be the more realistic one. A similar high growth rate may apply in estimating the total investment necessary in Latin America.

The total investment needed for new plants and expansions have been tabulated for the year in which it is expected that the new facilities will come into operation. This is, of course, unrealistic and a more accurate timing of the need for funds could be obtained by spreading the annual outlays over the number of previous years in which they will be needed for the construction of the plants. Because of the uncertainty regarding the implementation of these plans, this additional information is not presented.

Tables 26 and 27 indicate that the total requirements for reaching the production targets shown in the various tables in this paper by 1970 are equal to :

	Million dollars
Investments for new plants	1,855.0
Investment for expansions	2,467.4
TOTAL	4,322.4

If these plans are followed up and the investment made, the total capacity of the Latin American steel plants in 1970 would be around 21 million tons of ingot steel.

Problems of inter-Latin American complementarity for the steel industry

A review of the countries of Latin America, the distances between them and the resulting transport costs would suggest, other conditions being equal, the advisability of grouping them into three main sub-regions in order to study the prospects of integration within each group. They are:

(*a*) The Atlantic sub-region of South America, comprising Argentina, Brazil, half of Colombia, Paraguay, Uruguay and Venezuela;

(*b*) The Pacific sub-region of South America comprising Bolivia, Chile, half of Colombia, Ecuador and Peru;

(*c*) The northern area comprising the British West Indies, Central America (the five republics in the integration treaty), the Dominican Republic, Haiti, Mexico and Panama.

Table 23 shows projected demand and local production in these three regions in 1970, on the basis of the data given in annex I and table 15. Before reaching any conclusions, it is essential to verify two assumptions made in the annex and the table which tend to increase the deficit in production of bars and profiles. They are:

Table 28. Projected demand and local supply in 1970 in three geographical regions of Latin America [a]

(Thousands of tons of ingot steel)

	A	B	C	D	E	F
	Flat products			*Bars and profiles*		
Region and country	*Projected demand*	*Projected production*	*Results: difference B — A*	*Projected demand*	*Projected production*	*Results: difference E — D*
Atlantic region of South America						
Argentina	1,650	1,800	+150	2,190	1,552	−638
Brazil	3,160	6,620	+3,460	4,190	2,462	−1,728
Uruguay	138	—	−138	182	120	−62
½ Colombia	235	150	85	375	170	−205
Others	20		−20	20	—	−20
Venezuela	1,380	600	−780	1,860	694	−1,166
TOTAL, Atlantic	*6,583*	*9,370*	*2,597*	*8,817*	*4,998*	*−3,819*
Pacific region of South America						
Chile	470	600	+130	630	465	−165
Peru	280	100	−180	370	150	−220
½ Colombia	235	150	−85	375	170	−205
Others	70	—	−70	70	—	−70
TOTAL, Pacific	*1,055*	*850*	*−205*	*1,445*	*785*	*−660*
Central and North America						
Mexico	1,690	2,700	+1,010	2,240	1,662	−578
Others	430	—	−430	590	100	−490
TOTAL, North and Central America	*2,120*	*2,700*	*+580*	*2,880*	*1,762*	*−1,068*

[a] Based on information contained in annex I.

(*a*) that the production of small integrated and semi-integrated plants will increase at a cumulative rate of 3 per cent per year only. This may be lower than the real rate; and, (*b*) that the average product-mix of Latin American steel demand will be 43 per cent flats and 57 per cent other products. If it is considered that for the more industrialized countries this percentage varies between Chile's 39.6 and Mexico's 46.4, the percentage of flat products may well be higher than the average of 43 per cent estimated in these calculations. If so, the demand for flat products will be increased throughout the table and the indicated demand for bars and profiles will be lower, thus producing a more balanced picture with less excess planning of flats production and a smaller deficit of bars and profiles.

Apart from these points, table 28 indicates that the Pacific region will be unable to consume the whole output of a fully-fledged continuous strip mill before 1970, and that the countries concerned would do well to give careful consideration to any plans for the production of flats. The North and Central American region seems to be better balanced, in general, and there would be ample room for a continuous strip mill but, unfortunately, at the present time, three plants already participate in covering Mexico's requirements of this type of steel. Finally, the large excess planning of production of flat products is in the Atlantic region, notwithstanding the possible deficit in Venezuela.

All these projections of demand are overshadowed by one great problem which is outside the realm of the steel industry. It concerns the doubt as to whether the economic development of Latin America in general can attain the growth targets which have been used as a basis for the projections. The region's continuously deteriorating terms of trade are, to say the least, a clear danger signal.

Although the analyses in this paper have hardly been as exhaustive as the subject matter warrants, it is hoped that sufficient information has been provided on the steel industry of Latin America, to illustrate some of its main aspects and problems, and to give ground for consideration and study of the many questions which have been raised and which must still be left unanswered.

ANNEX I

PLANNED PRODUCTION OF THE MORE IMPORTANT LATIN AMERICAN STEEL PLANTS AND NEW PROJECTS THAT SEEM FEASIBLE

(Thousands of metric tons of steel ingot per year)

Country and plant	*1961*	*1964*	*1965*	*1966*	*1967*	*1968*	*1969*	*1970*
				Thousands of annual tons of ingot				
Argentina								
SOMISA, San Nicolas	128	650	850	850	850	2,000	2,000	2,000
ACINDAR	55	80	80	600	600	600	600	600
SIDERCA	—	100	100	100	250	250	250	250
ZAPLA (Jujuy)	—	160	160	160	160	160	160	160
Others [a]	259	284	293	302	311	321	331	342
TOTAL, Argentina	442	1,274	1,383	2,012	2,171	3,831	3,841	3,852
Brazil								
Volta Redonda	1,130	1,200	1,500	1,500	1,500	1,500	1,500	1,500
Vale do Paraopeba	—	—	—	—	—	2,000	2,000	2,000
Belgo Mineira	407	420	500	500	500	500	500	500
COSIPA	—	—	—	500	500	750	750	1,500
USIMINAS	—	500	750	750	750	750	2,000	2,000
Mannesmann	122	150	250	250	250	250	250	250
ACESITA	75	85	120	120	120	120	120	120
Mineracão Geral	223	300	450	450	450	450	450	450
COSINOR	—	120	120	120	120	120	120	120
Others [a]	486	532	550	567	585	603	622	642
TOTAL, Brazil	2,443	3,307	4,240	4,757	4,775	7,393	8,312	9.082
Chile								
CAP (Huachipato)	365	500	500	500	1,000	1,000	1,000	1,000
Others [a]	26	37	41	45	50	55	60	65
TOTAL, Chile	391	537	541	545	1,050	1,055	1,060	1,065
Colombia								
Paz del Rio	152	170	170	170	250	250	250	600
Others [a]	30	33	34	35	36	37	38	39
TOTAL, Colombia	192	202	204	205	286	287	288	639

ANNEX I *(continued)*

Country and plant	*1961*	*1964*	*1965*	*1966*	*1967*	*1968*	*1969*	*1970*
	Thousands of annual tons of ingot							
Mexico								
Altos Hornos Monclova	523	600	950	1,050	1,100	1,250	1,250	1,250
Fundidora Monterrey	278	500	500	500	500	1,000	1,000	1,000
Hojolata y Lemina	166	166	166	600	600	600	600	600
Rio Las Truchas	—	—	—	—		500	500	1,000
La Consolidada	151	160	160	160	200	200	200	200
Est. Sonora	—	—	—	. .	120	120	120	120
Others [a]	564	615	632	650	670	690	710	732
TOTAL, Mexico	1,682	2,041	2,408	2,960	3,190	4,360	4,380	4,982
Peru								
Chimbote	74	75	75	250	250	250	250	250
TOTAL, Peru	74	75	75	250	250	250	250	250
Uruguay								
Valentines	—	—	—	—		100	100	100
Others [a]	9	15	16	17	18	19	20	21
TOTAL, Uruguay	9	15	16	17	18	119	120	121
Venezuela								
Orinoco	—	350	700	700	700	1,200	1,200	1,200
Others [a]	71	77	80	82	85	87	91	94
TOTAL, Venezuela	71	427	780	782	785	1,287	1,291	1,294
Central America								
Honduras	—	—	—	—		100	100	100
TOTAL, Central America	—	—	—	—	—	100	100	100
GRAND TOTAL	5,304	7,978	9,377	11,628	12,625	18,782	19,742	21,485

[a] Including all integrated or semi-integrated plants that have not been specifically mentioned in relation to expansion plans or new projects. In 1961 they produced, taken together, some 1,545 tons of ingot steel, or about 33 per cent of total output. Most of them have expansion plans which individually do not warrant mention here but their expansion potential must be taken into account when studying the future prospects of the Latin American steel market. Here, an annual cumulative increase of 3 per cent in production has been envisaged, this being in the aggregate a very conservative figure.

ANNEX II

PRICES OF SOME IMPORTANT RAW MATERIALS AND SUPPLIES USED IN THE ECLA COST ESTIMATES AND OTHER BASIC ASSUMPTIONS IN CALCULATING FOR HYPOTHETICAL PLANTS

(US dollars)

	Unit	*Price*
1. Iron ore, 63 to 65 per cent grade, low phosphorus	ton	9.50
2. Straight coking coal or blend	ton	18.00
3. Limestone, high grade	ton	7.00
4. Cooling water	c.m.	0.005
5. Hydroelectric power	kWh	0.005
6. Thermoelectric power	kWh	0.016
7. Ferroalloys per ton of ingot (open hearth)	$/ton	3.60
8. Ferroalloys per ton of ingot (electric furnace)	$/ton	2.25
9. Ferroalloys per ton of ingot (Thomas)	$/ton	4.50
10. Ferroalloys per ton of ingot (L.D. or L.D./A.C.)	$/ton	3.15
11. Refractories per ton of ingot (open hearth)	$/ton	4.00
12. Refractories per ton of ingot (electric steel furnace)	$/ton	1.50
13. Refractories per ton of ingot (L.D.)	$/ton	0.80
14. Refractories per ton of ingot (L.D./A.C.)	$/ton	1.00
15. Direct labour	man/hour	1.50

		Unit	Price
16.	Fuel oil	ton	20.00
17.	Natural gas	1,000 cm	12.00
18.	Blast furnace gas	1,000 cm	1.17
19.	Steam	t	2.10
20.	Oxygen, varying with size of plant		
21.	Production of sinter, direct cost per ton of steel	$/ton	0.80
22.	Graphite electrodes	kg	0.60
23.	Common electrodes	kg	0.13
24.	Coking plant gas	1,000 cm	4.50
25.	Tar oil	ton	40.00
26.	Fuel tar	ton	20.00
27.	Purchased scrap	ton	24.0 to 30.0

The prices established for coking coal and iron ore are slightly lower than the cost at certain importing plants, but are also slightly higher than the average in the Latin America steel industry.

The costs of thermoelectric power and steam are based on assumed generation at the plant, using blast furnace gas as a fuel, at a price of $0.012 per unit of 9,200 calories. It has also been assumed that the costs remain constant for different sizes of plant, which is not true, but introduces only a very small distortion.

ANNEX III

Design of the rolling mills used in calculating investment and costs in hypothetical plants

A. Blooming and roughing mills and continuous casting

Case 1. For capacities up to 300,000 tons of ingot a year

Three high non-reversing mill with tilting tables at both ends of the stand. Yield in blooms and billets: 88 per cent (rimmed and semi-skilled steel).

Case 2. For capacities from 300,000 to 500,000 tons of ingot a year

Modern two high reversing blooming and roughing mill with one reversing motor. Yield in blooms, slabs and billets: 81 per cent (rimmed and semi-skilled steel).

Case 3. For capacities over 500,000 tons of ingot

Two modern high reversing mill with two reversing motors. Producing blooms, slabs and billets with a yield of 86 per cent (rimmed and semi-skilled steel).

Case 4. Continuous casting machines with a capacity of up to 300,000 tons a year

Continuous casting machines to produce blooms of 5 × 5 or 6 × 6 inches for rolling from 100,000 to 300,000 tons a year of merchant bars and wire rods.

B. Rolling equipment for flat products

Case 1. Capacities for tinplate, plate and sheet between 100,000 and 300,000 tons a year. Steckel mill for plate and reversing stands for cold rolling

Three-high non-reversing blooming and roughing mill; Steckel mill for hot rolled plate; finishing stands; pickling and cleaning; cold rolling reversible stands; temper stands; hot-dip tinning installation; cutting and finishing of sheet and tinplate, plus necessary heating furnaces. The product-mix is assumed to be such as to give an average yield of 70 per cent of semi-products.

Case 2. Capacities for plate, sheet and tinplate varying between 300,000 and 500,000 tons. Semi-continuaes rolling mill for plate and reversing stands for cold rolling

Semi-continuous rolling mill for plate with a reversible blooming stand and finishing stands, reversible stands for cold rolling temper stands; pickling and cleaning; hot-dip tinning installation; cutting and finishing, plus necessary heating furnaces. The product-mix is assumed to be such as to give a yield of 74 per cent of semi-products

The cost of oxygen has been established for the various hypothetical plants on the assumption that there are no other activities using oxygen in the neighbourhood, which would permit a reduction of cost.

The labour rates established in these calculations are higher than those applying in any of the existing plants, but present wages have a tendency to rise and may, sooner or later, reach the figure adopted here.

Labour productivity has been considered to be the same in all the hypothetical plants.

The cost of imported equipment has been estimated to be the same at any location, and the figures adopted are 20 per cent more than the equipment would cost in the United States, to cover transport charges and other incidentals.

It has been estimated that 30 per cent sinter would be used in iron ore reduction. It is thought that the proportion of sinter in Latin American steel plants should, at least for the time being, correspond to the percentage of fines under 1/8 of an inch. Thirty per cent is considerably above the figures obtaining in most of the steel plants in operation, but it has been thought that greater care in ore sizing and screening of the feed will soon make it necessary to reduce the maximum size of the ore lumps which go into the blast furnace. The larger sizes now being used will then have to be crushed, and this will increase the percentage of fines.

Circulating scrap has been estimated, in each case, at 90 per cent of the cost of pig iron produced at the plant.

Unit capacities of reduction and steel-making furnaces have been established in the hypothetical calculations as varying between the following limits:

	Minimum (tons)	Maximum (tons)
Blast furnace, per day	300	2,000
Electric reduction furnaces, per day		260
Open hearth furnaces	25	500
Bottom blown converters	10	75
LD and LD-LDAC converters	10	150
Electric steel furnaces	15	150

Investments and departmental production costs at the hypothetical plants have been estimated on the assumption that all the technological improvements applicable in Latin America are simultaneously applied. Their effects have been evaluated by comparison with figures obtained in actual practice, where possible in Latin America, and otherwise in the more industrialized countries.

Case 3. Capacities between 600,000 and 800,000 tons of ingot per year of plate, sheet and tinplate. Semi-continuous plate mill and tandem stands for cold rolling

Hot rolling mill with reversible roughing stand; non-reversing preparatory stand and finishing stands; tandem stands for cold rolling; temper stands; pickling and cleaning; continuous tinning; cutting and finishing, plus necessary heating furnaces. The product-mix is assumed to be such as to give a yield of 81 per cent of semi-products.

Case 4. Capacities between 1 and 1.5 million tons of flat products per year. Continuous hot plate rolling mill with tandem stands for cold rolling

Continuous plate rolling mill; tandem stands for cold rolling; temper stands; pickling and cleaning; continuous tinning installation; cutting and the necessary heating furnaces. The product-mix is assumed to be such as to give an average yield of 83 per cent of intermediate products.

III. SUMMARIES OF DISCUSSIONS

Joint session "A"

RAW MATERIALS AND THEIR PREPARATION

Prague Tuesday, 12 November

Chairman: Mr. Z. I. NEKRASOV (USSR)
Secretary: Mr. J. E. ASTIER (France)
Rapporteur: Mr. L. CORREA DA SILVA (Brazil)

Papers presented

"Raw materials and their preparation" (Sect. 2) by K. I. Chirkeva (USSR) and V. J. Miller (USSR)

"Raw materials in Africa for iron and steel manufacturing" (ECA.1)[1]

"Availability of raw materials for iron and steel making in the ECAFE region" (ECAFE.1)[2]

"Trends in production and consumption of iron and steel-making raw materials in Europe and the United States" (ECE.1)[3]

"Steel-making raw materials in Latin America — General situation" (ECLA.1)[4]

DISCUSSION

Mr. NIJHAWAN stated that Indian ores had always been considered as rich ores. However, for efficient mechanized exploration, the need for their preparation also arose. At present, India was seriously considering large installations for the beneficiation of its ores and also of other raw materials like limestone. In doing so, it had in mind increased efficiency in mining operations and greater productivity of its blast furnaces.

Mr. ASTIER said that developed countries needed increasing amounts of imported ore, which created opportunities for the less developed nations. However, requirements concerning the characteristics of raw materials were becoming more and more severe. Ore preparation must be considered even for rich ores.

Mr. LAKHDARI pointed out that in the case of countries like Algeria, ore preparation presented serious economic problems owing to the high investment needed. The domestic use of indigenous ores could be considered only as a partial solution to the problem of utilization of Algerian resources.

Mr. MULLER called attention to the fact that the United Nations had decided to prepare a study of raw materials for the iron and steel industry on a world scale. The contemplated study would examine questions related to iron ore reserves and future demand.

Mr. MACH mentioned that Czechoslovakia had devoted much attention to the study of its raw materials, having successfully developed processes to eliminate objectionable elements like arsenic and chrome.

Chairman NEKRASOV stated that the elimination of undesirable elements like arsenic had also been solved in the USSR.

Mr. BUCK mentioned that the exploration of raw materials for the iron and steel-making industry was highly developed in Canada, where 20 to 25 million tons of ore were exported each year. Production would increase to 45 million within a decade, ore preparation being widely used. Canada also had considerable resources of coal, but for reasons of location it imported from the United States the coal it needed for its steel industry.

Mr. STAKHOVITCH emphasized the importance of the study announced by Mr. MULLER. The evolution of the iron and steel industry, the discovery of new reserves of iron ores and the decrease in the cost of transportation had changed the problem of raw material for the iron and steel industry from a regional to a world one. Mr. STAKHOVITCH also suggested that besides the two aspects already mentioned by Mr. MULLER (ore reserves and future requirements for iron ore) a third one should be considered; i.e., price.

[1] See page 17.
[2] See page 34.
[3] See page 40.
[4] See page 52.

Joint session "B"

PROBLEMS ARISING FROM THE ESTABLISHMENT AND DEVELOPMENT OF IRON AND STEEL INDUSTRIES IN DEVELOPING COUNTRIES

Prague

Tuesday, 12 November

Chairman: Mr. F. AGUIRRE (Chile)
Secretary: Mr. J. SKELLY (United States)
Rapporteur: Mr. L. CORREA DA SILVA (Brazil)

Papers presented

"Problems arising from the establishment and development of the iron and steel industry in developing countries" (SECT. 3)
"Review of the iron and steel industry in the ECAFE region" (ECAFE.2)[5]
"Present and future trends of production and consumption of pig-iron and crude steel in Europe and the United States" (ECE.2)[6]
"The iron and steel industry of Latin America" (ECLA.2)[7]

DISCUSSION

Mr. NIJHAWAN said that he disagreed with some of the cost figures mentioned in the ECLA paper. He also mentioned that where capital was limited, small plants might be advisable even though operating costs were higher. India was planning to build large integrated plants as well as small indigenous ones, the latter being designed and financed domestically.

Mr. ASTIER pointed out that the problem of size must be considered carefully. For flat products large integrated plants were necessary, but for certain specialized products (concrete bars and small sections) small specialized plants might be very efficient, and economically interesting.

Mr. SANT'ANNA called attention to the fact that two large plants were now being built in Brazil (COSIPA and USIMINAS) both for an initial capacity of 500 thousand tons per year.

Mr. SKELLY asked about the best way to establish new industries in developing countries: progressive installation of rolling mill, steel furnace, blast furnace, or installation of integrated plants.

Mr. CORREA DA SILVA mentioned that the Martijena projection cited in the ECLA paper, foreseeing a production of 6,650,000 tons for Brazil in 1975, was very low. With existing plants and their planned expansion, production should reach at least 6 million tons by 1970.

Mr. STAKHOVITCH said that the method used for establishing projection figures did not need to be perfect with regard to prevision of the estimates. For the purpose of the ECLA paper what was needed was only an approximate figure. Mr. STAKHOVITCH said that he was impressed with the examples cited by Mr. LEUSCHNER in the ECLA paper, which showed the great importance of transportation facilities. He believed the comparison between imported steel prices and local prices was too extreme.

Mr. BASTOS stated that the reference to a new plant in the Paraopeba Valley, for expansion of the National Steel Company of Brazil, did not correspond to the plans of that company.

Mr. LEUSCHNER replied to Mr. CORREA's remark concerning the Martijena project and said that the figure used was 9,082,000 tons for 1970. Regarding Mr. NIJHAWAN's remarks about costs, Mr. LEUSCHNER justified the data used. Mr. LEUSCHNER also pointed out that plants in Latin America usually had to have a broad spectrum of products even though this increased the price. ECLA would promote a study of the influence of size in the range between 25,000 and 100,000 tons per year. Very small plants might be justifiable and economical in certain locations in Latin America. Regarding Mr. SKELLY's question, he said that the establishment of a plant based on scrap might cause difficulties later. Regarding the question of projections, Mr. LEUSCHNER pointed out that they were very difficult to make for Latin America, for many reasons, including the question of transportation prices.

Mr. HESP mentioned that the remarkable increase in the iron and steel industry in Japan had been achieved with use of large amounts of imported Australian ore (6 million tons per year). Coal was also exported from Australia to Japan.

Two questions were raised from the floor: in view of the fact that most steel plants must expand every few years, how did the planners go about establishing its capacity? Did the new facilities for iron and steel production in the ECAFE region correspond to 100 per cent of present consumption and was provision for expansion made?

Mr. SUBRAMANIAN answered that planners attempt to provide for the present market but of course also took into account future expansion needs for at least ten years.

[5] See page 76.
[6] See page 83.
[7] See page 95.

Mr. ABRERA asked whether there should be a compromise between the economic and the social factors when planning steel industries for emergent countries. Mr. MIKHALEVICH emphasized that the building of steel plants was the only way to raise the standard of living of developing countries. The compromise mentioned by Mr. ABRERA must, of course, be made. However, such plants must conform to the markets and could not depend on exports.

Mr. ANDERSON pointed out that there was no example of sustained economic growth in a country without a corresponding increase in steel production. In fact, with two exceptions, there was no case of high standards of living existing without a developed steel industry. In regard to costs of production, these were important in the long run but not necessarily so in the initial stage of a new plant.

Mr. ALI described the situation of Pakistan's iron and steel industry and strongly emphasized the necessity of maintaining contact with the financing agencies.

Mr. LAKHDARI described the situation in Algeria, mentioning present plans for construction of a large integrated steel plant. He also stated that the basis for industrialization was the iron and steel industry. He believed that the problem of establishing new steel plants should be planned not on a national but on an African scale. He said that the only countries in Africa to have integrated steel plants were South Africa and the United Arab Republic.

Mr. EKECHUKWU mentioned that Nigeria had a small rolling mill. He also called attention to the problems of selecting consultants for new plants in developing countries.

Mr. WELLS pointed out that Rhodesia had had an integrated steel plant for a long time.

Mr. MILLER announced that the United Nations Centre for Industrial Development would be available to advise countries with problems concerning iron and steel plant establishments and/or developments. He mentioned the results of a recent study made for the Algerian Government showing that there, as in many other countries, the problem of establishing new steel plants must be studied, taking into consideration local conditions. There was generally not one problem or one solution but many factors that had to be considered. An interesting feature of the project now under study for Algeria was the intensive use of hydro-carbons in the blast furnaces, with an ultimate objective of reducing coke requirements to about 150 kg/ton of iron.

Technical session "A.1"

EXPLORATION AND EXPLOITATION OF IRON ORE RESERVES

Prague — Wednesday, 13 November

Chairman: Mr. B. P. ABRERA (Philippines)
Secretary: Mr. E. PALACIO (Peru)
Rapporteur: Mr. H. B. GOODWIN (United States)

Papers presented

"Exploration of a small iron ore deposit" (A.1) by J. Caorsi (Uruguay) and G. Bossi (Uruguay)

"Ore exploration and exploitation — Intermediate scale" (A.2) by R. Wasmuht and R. Tschoenke (Fed. Rep. of Germany)

"Ore exploration and exploitation on a large scale" (A.3) by H. Reno (United States)

"Large-scale ore exploration and exploitation in Liberia" (A.24) by A. M. Massaquoi (Liberia)

DISCUSSION

Mr. U SOE MYINT asked Mr. CAORSI, with regard to page 8, paragraph 6 (English version) of his paper if he could give an estimate of the cost of open-pit mining for a production of 400,000 to 600,000 tons annually. Mr. CAORSI replied that they had not determined the exact cost but that they were sure open-pit mining was cheaper and so had determined on that method.

Mr. GOODWIN asked Mr. CAORSI what factors specifically caused Uruguay to feel that in 1956 it was ready to embark on the project. Mr. CAORSI replied that this was outside the scope of the Geological Institute but he understood it was because the market study had shown that consumption had reached the point where an industry was warranted.

Mr. WARGANEGARA presented a short summary of exploration efforts in Indonesia. He then asked Mr. TSCHOEPKE as to the means of transportation and the advisability of setting up more than one beneficiation plant in order to locate near the mines *vs.* setting up a centralized plant serving many mines. Mr. TSCHOEPKE replied that transportation costs and selection of methods would depend on geographical and topographical considerations. A second question concerned the use of aero-magnetic surveys in a cloudy country. It was replied that the aero-magnetic survey would have to be compared with ground magnetic survey and the two co-ordinated for most efficient results.

Mr. U SOE MYINT asked Mr. TSCHOEPKE for details on investment and production costs for annual production of 300,000 to 500,000 tons by open-pit mining. Mr. TSCHOEPKE replied that he could not answer specifically without knowing such details as overburden thickness, water availability, labour costs, etc. for the particular deposit.

Mr. LAKHDARI asked if it was possible to obtain a further cost breakdown of the cost on page 13 (page 12 of English version) of Mr. TSCHOEPKE's paper. Mr. TSCHOEPKE replied that the figures were based on a market analysis which considered both local and export markets and that the other items were self-explanatory. He also commented on the cost figures given of $1.50 to $2.00 per ton for open-pit mining (page 11 of English version). He stated that if these figures seemed low, actually that was not the case. They were high compared, for example, to a cost of $0.30 in one instance in Norway. In other mines costs were much higher, so that in this paper intermediate values had been selected.

Mr. GOODWIN asked if there were any circumstances under which a developing country should import ore. Mr. TSCHOEPKE replied that use of low-grade home ores would be a heavy burden on the total economy of the country where high-grade foreign ores could be obtained to give a cheaper end product. The case of Pakistan cited the previous day was an example of a developing country importing ore.

Mr. BUCK said that with regard to Mr. CAORSI's paper it might be too optimistic to expect to beneficiate ore to 68 to 72 per cent. He believed lower concentrations would be achieved full-scale than were obtained in the experimental-scale work. Also he believed it might be necessary to grind the ore more finely than was contemplated in order to pelletize it, even though that was not necessary for beneficiation.

With regard to Mr. TSCHOEPKE's paper, he suggested that developing countries should consider the social consequences of the technical revolution which new methods would bring about. He also stressed the need for continuous re-evaluation of projects. Knowing when to stop was important. A country should know a project's true costs even though it might go ahead with an uneconomical project for political or social reasons.

With regard to Mr. RENO's paper, he said that Canadian experience confirmed the long time required to get a project into production. He stated that he differed with a previous comment by Mr. ABRERA and that he felt there was no shortage of good high grade ore and that there would be a "buyer's market" for ore for a long time to come.

Mr. ABRERA replied that he did not say there was a shortage, only that every producing area was undergoing continuous depletion.

Technical session "B.1"

BLAST FURNACE: OPERATION AND DEVELOPMENTS

Prague

Wednesday, 13 November

Chairman: Mr. D. FINK (OAS)
Secretary: Mr. W. R. HESP (Australia)
Rapporteur: Mr. L. CORREA DA SILVA (Brazil)

Papers presented

"Technical progress in the production of pig-iron in blast furnaces" (B.1) by V. G. Voskobojnikov (USSR)

"Charcoal blast furnace operations" (B.2) by Mr. Constantine (Australia)

"General review of direct reduction processes" (B.3) by Mr. F. M. Wiberg (Sweden)

DISCUSSION

Mr. MILLER, replying to a question regarding the operation of blast furnaces with only 150 kg of coke per ton of pig iron, stated that this did not seem unreasonable as an ultimate objective. He cited documentation that had recently appeared in the October 1963 issue of the new journal issued by Nippon Kokan concerning fuel oil substitution (for coke) and the proceedings of the 1962 "Journées de la Sidérurgie" with regard to gas replacement (for coke). He referred to a paper published last year by Mr. CORREA DA SILVA setting 125 kg per ton as a possibility, and asked the latter to comment.

Mr. CORREA DA SILVA pointed out that blast furnace operators were achieving increasing control of B. F. variables. There had been a "pellet revolution" and now a new revolution was beginning, with the use of self-reducing pellets. Coupled with improvements in B. F. practice it could be expected that the coke rate might be decreased to 150 kg/ton pig iron, as Mr. MILLER had suggested. He mentioned that at this low level of carbon requirement it was possible that instead of coke other forms of industrial carbon might be used. Regarding charcoal B.Fs. he mentioned that Brazil produced about one million tons of pig iron per year from charcoal blast furnaces. Most of this iron was converted into steel in integrated plants.

Mr. ASTIER stated that in view of results already attained, in particular at the Bureau of Mines and at the Bas Fourneau at Liege, it was hoped that the consumption of 150 kg of coke/ton could be reached in the future.

Mr. WENZEL asked whether any difficulty with fines had been encountered when using pellets, since it seemed that the fines in pellet charges occupied the spaces between the pellets, while when using sinter they filled the sinter pores and were less objectionable. Regarding the low shaft furnace it must be remembered that it might be of interest to developing countries in view of the fact that it utilized non-coking coal.

Mr. MIKHALEVICH answered a question on top-pressure by stating that in the USSR top pressures of 2.5 atmospheres had been attained, but this required very strong construction for the B.F. Normal practice was to operate at 1.5 atmo. The increase in pressure required special design not only in the B.F. but in all of its subsidiary installations. The increase in pressure made for easier operation of the B.F. With respect to investment and operating costs, these depended on the characteristics of a given B.F. and of the changes required. Referring to the characteristics desirable for pellets at high temperatures, it would be interesting to develop internationally accepted tests in order to be able to compare them. In the United States pellets were required to be strong enough to stand transportation.

Mr. LEUSCHNER mentioned that Peru had anthracite and was interested in preparing coke from it, with asphalt. He asked if anybody had had experience in producing briquettes with increased surface, in order to increase reactivity.

Mr. HESP mentioned that the National Board had experimented with briquettes of different shape. The pressure drop and the reactivity of coke were studied as a function of shape. He could supply the reference to those interested.

Mr. NIJHAWAN said that indiscriminate use of oil injection might not lead to useful results unless the blast temperature was increased or oxygen added. He also mentioned that the use of non-coking coals, at least for a small B.F., was interesting to developing countries. He said that the use of pellets must be studied carefully.

Mr. HESP remarked that the reduction of the coke rate to 150 kg/ton might be difficult because coke acted as a support for the burden. Regarding the strength of coke, he said that a compromise must be reached between shattering resistance and hardness. Results of research at Monroeville (United States) showed that the size of coke was a much more important factor than its strength. Size distribution control was also important for the ore.

Mr. TAHER thought that a B.F. with a 150 kg/ton coke rate was no longer a blast furnace: it would have to be constructed differently. Spectacular results could be attained in B.Fs, but they might not lead to good quality and low cost. Concerning high-pressure operation, he asked whether it was really economical to increase the top pressure when there were other ways of increasing B.F. production.

Mr. NEKRASOV stated that besides increasing production and decreasing flue dust, top pressure also induced economies, smoother operation and more regularity in the pig iron produced.

Mr. MAERTENS said that the problem in using very high pressures was mainly the blower; it must be of such special design that it might even be advantageous to go all the way and compress the air even more and use enriched blast. Regarding the use of higher pressures in B.Fs. already installed, he stated that there was no difficulty if the working pressure was not too high. He pointed out that it was necessary to use fully both the pressure and the contained heat of the gas, by utilizing specially designed turbines. One of these was now under test.

Mr. LEUSCHNER asked whether the utilization of the by-products of wood distillation was of any interest in Australia, since in Latin America it had been found out that it was not.

Mr. HESP said that the situation in Australia was similar to that in Latin America.

Mr. EKECHUKWU asked what factor contributed to successful operation of charcoal B.Fs. Mr. MILLER said that the moisture content was probably the most critical variable.

Mr. ASAD ALI mentioned the existence of a new process for the production of steel directly from ore. The process consisted in mixing finely ground ore and carbon, pelletizing and heating to promote reduction in an electric furnace. He also suggested that the United Nations should undertake a special study of direct reduction processes and of their applicability to developing countries.

Mr. WENZEL asked Mr. WIBERG what was the best process to prereduce iron ore, attaining iron contents of 60 to 70 per cent in order to export it to developed countries or to reduce it in blast furnaces with low coke consumption. He believed this presented an opportunity for developing countries. The process should be simple, have a high fuel efficiency and large capacity.

Mr. WIBERG said he has never heard of the process mentioned by Mr. ASAD ALI, but that other processes existed which used briquettes of iron ore and carbon, as described in his paper. It was possible to make steel directly from ore, but the heat required was high. The prereduction of ore mentioned by Mr. WENZEL might be interesting since its use in B.Fs. would lead to a better use of B.F. gas although it might not reduce coke rate much.

Mr. KASSEM asked if there was difficulty with the blowers in the Wiberg process. He also asked why the CO_2 content of the electric reduction furnace gas was lower when using lump ore than when self fluxing sinter was used, and why Fe_2O_3 could be reduced faster than Fe_3O_4 if during reduction Fe_2O_3 had to pass by Fe_3O_4.

Mr. WIBERG stated that there was no difficulty with the fan in the Wiberg process. Heat resisting alloys were used, working at about 800°C. The CO_2 content of the gas in electric furnaces depended very much on the reducibility of the ore or the sinter. The higher reducibility of Fe_2O_3 was due to the higher porosity occurring during reduction.

Mr. WOOD asked if the iron reduced below 570°C was always pyrophoric.

Mr. WIBERG answered that it was. It could be passivated either by heating to higher temperatures or by briquetting.

Mr. CHOUDHARY pointed out that the main feature of the S-L kiln was the fact that it had burners which rotated, enabling close control of temperature gradient and atmosphere, leading to low total fuel consumption.

Mr. MILLER said that Mr. ALI's suggestion for a United Nations study of direct reduction processes would be considered. He mentioned that as many as 50 patents were asked for each month on new direct reduction processes. The subject of direct reduction was one for which the answer had not yet been found, except in special situations.

Technical session "A.2"

BENEFICIATION AND CONCENTRATION

Prague

Wednesday, 13 November

Chairman: Mr. V. M. SUBRAMANIAN (ECAFE)
Secretary: Mr. A. STAKHOVITCH (CECA)
Rapporteur: Mr. R. MAYORCAS (United Kingdom)

Paper presented

"Standard methods of beneficiation and concentration — Blending, separating, sizing and agglomeration (A.4) by M. Nakatsuyama (Japan)
"Pelletizing" (A.5) by J. E. Astier (France)
"Krupp-Renn experience in Czechoslovakia" (A.6) by J. Mach (Czechoslovakia) and B. Verner (Czechoslovakia)

DISCUSSION

The importance of improving burdens in Japan was stressed by Mr. NAKATSUYAMA on account of the low supplies of home coke and of poor-quality ores. Hitherto ores from sands were considered uneconomic, but a big programme of beneficiation, developing methods suited to the granulometry of the sand and its magnetic nature, had made it interesting economically to stope these sands, where applicable. Paper A.4 included data on conditions required of the material which could help to decide the choice of the beneficiation method.

Mr. CORTES asked whether the deposits of 100 million tons of an average of 46 per cent iron but with 2 per cent sulphur would be interesting as an import to Japan. A complete answer could not be given without knowledge of the other constituents of the deposits, but it was implied that Japan would not be interested.

Mr. TAHER asked what happened to the titanium in the sand; and it was stated that providing there was less than 10 per cent of titanium dioxide, the material, up to 3 per cent of the total burden, could be charged to the blast furnace.

Mr. MAERTENS suggested that it was not possible to distinguish between the advantages of pelletizing and those of sintering and these should be considered as complementary and not opposing techniques. Experiments made in France showed an improvement when using 35 to 40 per cent of pellets with crushed ore in the burden, the CO_2 in the gas going up to 16 per cent. The choice usually depended on the Fe content of the respective material.

Mr. ASTIER spoke of the very rapid increase in the use of pellets in the last few years, although still amounting to only 10 per cent of sinter production. Good progress was being made in pelletizing ores which hitherto were considered uneconomical. A very important reduction in the fuel required for the process had been achieved by improved design. We compared the fuel requirements with the sinter process and showed that it was about half. It was not clear how advantageous pellets were over sinter on blast-furnace iron production. A curve of tons per day of iron output against diameter of furnace hearth showed points for pellets and sinter completely intermingled. With regard to cost, the recirculation load required to produce good sinter which could compete productionwise with pellets in the B.F. might well make the over-all production cost of pellets competitive.

Mr. MAERTENS said that the flue dust with pellet operation was more than twice that when operating with good sinter.

Mr. ASTIER replied that this depended on where the pellets came from and it was to be hoped that a large integrated works would make its own pellets on the spot, and the problem of dust should not arise. He gave details of experiments showing that the hot strength of pellets varied greatly with the manufacture and composition; but he looked forward to a self-fluxing pellet with

8-10 per cent self-fluxing gangue, which would be the final answer for the blast-furnace burden.

Mr. ASTIER said that the decision whether to sinter or pelletize might depend on the granulometry of the fines. Freeze is not required for pelletizing, and that this factor alone might play an important part in the decision.

Mr. TARMANN said that new designs of furnace for pelletizing machines would give better results and lead to a plant which could be installed as additional capacity to an already existing good sinter plant installation.

Starting with the two premises that some rich ore deposits would soon be exhausted and a rapid shrinking of coking coal reserves was to be foreseen, Mr. VERNER explained the growth of the Krupp-Renn process and described the new approach to the design of kiln and combustion control which had contributed largely to overcoming problems of slag control. The throughput of ore to make luppen had grown to 5.5 million tons per year in nine countries and this included sixteen units in Czechoslovakia making half a million tons a year of luppen from a throughput of 1.6 million tons of ore. Only a small part of this iron, particularly in Korea, was of low sulphur quality because of the favourable composition of the raw materials and therefore suitable for charging directly to electric furnaces making special steels, the rest of the world production of luppen with a range of 0.4-2 per cent of sulphur had to go to blast furnace.

Mr. TAHER asked why the method was necessary at all when there existed better beneficiation methods for the materials to be charged to the blast furnaces. A plant had been recently shut down in the Federal Republic of Germany, and in Pakistan a planned scheme for Krupp-Renn operations did not get past the experimental stage. There seemed to be a contradiction here.

Mr. VERNER said that the Krupp-Renn process was the best for ores in which the very fine grained iron oxide was very intimately mixed with the gangue and would require costly fine grinding to be suitable for agglomeration. The silicate ores also were particularly suitable for treatment by the Krupp-Renn process. There were successful plants working in the Federal Republic of Germany, but the variations in the price of scrap influenced the over-all economy. In Czechoslovakia the Krupp-Renn process was introduced to make use of home ores and low-grade reduction fuel — namely, brown coal semi-coke.

Mr. STAKHOVITCH noted that it was probable that the price of scrap, which was an important factor in feasibility considerations, would tend to remain relatively low in the foreseeable future for reasons of supply and demand.

Technical session "B.2"

DIRECT REDUCTION PROCESSES

Prague — Wednesday, 13 November

Chairman: Mr. B. LEUSCHNER (ECLA)
Secretary: Mr. T. B. WINKLER (United States)
Rapporteur: Mr. F. GROSSI (Argentina)

Papers presented

"Comparative evaluation of direct reduction processes" (B.4) by H. Poblete

"The SL direct reduction process" (B.5) by D. J. Hains (Canada)

"The HyL process" (B.6) by J. Celada (Mexico) and J. Skelly (United States)

"The Echeverria ore reduction process" (B.7) by G. Cedervall (Switzerland)

"The Strategic-Udy process" (B.8) by K. Sandbach (United States)

"The Purifier direct reduction process" (B.25) by L. von Bogdandy (Fed. Rep. of Germany)

DISCUSSION

Mr. LEUSCHNER recalled that direct reduction processes had two objectives: to obtain better quality steel and to be used in a small plant where the blast furnace was not justified. He hoped that studies under way would soon give successful results.

Mr. CHOUDHARY said that the data mentioned on the S-L process in the paper did not correspond to the figures published by Sibakin. Referring to table II, the size of the plant under reference was 100 tons per day and not 50 tons as given. The figures given in the same table for investment, cost, labour, and maintenance cost were higher than actual figures. Referring to table 12 the values given for power requirements and heat requirements were also higher than actual figures. S-L process required a power consumption of about 30 kWh/ton and the heat consumption was about 3.2 million kcal/ton sponge iron.

Mr. FISCHER noted that reference had been made to the fuel requirements of this process and it had been compared unfavourably to other processes. Reference should be made to Mr. HAIN's paper on the S-L process with regard to fuel requirements. The average figure was about 13.3 × 10^6 B.T.U. per net ton of metallic iron. He compared this with the figure used in Mr. WIBERG's paper, page 7, and Mr. POBLETE's table 12 (page 18). Table 11 was also in error.

Mr. WIBERG confirmed the heat consumption data given in million B.T.U./net ton, of the S-L process.

Mr. LEUSCHNER agreed that some confusion had arisen between the data furnished by Mr. POBLETE's paper and Mr. CHOUDHARY's statement; the data must be checked further.

Mr. CHOUDHARY said that a plant in Canada had shown that the heat consumption for S-L process was around 3.0 million kcal/ton sponge. However, a higher figure of 3.2 million kcal/ton was always quoted. The figure of 3.5 million kcal as given by Mr. WIBERG must be based on metallic iron the sponge. The greater part of the total iron in the sponge was in the form of metallic iron.

Mr. LOWNIE said that there were people interested in selling or buying D.R. plants. It would be better to have these problems studied as research without direct interest. Cost estimates of the plant passed through optimistic, realistic, pessimistic and actual costs phases. Many problems arise in passing from a pilot plant to a commercial one and the difficulties involved were often forgotten. It was necessary to be careful about optimistic costs given for new processes.

Mr. LOWNIE said that sponge-iron was not pig-iron and was not steel and was not steel scrap. Present processes for steelmaking needed adaptation to use sponge iron as a charge. Adaptation increased costs. Sponge iron could be cheap, but steel could be expensive. HyL did not make sponge-iron — it made partially reduced iron ore.

The charge to the steelmaking furnace was partially reduced ore plus some residual carbon. This led to two questions:

(*a*) On carbon content of steel — What was the statistical frequency with which HyL met specified carbon contents for a particular heat?

(*b*) Did Mr. SKELLY regard the consistency of quality and cleanliness of HyL steel as now produced, the equal of steel produced by conventional processes, say, in Texas?

Mr. SKELLY answered that he had no available data on carbon contents. As for the quality he did not know if steel produced in HyL was better or not than other steel produced in the United States or elsewhere: but it was good enough for HyL necessities.

Mr. KASSEM said that from the description of the process, it must be deduced that it worked under pressure, and asked how high the pressure was, and whether it caused operation troubles in view of the fact that it was a batch and not a continuous process. He also said that after steam reforming of the natural gas, the reformed gas was quenched which meant loss of large amounts of heat. Was this true or was it used in any other way?

Mr. SKELLY answered that the pressure was a little higher than atmospheric. Engineering details on the plant could be found in the literature. Secret details were only given to people who seriously intended to build a new plant. Ore reduction was 85 per cent of iron metal which gave no particular trouble. They always had drilling equipment on hand in the event of sticking.

Mr. GROSSI thought that HyL process would have some serious disadvantages with regard to purity of ore required, high investment and production costs, skilled personnel required for operation and maintenance and finally, difficulties in getting economic results in the electric steel furnace with a low cost of the final steel product.

Mr. SKELLY confirmed that the cost of melting was raised by the amount of material included (Al, Si, etc.). S could be removed almost totally in the process. As for the electric furnace operation he confirmed that sponge iron was charged as received from reduction plant.

Mr. EKECHUKWU asked if the operating difficulties could be anticipated in the HyL process. What was the point of "diminishing returns" in terms of output? What could be expected of the HyL process? What was the economic unit in terms of size?

Mr. SKELLY answered that operating disadvantages might be uniformity of iron to be supplied, skilled personnel for use and maintenance of control investments and to prevent damage to the equipment for excessive heating, sticking of material. The point of diminishing return had not been calculated.

U SOE MYINT, asked whether it could be feasible technically and economically to increase the percentage of HyL sponge iron (i.e. more than 60 per cent) in the steel-making furnace charge without affecting the performance and efficiency of the steel-making unit. Would it be economically worthwhile to consider utilization of sintered ores and producer gas as raw materials for the HyL process?

Mr. SKELLY answered that a charge of 100 per cent could be done and had been melted; of course costs went up for a longer time, there were more fluxes, etc. He thought that probably it would not be worthwhile to use sintered ores.

Mr. RAIMONDI asked how the electric steel plant would be operated with sponge iron, from a technical and economical standpoint? It seemed that sponge iron decreased ton/h production, so that sponge iron increased steel production costs also for refractory linings and electrodes and perhaps kWh.

Mr. SKELLY's answer to the first question was that production costs rose with sponge iron but it would not be used when hot metal or economic scrap was available.

Mr. GROSSI asked what was happening with investment costs and good operation in the retorts when passing to a 250,000 HyL plant and bigger retorts.

Mr. CEDERWALL answered that only large plant schemes had been done, until now, but retorts had been modified enlarging cross-sections from 1 ft to 4 ft.

Mr. LEUSCHNER asked Mr. WIBERG if he thought that silicon-carbon retorts (instead of stainless steel) could be made in under-developed countries.

Mr. WIBERG thought that they must be imported.

Mr. MYINT asked if arsenic could be removed in the production kiln.

Mr. Sandbach replied that in common practice As is removed like S.

Mr. Kassem asked if there was any trouble in electric furnace (costs, cooling, etc.) due to the preheating and prereduction. Mr. Sandbach explained the details of the operation of the electric furnaces and their automatic controls.

Mr. Johansson asked how much reoxidizing took place when discharging from the rotary kiln to the transport buckets, Mr. Sandbach answered that there was practically no reoxidation in charging transport buckets.

Mr. Halliday said that in relation to papers B.4 and B.6, he was interested in the references to integrating with electric steel making and continuous casting. He asked whether the Wiberg process and/or the HyL process could deliver hot reduced material to the steel-making units which might be considered as equivalent to a blast furnace (hot metal transfer) integrated operations. Were the costs shown in table 9 in paper B.4 and in table 4 in paper B.6 based on transfer of material in the cold to the steel-making units? If hot transfer were possible what would be the average temperatures of the reduced product in each case — Wibery and HyL? At what time intervals would hot transfer be possible? In the case of paper B.8 on the Strategic Udy process and in the film shown, the semi-reduced material was delivered hot from the kiln. Later it was fed to the electric ore unit. Mr. Halliday asked at what temperatures is it fed, and how hot could it be charged without the operation becoming too complicated.

Mr. Skelly answered that in the first HyL plant hot metal was transferred and charged at about 600°C as delivered. In the new, bigger plant the sponge was transferred cold.

Mr. Sandbach answered that the temperature was around 500°F. When going to 400 t/d production, it would probably result in an increase in temperature. He pointed out finally that the main advantage of the Udy process was to substitute part of the electric power required by the furnace with cheaper combustion elements in the kiln.

Mr. Wiberg made a statement on the H-Iron process. He said that this process operated on fine ores. Reduction was made by natural gas at high pressure 500 PS and low temperature 1000°F. Alan-Wood Steel Co. had a plant of 50 t/d and Bethlehem Steel Co. a 100 t/d plant. Costs were around $25 per ton of iron owing to the high cost of gas and low tonnage plant. With a 200,000 t/y plant cost could be lowered to $13 and to $10 after engineering improvements. The product must be protected from atmosphere before use. Product melted better in electric furnaces when charged either as briquettes or as powder.

Technical session "A.3"

SINTER PRACTICE

Prague — Thursday, 14 November

Chairman: Mr. F. M. Wiberg (Sweden)
Secretary: Mr. A. Lakhdari (Algeria)
Rapporteur: Mr. M. N. Dastur (India)

Papers presented

"Sintering — A general review" (A.7) by H. Lehmkuhler (Federal Republic of Germany)

"The production of high quality sinter" (A.8) by J. E. Greenawalt (United States)

"Sintering practice on a large scale" (A.9) by A. Rudkov (USSR)

"Sintering practice in continuous strand plants" (A.10) by G. Brandes and L. R. Choudhary (Federal Republic of Germany)

"Sintering practice — Operating results" (A.11) by F. Maertens (Belgium)

Discussion

Mr. Hesp inquired whether a certain amount of carbon in the sinter-mix was needed to achieve sintering, because this would mean that a greater quantity of low-temperature coal or high-volatile coal, low in carbon, was needed for sintering of a given charge than high-temperature coke. Also he asked about the effect of the volatile content of solid fuels on sintering, because of the evolution of tar, and if it was possible to use low-temperature fluidised char in sintering.

Mr. Brandes said that 10 to 20 per cent coal with volatile matter was used together with coke for the sinter-mix in the Saar District. Also low-grade coal from lignite worked very well at Watenstadt.

Mr. Lehmkuhler said that 70 per cent high-temperature coke breeze together with balance coal gave the same result in sintering as achieved with 100 per cent normal high-temperature coke.

Mr. Taher discussed the use of solid fuels in sintering (coke breeze, petroleum coke, anthracite and bituminous coals), and cited published literature where it was stated that the best results were obtained with normal coke breeze and the worst results with petroleum cokes. There was a problem of return fines at a Cairo plant when using additions of lime to the sinter charge. Therefore they used lump sinter in the blast furnace and they intended to remove the fines to produce iron directly in an electric smelting furnace and not to charge fine sinter to the blast furnace.

Mr. COLLIN inquired what work was being done to develop international standards for testing of sinter strength and what was the size of the sample for testing.

Mr. BRANDES replied that they normally tested the sinter in their laboratory by dropping it into a pan from a height several times, i.e., a shatter test. But they proposed to use tromel in a plant which was producing on a continuous basis. Regarding the question of return fines, he did not think it was disadvantageous to use a high proportion of return fines on the sinter bed itself.

Mr. WENZEL said that a group, of which he was head, was preparing a report on testing various aspects of sintering, i.e. mixing, ignition, strength, etc.

Mr. CHOUDHARY asked if cooling of sinter was now essential in the USSR, because previously it seemed they charged it hot.

Mr. NEKRASOV replied that the quality and strength of sinter was not only determined by the drum test, but it was also the granular size which determined the quality. He was of the opinion that it was better to have properly sized and screened sinter going to the blast furnace and this could not be done hot, therefore now they had cold-sinter charge.

Mr. DASTUR asked what was the best sinter cooler for large sinter plants. Regarding fuel for sinter he mentioned the problem at the Tata Steel Works in India where, owing to the difficult iron ore (very high in alumina) and low-grade fuel, i.e., coke breeze with about 28 per cent ash, the difficulty was solved by cutting down the proportion of coke breeze in the sinter-mix and having an extended hood operation with coke ovens gas firing.

Mr. BRANDES said that circular coolers might not be very practical for a very large production unit if sinter had to be carried on a belt to the furnace, and he would suggest the straight cooler or cellular cooler. Also he mentioned that there were 13 plants in Germany which had the extended hood operation with partial coke and balance gas firing.

Mr. MILLER referred to the electric pig iron furnaces and asked if sinter was as beneficial for this operation as in a blast furnace.

Mr. DASTUR said that the sinter was beneficial, but the benefit of sinter in an electric smelting furnace operation was not so great as in a blast furnace.

Mr. NEKRASOV said that in the USSR they used a 100 per cent self-fluxing sinter wherever possible, and do not use any raw limestone in the burden. They have no experience with electric pig iron furnaces, but the results of using 100 per cent sinter are very good, and he quoted examples of their 2,000 m^3 furnaces producing 3,000 to 3,650 tons per day.

Mr. COLLIN mentioned that they had experience in Norway with sinter in electric furnaces and they had improvement of power consumption from 2,500 to 2,000 kWh.

Mr. ILIEV inquired if anybody had experience with iron ore containing lead, and if it could be removed during sintering. He also asked about the effect of moisture in the concentrate used for pelletizing, and if there was excess moisture, how was it to be removed? He also asked about production of sinter with low FeO content which had low reducibility.

Mr. WIBERG answered that for good reducibility it was necessary to oxidize the sinter and therefore as little fuel as possible was used and the sinter time was prolonged.

Mr. BRANDES said that the lead was removed in the blast furnace if there were no big quantities. Also the moisture in the concentrate could be dried in a drying tromel.

Technical session "B.3"

DEVELOPMENTS IN AND COMPARISON OF STEEL-MAKING PROCESSES

Prague

Thursday, 14 November

Chairman: Mr. B. R. NIJHAWAN (India)
Secretary: Mr. M. A. ALI (Pakistan)
Rapporteur Mr. L. CORREA DA SILVA (Brazil)

Papers presented

"Comparison of steel making processes" (B.10) by the Economic Commission for Europe

"Open-hearth steel making with oxygen" (B.11) by M. Trotta (Italy) and B. Sommacal (Italy)

"Oxygen-lime steel-making practices" (B.12) by B. Trentini (France)

"The Kaldo process" (B.26) by F. Johansson (Sweden)

Discussion

Mr. Astier pointed out that in the decision for a new plant in a developing country there was a choice between a scrap-melting plant and a small integrated plant. In both cases there might be problems in which developed countries could help. In certain cases it might be interesting to resort to experimentation at well-established and experienced laboratories.

Mr. Fisher said that with regard to the future of the open-hearth, with improvements now being tried it might be possible in the future to reduce tap-to-tap times to about 2 hours. Flame control, injections, better refractories and improved charging methods might lead to productivities of 150 t/hr in 300 ton furnaces and 250 t/hr in 500 ton furnaces. When these levels of productivity were attained it was questionable that the L.D. would be much lower in investment and operating costs.

Mr. Mikhalevich called attention to the fact that the choice of process depended very much on local conditions. Thus the electric furnace could be interesting for a country with plenty of electric energy, and, of course, the open hearth would still find use too.

Mr. Krishnamachar asked Mr. Mikhalevich if he could make recommendations for a case where the P content of the hot metal was about 0.2 to 0.3 per cent. He also asked why L.D. steels were not yet accepted in some countries for uses like boiler tubes, shipbuilding plate, etc. Mr. Mikhalevich said that there was no difficulty in eliminating P contents as those cited.

Mr. Trentini answering Mr. Krishnamachar's second question said that L.D. steels were more and more avidely used for purposes mentioned.

Mr. Correa da Silva asked whether anyone present had had experience with the addition of solids (powders) in suspension in O_2 or air to the open-hearth.

Mr. Winkler related some experience acquired in his company. This has a 275 t OH with O_2 lances and injection of solids, and could inject fluxes (lime or limestone) and ore (fines or pellets). To do this there were two auxiliary lances next to each O_2 lance. Solids were moved by air pressure being injected at the same time as O_2, that is, from hot-metal charge finish to tap. The lance for solids was 2 ft. above the surface of the bath. It was possible to inject the total required flux or only part, as desired. It had been found that it was better to inject mixtures with the lime, so that this dissolved more readily. Pellets were better than ore fines, promoting faster CaO solution. Lime was better than limestone in so far as the heat time and solution rate of flux were concerned. Results obtained: gained about 40 minutes in relation to practice with O_2 but no solid injection. The final S was below 0.02 per cent and the practice was used for best quality sheet for deep drawing. For higher specified (S: 0.027 to 0.035) there was no advantage in the practice, since limiting the factor was then carbon and not sulphur removal. The use of solid injection causes savings in the amount of fluxes, but over-all cost of flux was higher since burnt lime had to be used. The plant was now evaluating the eventual economic interest of the method.

Mr. Stakhovitch called attention to the fact that comparisons made on the ECE and Kaldo papers were valid for specific economic conditions. It was necessary to review the data carefully before application to a developing country. Differences shown were very small, and small changes in the assumed conditions might even invert the comparison. It must also be remembered that the cost of labour was going to go up even in developing countries.

Mr. Trentini referring to earlier discussion said that IRSID experimented 6 years ago with CaO injection with O_2 in O.H. working in "scrap process". They wished to accelerate desulphuration but had no success. Early injection, before scrap was melted, gave thick slag. Injection had to be made only after the temperature reached 1,550-1,580°C, then causing a decrease in percentage S. Injection was made through the doors.

Mr. Hachette said that if the ore available had high S and P, it was better to concentrate it to eliminate at least most of the sulphur. The remainder could be further decreased by sintering (perhaps as self-fluxing sinter). If S remained in the hot metal, a desulphuration process should be used, perhaps the classical one of treating with Na_2CO_3.

Mr. Hachette also pointed out that for developing countries it was not necessary to use processes giving the best steel. Investments should be made in order to initiate progress, not necessarily to give the lowest operating cost.

Mr. Ali referring also the ECE paper commented that although the O.H. with cold charge might have little interest for Europe, it might be interesting elsewhere. Pakistan, for instance, intended to build a plant for melting imported scrap.

Mr. Mikhalevich said that in the case of impure ores enrichment by concentration was of course indicated.

Mr. Nijhawan stressed the necessity of studying carefully the processes recommended for developing countries. He pointed out that the USSR was prudent in the recommendation to India of oxygen converters, having in fact recommended O.H. He mentioned other developments, and stressed the necessity of studying them in the light of conditions existing in developing countries.

Mr. Musialek, referring to the experience related in paper B.11, of the use of O_2 in O.H., stated that a refractory consumption of 14 kg/t was not high. He asked what refractory was used for the roof and for the bottom.

Mr. Barnaba stated that the roof was magnesite and chromite, the bottom was dolomite. The duration of the lining was 230 heats.

Mr. Winkler noted in regard to refractory life in O.H. furnaces that practice at Bethlehem Steel Co. was to use basic roofs. Attention to certain points was essential. Lances should be carefully positioned above bath to decrease splash — roughly 3 to 4 inches from it. They should operate with excess of O_2 in waste gases: at least 5 per cent. Negative pressure should be insured: air should be drawn by the doors. The roof should operate at about 40°C less than for conventional O.H. with no O_2. Finally, the dimensions were important, the larger furnaces giving better life.

Mr. ROMANUTTI asked Mr. TRENTINI to clarify a point mentioned in his paper, relative to the efficiency of utilization of two converters.

Mr. TRENTINI answered that normally only one of two oxygen converters were used, the other being kept in reserve. The simultaneous operation led to difficulties with the O_2 supply and in the liquid-steel delivery.

Mr. ROMANUTTI asked whether two or three oxygen converters were recommended for a large plant of one million ton/year.

Mr. TRENTINI said that to attain one million tons, either two vessels of 110 tons or 3 of 50 to 60 tons were needed. The latter would be more convenient for continuous casting.

Mr. MIKHALEVICH said, regarding Mr. NIJHAWAN's comments that the USSR did not recommend an oxygen converter for Bihar because in 1955 their use was not yet firmly established, there were problems to be solved regarding the gas cleaning.

Mr. PETRMAN declared that the duplex process might be of interest in some cases. In order to save electric energy, duplexing might be interesting. Open hearth plus electric furnaces might be adapted to melt light scrap. However, there were disadvantages: more complex installation and the necessity of very good works organization. The combination of oxygen converters and electric furnaces might be attractive if there was enough hot metal.

Mr. ASAD ALI asked for clarification on gas purification in the Kaldo process.

Mr. JOHANSSON said Kaldo, like L.D., must have gas cleaning. The equipment needed was smaller and the cost was about half.

Technical session "A.4"

NON-INTEGRATED AND SEMI-INTEGRATED PLANT OPERATIONS

Prague

Thursday, 14 November

Chairman: Mr. W. MUSIALEK (Poland)
Secretary: Mr. F. C. COLLIN (Norway)
Rapporteur: Mr. M. N. DASTUR (India)

Papers presented

"Small steel plants — Their influence on developing countries" (A.12) by M. N. Dastur (India)

"The Canadian steel industry — A pattern of growth" (A.13) by W. K. Buck (Canada) and R. B. Elver (Canada)

"Growth pattern of the iron and steel industry in India's economic development" (A.14) by B. R. Nijhawan (India)

"Problems of steel plant expansion" (A.15) by W. Musialek (Poland)

"Economic considerations for steel plants in developing countries" (A.16) by W. T. Hogan (United States of America)

DISCUSSION

Mr. CORTES made a statement on the resources and raw materials availability for starting new steel plant in developing countries.

Mr. BUCK said that the developing countries had raw materials which could be used as a source of capital and for investment in local industry.

Mr. ABRERA asked Mr. BUCK the source of the capital for the investment in the Canadian steel industry amounting to $1,000 million since 1950.

Mr. BUCK replied that most of the financing was done from internal funds of the steel companies themselves, however, a very small part was foreign capital.

Mr. ABRERA asked Mr. HOGAN about the implications of postponing or delaying establishment of steel plants in developing countries and importing steel for the next five years.

Mr. HOGAN pointed out that he expected steel prices to drop since there was excess capacity in the steel-exporting countries today. He therefore recommended import of cheap steel for the present.

Mr. ASTIER inquired if small plants were suitable for both developing and already developed countries. He also asked about the possibility of making flat products economically on a small scale.

Mr. DASTUR said that the economic viability of small plants was equally valid for both developed and developing countries; also, it was possible to produce flat products on a small scale because of the advance of technology and aids, such as continuous casting and hot planetary mills which were available today. Regarding the question of postponing the construction of steel plants in developing countries, it was India's experience that they had made a mistake in making a decision in 1950 not to build a steel plant then. Steel was essential for the growth of any country, and therefore it was recommended that they go ahead with their steel programme.

Mr. LEUSCHNER said that the decisive factor for erection for a steel plant in a new country was the availability of raw materials. In Latin America it was the availability of a market. With low steel prices currently prevailing, countries would be well advised to postpone construction of a plant. He cited the table in paper ECLA.2. giving the time needed to amortize in a steel plant, and the foreign exchange component of the investment. The low prevailing price would make the time of amortization longer and certainly frighten some of the entrepreneurs thus, partially at least, following Mr. HOGAN's advice.

Unfortunately large quantities of steel were indispensable for economic development, and Mr. LEUSCHNER could not see from where the money would come. Even if steel was received on credit, it would never be sufficient or in time. All forecasts were that the terms of trade of Latin America would continue dropping, and even to maintain present import figures a considerable effort would be required.

It was necessary to have it clearly understood that what was pushing Latin America into making steel was not the desire of increased prestige of the countries, but the impatience of the masses of population for a better standard of living. The people would not wait until the errors of overplanning in European countries, Japan and USA were absorbed by the passing of a very long time.

Mr. HOGAN was of the opinion that the situation regarding availability of steel in 1950 was different from that in 1963. Also capital was tightening up, and he was merely advocating a middle course so that steel manufacture could be started by building the finishing facilities first.

Mr. SKELLY was of the opinion that supply of capital was difficult and it might be advisable to take the view of a financing institution before launching any new processes because they had to be convinced before obtaining financial approval early in the planning stage.

Mr. TAHER stressed the importance of arranging for training and management of steel plants in developing countries after they were constructed.

Mr. TARMANN thought that it might be better to exploit consumer goods industry in developing countries before launching on capital-intensive steel projects.

Mr. GROSSI agreed with this view of the important role of small steel plants in the developing countries and was of the opinion that the field of finished products, such as pipes and tubes, was of particular interest for developing countries. This was especially important because of the fact that developing countries generally had underground resources of oil and also required piping for water, gas and other domestic uses.

Technical session "B.4"

QUALITY FACTORS AND STANDARDIZATION

Prague — Thursday, 14 November

Chairman: Mr. J. A. BERGER (United States)
Secretary: Mr. O. MASI (Italy)
Rapporteur: Mr. L. CORREA DA SILVA (Brazil)

Papers presented

"Problems of quality in steel production" (B.13) by J. Pearson (United Kingdom)

"Steel standards and standardization on a country-wide basis" (B.14) by B. S. Krishnamachar (India)

"Steel standards and regional standardization" (B.15) by F. Aguirre (Chile) and A. Gomez (Chile)

DISCUSSION

Mr. PEARSON, in answer to a question, said that in bottom teeming only about 3 per cent of inclusions originated from refractories, 97 per cent originated in deoxidation. In answer to another question he said that he thought the minimum ratio of Mn to S for ordinary steels was about 8 to 1. Concerning the use of tar as mould coatings he mentioned work done at BISRA pointing to the fact as the metal filled the mould the heat decomposing the tar and the gas generated blowing away foreign materials from the ingot wall.

Mr. MAYORCAS called attention to the fact that steel quality depended not only on ingot quality but also on the 4 or 5 following steps from ingot to strip. Most defects originated in the latter, including the packing operation.

Mr. KRISHNAMACHAR asked if Mr. PEARSON could give information on the percentage of off-heats, in normal practice, when producing steel of B.S.15 specification.

Mr. PEARSON answered that this percentage varied from plant to plant and the information was not easily available.

Mr. MUSIALEK mentioned the possibility of improving steel quality by mixing O.H. with electric steel. He mentioned results obtained in Czechoslovakia with this technique. Intensive mixing leads to exceptional cleanliness. He asked Mr. PEARSON's opinion on the desirability of intensive use of deoxidizers.

Mr. WELLS asked Mr. PEARSON whether semi-skilled steels gave more trouble with seams, than skilled or rimming steels.

Mr. PEARSON stated that rimming steels give the least trouble; then skilled and semi-skilled, in that order.

Mr. BERGER, with regard to papers B.14 and B.15, asked how much money was actually saved as a consequence of the Indian work on specifications. He also asked whether tubular sections other than rounds, had been studied.

Mr. KRISHNAMACHAR answered that the work was too recent to know the practical savings for the nation as a whole. Certain sections were beginning to be rolled and India was studying other tubular sections (square and rectangular tubes).

Technical session "A.5"

IMPROVEMENT OR SUBSTITUTION FOR NON-COKING COALS

Prague

Friday, 15 November

Chairman: Mr. G. ANDREJEVIC (Yugoslavia)
Secretary: Mr. D. ROBSON (Madagascar)
Rapporteur: Mr. H. LEON (Honduras)

Papers presented

"The use of non-coking coals for iron-making operations" (A.17) by R Loison (France)

"Substitutes for coking coals in the blast furnace" (A.18) by M. Fine, J. de Carlo and E. Sheridan (United States)

"Substitutes for coking coals in iron ore reduction" (A.19) by H. R. Brown (Australia) and W. R. Hesp (Australia)

DISCUSSION

Mr. CHOUDHARY pointed out that Mr. HESP's document (page 9) was in error since the low temperature carbonization plant for lignites (from South Arcot) in Neyveli (India) was according to the Spülgar process and not by the Otto Company.

Mr. HESP asked about the characteristics of the semi-cokes used in French plants for blending with high-volatile coals in the manufacture of metallurgical coke.

Mr. LOISON replied that charging and exact regulation of temperature were important. Mr. LEUSCHNER made the following statement regarding developing countries: In Latin America, with the exception of Altos Hornos de Mexico at Monclova, Furdidora de Hierro y Accro of Monterrey, and Pas del Rio in Colombia, all plants used blends in their furnaces.

In the United States it was estimated that 90 per cent of the producers used blends and only 10 per cent straight coke. The manner in which the coal seams were encountered made modern methods of coal extraction rather difficult, and in the case of Chile coal was extracted from 7 km under the sea. The cost was in the neighbourhood of $20.00 per ton as against $18.00 imported from coke producers in the United States.

Brazil mined from seams that were 60 cm thick with 80 cm of shale in between and with 5 per cent sulphur. They had to resort to costly washing of which 50 per cent was used for blast furnace, 15 per cent for steam coal, and 14 per cent ore carbonaceous pyrites.

Mexican coal was mined easily, but was concentrated in the North, which created congestions in the rail transportations.

Mr. LEUSCHNER asked about the crystallography of coal before it was converted into coke. It was submitted to grinding followed by screening.

Mr. ANDREJEVIC referred to the case in Yugoslavia where they had plenty of lignite of which they used 30 per cent with 70 per cent imported coal. The burdens usually contained 50 per cent semi-coke and 50 per cent straight coke. In the burden he estimated that 10 per cent of the semi-coke had some rather high sulphur content. The primary reason for using local lignites was to save foreign currency as much as possible. Yugoslavia was happy to show any data regarding the lignite operation.

Mr. HESP inquired about the economics of hydrocarbon injection into the blast furnace. In Huachipato there had been some injections of hydrocarbons and also of oxygen. Recalling that the average price of coke was between $18 and $20 and petroleum had an international price of $20, Mr. HESP pointed out that the greatest advantage of fuel injection was lower cost and increased iron output.

Mr. NIJHAWAN made several comments on the use of non-coking coal in India. They had been used for low-shaft smelting, in electric furnaces, in pelletizing, and fines minus 1/2" for sintering. Completely non-coking product processed by low temperature carbonization, but highly reactive, was used in small blast furnaces. The ash content was lowered from 37 to 22-23 per cent for sintering. Briquettes made with such coals fluidized in experimental furnaces and thus their use was not suitable for the blast furnace. Cupolas had used oil introduced by spraying only.

Mr. ABRERA talked of the utilization of some lignites that they had next to their low-shaft furnaces. The poorest quality was used for thermo-electric power that was sold to a nearby town to aid the economy of the plant. Lignite was used of 20-30 mm and the fines were briquetted.

Mr. RENO said that the US Bureau of Mines would help on any problem. Blast furnace tests on briquettes were not always publicized, but they were available upon request. There were vast fields of lignites in the Dakotas of the United States and three comprehensive studies had been made, but the economics have been negative.

Mr. KASSAM asked whether the savings in dollars by fuel injection were limited to what was spared from the coke. Mr. LEUSCHNER cited the example in Huachipato and Mr. HESP said that the gain was in more and better iron.

Mr. ANDRIJEVIC pointed out that the low-shaft furnaces in Yugoslavia all used dry lignites. It was also used in pre-reduction to lower the kilowatt consumption from 2,200 to 1,600 per ton of pig. Yugoslavia had plenty of ore but no coke and semi-cokes are obtained out of dry lignites. They had ten furnaces with classical coke but also four low-shaft and would install five more electric ones with pre-reduction. The main point with them was economics.

Mr. EKECHUKWU wanted to know what "hot screening" was in a direct reduction that employed 50/50 lignite and bituminous.

Mr. CHOUDHARY replied that it was the "hot screening" of excess reducing agents at 800/900°C before charging the electric furnaces.

Technical session "B.5"

CONTINUOUS CASTING

Prague — Friday, 15 November

Chairman: Mr. M. L. ALLARD (France)
Secretary: Mr. B. S. KRISHNAMACHAR (India)
Rapporteur: Mr. P. P. MANIKAM (Ceylon)

Papers presented

"Continuous casting — Developments and current installations" (B.16) by I. M. D. Halliday (United Kingdom)

"Continuous casting — Present and future prospects" (B.17) by E. I. Astrov (USSR)

"The continuous casting of round sections" (B.18) by B. Termann (Austria) and W. Poppmeier (Austria)

DISCUSSION

Mr. J. PEARSON inquired whether work had been carried out to develop the S-type machine for the casting of 3-3/8 inch sections from five-ton ladles to the casting of wide slabs from 300-ton ladles and possibly in rimming steel.

Mr. HALLIDAY answered that it must be borne in mind that the S-type machine came into commercial production only in April that year. However, there were sufficient data available to indicate that no major difficulties were likely to be encountered in increasing the capacity of these machines. In was only a question of time.

Mr. WINKLER asked whether Mr. HALLIDAY anticipated any limitations of the curved-mould machines as compared with vertical-mould machines in regard to quality of the final product to be made. He also asked whether in order to consolidate the central porosity of continuously cast material by hot work, the required reduction of area was influenced by section size. For instance, for the same kind of final service, would a 9″ × 9″ billet require a different reduction of area from a 4″ × 4″ billet?

Mr. HALLIDAY said that as cooling was carried out in S-type machines to produce the same conditions as in the vertical moulds there were no particular problems with regard to skilled qualities. A 10 to 1 reduction in area was adequate to eliminate central porosity effects.

Mr. FISHER asked whether it was possible to cast rimming steel without degasing for sections up to 60 inches wide and 5 to 7 inches thick.

Mr. HALLIDAY answered that it had already been done. Experiments were being continued and rimming steel produced in vacuum in continuous casting machines had a great future.

Mr. TAHER asked if, according to specifications for the rolling of rails for instance, it was necessary to use ingots of not less than 4 tons in weight. This implied that there was a minimum required reduction in cross-section area. Was it feasible to do this in the case of billets from continuous casting machines?

Mr. TARMANN stated that from continuously cast slabs 200/250 mm rails had been rolled with reduction of area of 10 times. The properties of these rails were much higher than those produced from ingots.

Mr. KRISHNAMACHAR inquired whether there was an optimum, minimum tonnage for the installation of a continuous casting steel plant for it to be economical.

Mr. HALLIDAY explained that the economics of any plant depended on a variety of conditions and in particular of the specific country concerned. According to the data available and for the conditions in England, he would say that a continuous casting plant with an output of 50,000 ton/year would be more economical than the conventional process. There was also a relationship between the cost of steel produced by continuous casting and other methods. However, it might vary from 55 to 95.

Mr. ASTROV confirmed this and said that from data available in the USSR continuous casting plants had many advantages, even with outputs as low as 50,000 tons.

Mr. ALI asked whether there was any flexibility for varying the size of the sections to be produced in continuous casting machines and whether open hearth furnaces were suitable for operation with continuous casting machines.

Mr. HALLIDAY replied that a wide range of sizes could be cast in a continuous casting machine. This had to be decided at the very beginning. Increasing the range of sizes would necessarily involve additional investment and the cost of spares alone might amount to more than the cost of a second machine. It was preferable to have, say, two machines each with two or three strands rather than a single machine with six or more strands. The time taken for changing moulds etc. was relatively short and could be completed during the maintenance shift. Open-hearth steel was as good or better than electric furnace steel for continuous casting.

Mr. SHEROVER stated that according to figures furnished in some technical articles, savings ranging from $3 to $29 per ton had been cited. He wished to know why there was such a discrepancy.

Mr. HALLIDAY replied that savings depended on several factors, such as selling price, cost price, quality of steel etc. and therefore it was bound to vary widely.

Mr. SHEROVER inquired whether the relative advantages and disadvantages of the two types of pouring, that is bottom and lip, were significant.

Mr. HALLIDAY and Mr. ASTROV answered that there were advantages and disadvantages in both types of pouring and the subject is still being investigated.

Mr. U SOE MYINT asked how production could be kept going without interruption in case of a break-down of the C.C. machine?

Mr. HALLIDAY answered that the best solution would be to have two machines, either for two ranges of production; there could be a stand by if necessary. In an integrated steel works difficulties were likely to be encountered in steel-making operations in the rolling mills, and, of course, in the C.C. machine itself. However the chances of break-down with the former two were much greater.

Mr. DONALDSON asked what guarantee regarding quality and quantity of performance was given regarding the performance of the low-head machine.

Mr. HALLIDAY replied that when a contract was concluded such a guarantee was usually given. There were, of course, risks but very steadfast performance could be guaranteed.

Mr. DASTUR asked if very large slabs 1,500-2,000 mm wide could be cast in the curved mould.

Mr. TARMANN said that his company was now installing a C.C. machine for the production of slabs up to 500 mm. This plant was to be in operation by the end of January. By the end of May or June a further machine for the production of 1,500 mm-wide slabs was to be in operation.

Mr. SKELLY asked Mr. ASTROV about the differences in quality between vertical strands and incurved strands.

Mr. ASTROV said that from the technical data available to him from actual operation of these machines in the USSR, vertical moulds had given positive results whereas he was not in a position to say the same about inclined moulds.

Mr. ALLARD asked whether some trials were conducted with polygonal sections instead of round sections as both were suitable for forging purposes.

Mr. TARMANN answered that moulds were difficult to make for polygonal sections and some work had been carried out in that.

Mr. WINKLER asked if round sections were more applicable to producing forgings directly from continuous cast material than rectangular or square sections.

Mr. TARMANN wished to know from Mr. ASTROV whether non-metallic inclusions in continuously cast products occurred only when a tea-pot ladle was used.

Mr. ASTROV replied that it did not mean that bottom pouring was always good or the other method always bad. Only the possible advantages or disadvantages based on the data from research conducted in the USSR are referred to.

Mr. RAIMONDI asked what was the maximum round billet poured and then rolled to pipes. How many tons of pipes had been rolled from continuous castings and how high was the yield? With regard to the piercing operation, was it performed with the same elongation as working with rolled bars? Was the steel for pipe production elaborated from scrap or furnished from an integrated plant?

Mr. TARMANN said that the tube production was not carried out in their mills, but in Italy and Germany. Altogether 600 tons were produced and yield was approximately 10-15 per cent higher than in the case of rolled bars. As far as the steel is concerned it was both from scrap and iron.

Mr. ABRERA stated that blooming mills had been in operation in many parts of the world and therefore people were well acquainted with their operation and maintenance. C.C. machines were relatively new and therefore might be more difficult to operate and maintain. He wished to know whether the authors of the papers presented would recommend the introduction of C.C. machines in under-developed countries.

Mr. HALLIDAY repeated his earlier statement and emphasized that break-down in C.C. machines was less likely than in rolling mills or steel-making facilities.

Technical session "A.6"

ELECTRICITY IN THE STEEL INDUSTRY

Prague Friday, 15 November

Chairman: Mr. P. TRIANA (Colombia)
Secretary: Mr. I. A. M. HALLIDAY (United Kingdom)
Rapporteur: Mr. S. TAHER (United Arab Republic)

Papers presented

"Electric energy requirements for steel plants" (A.20) by H. W. Lownie, Jr. (United States) and H. E. Presnell (United States)

"Electric pig-iron smelting" (A.21) by H. Rekar (Yugoslavia) and J. Stare (Yugoslavia)

"Electric steel melting" (A.22) by G. Scotti (Italy) and F. Grossi (Argentina)

"Electric furnace steel production in Peru" (A.23) by E. Palacio (Peru)

"Progress in electric smelting furnaces" (A.25) by F. C. Collin (Norway)

DISCUSSION

Mr. PETRMAN asked for details and information about the type and operation of gas cleaning equipment on electric iron and ferro-alloy smelting furnaces.

Mr. COLLIN replied that the gas volume resulting from iron production was very low and that it was first scrubbed with water and then finally cleaned in disintegrators. After such cleaning it contained less than 0.05 gm/m^3 of solids. When ferro-alloys were produced in closed-top furnaces, the conditions prevailing were similar to those for iron production. When ferro-alloys were produced in open-top furnaces, the gases were neither collected nor cleaned, with the exception of very few cases where gas collection and cleaning was dictated by local sanitary regulations.

Mr. TAHER asked to what extent fines were tolerated in electric iron smelting furnaces and how they affected the furnace operation and performance. Mr. COLLIN replied that with submerged arc and cold charge operation it was advantageous to have as little fines (below 3 mm) as possible in the charge. This was particularly important for larger furnaces. The presence of fines in the charge in large amounts led to irregular operation, blows, hanging, high gas temperature and high power consumption. When the charge was preheated and pre-reduced in a shaft furnace prior to charging into the electric reduction furnace, the same rules applied, since the presence of fines hindered the shaft preheating furnace operation. On the other hand, if preheating and prereduction were carried out in a rotary kiln there was a greater freedom and the presence of fines was better tolerated in the furnace charge. When smelting iron ores in an open bath furnace, fines in the charge did not create a problem.

Mr. HALLIDAY asked for an indication of the range of power factors obtaining for individual units in electric iron smelting plants. Mr. COLLIN replied that the power factor depended on the size of the furnace; as the size increased the power factor decreased. It also depended on the voltage, which in turn was affected by slag volume and the characteristics of the reducing agent. Typical figures for power factors were 0.9 for 10 MW furnace, and 0.8 for 20 MW furnace.

Mr. HALLIDAY asked for indications of the maximum practical transformer capacity in relation to electric arc steel melting furnaces shaft diameter, for obtaining the highest possible production rates. Mr. GROSSI replied that in his experience a 15 ft. furnace could have a transformer capacity of 12,500 kVA and a charge of 50 tons, in spite of the fact that such a furnace size was usually designed with a transformer capacity of 8,000 and 10,000 kVA, and its nominal charge was 35 tons.

Mr. TAHER added that in his experience a 12-ton arc furnace which was normally designed for a 4,000 kVA operation gave very good performance when the transformer capacity was increased to 6,000 kVA, the production was increased by about 25 per cent and a roof life average of 130 heats.

Mr. TAHER then gave a short description of the Sinai pig-iron and ferro-manganese project, which would go into production in 1964. In the Sinai peninsula (United Arab Republic) there were several factors which led to the implementation of a small-scale, low-capital, high-return project. There was an abundance of low grade manganese ore fines which were not easily marketable; natural gas which was not being used; a low standard of living in the area; a need for standard ferro-manganese and pig iron inland.

The ore contained 18-20 per cent Mn and 30-33 per cent Fe and the natural gas was too little to pipe inland. The equipment of the plant consisted of a rotary kiln for preheating and prereduction; a 10 MW submerged arc reduction furnace; and a gas turbine power station.

The metallurgical process was to be as follows: The manganese ore would be selectively reduced in the furnace using an acid slag, thereby producing pig-iron and a manganese-rich slag, which was to be kept aside until a sufficient stock was created. Then the Mn-rich slag would be reduced in the furnace using a basic slag to produce 15 per cent ferro-manganese. It was estimated that the annual production would be 7,000 tons of standard ferro-manganese and 20,000 tons of pig iron.

Mr. GROSSI than asked whether it was technically feasible to use an iron-smelting furnace for the production of ferro-manganese.

Mr. COLLIN replied that it was feasible; however, for the production of ferro-manganese, the load should be reduced to 70 per cent of the normal furnace rating; the capacity of the furnace would similarly be reduced to 70 per cent of its capacity when producing pig-iron.

Technical session "B.6"

PROJECT PLANNING AND CONSTRUCTION

Prague

Friday, 15 November

Chairman: Mr. M. A. KASSAM (United Arab Republic)
Secretary: Mr. O. EKECHUKWU (Nigeria)
Rapporteur: U. SOE MYINT (Burma)

Papers presented

"Project planning and construction — Intermediate scale" (B.20) by M. Perez (Chile)
"Project planning and construction — Large scale" (B.21) by M. Gonni (Italy)
"Technical and economic feasibility planning for a small iron and steel plant" (B.19) by I. D. Dick (New Zealand) and T. Marshall (New Zealand)
"Problems involved in development of a steel plant" (B.22) by M. Allard (France)
"The iron and steel industry of Southern Rhodesia" (B.27) by W. Wells (Southern Rhodesia)

DISCUSSION

Mr. WATANASUPT inquired if it was economically justified to produce 180,000 tons of flat rolled products and if Mr. PEREZ could indicate the full capacity of the cold rolled sheet mill of Huachipato plant in Chile. Mr. PEREZ answered that it would be economical to install a four-high Steckel Mill for cold rolled sheets for an annual production tonnage of 180.000 tons of flat rolled products.

Mr. LEUSCHNER said that the statement made by Mr. ALLARD regarding the management and operational personnel was rather optimistic. In planning for personnel recruitment for an iron and steel industry, it would be necessary to take into consideration that a high percentage of the personnel trained abroad usually left the job. He suggested that the contractor firm should train the local personnel.

Mr. CORREA DA SILVA asked if there was any blast furnace operating partially with solid fuels other than coke and charcoal. He called attention, (with reference to the experience of some of the Latin American countries in developing their iron and steel industry), to the future evolution of the iron and steel industry in those countries and to some very important steps to be taken.

Mr. ALLARD, in reply to Mr. LEUSCHNER, said that Bhilai Steel Works in India had no difficulty with the personnel trained in Russia and working with the Russian machinery. He emphasized the importance of training the team at one place only. Regarding Mr. CORREA DA SILVA's question, he recalled the use of anthracite coal in blast furnace practice in some places and remarked that the need for metallurgical coke was less than it used to be, because of better techniques.

Mr. LOWNIE wanted to know the estimated amount of money already spent on or committed to the Venezuela Steel Work.

Mr. ABRERA inquired about the cost of average electrical energy used in the smelting furnaces and why open hearth process was selected for Venezuela Steel Progress.

Mr. GONNI replied that the amount of money already spent was $US 350 millions, 20 per cent of which was for the erection and another 20 per cent for the civil engineering and the remainder for the machinery and the transport facilities. In reply to Mr. ABRERA, he mentioned that the cost per unit (kWh) of electrical energy was about $3 mills (US). In the year 1959, the development of L.D. steel-making process was not in progress and therefore open hearth was selected.

Mr. MILLER stated that the Venezuela plant was, for the greater part, designed for 1.2 million ton capacity. Estimating 100 million dollars for completion, including a hot strip mill, the plant unit cost would be $375 per ton. Referring to the cost of building an integrated iron and steel complex, he pointed out that it would be difficult nowadays to build an integrated iron and steel plant at the cost lower than $US 300 per annual ton of ingot steel.

Mr. CORTES suggested that technical personnel as well as management should, quite often, exchange ideas and hold discussions with similar groups from foreign countries.

IV. INSPECTION TOURS

During the week of 18 to 23 November 100 members of the Symposium were divided into six groups, each of which visited representative sections of the iron and steel industry in a different country, Czechoslovakia, Federal Republic of Germany, France, Italy, Poland and the United Kingdom. The Symposium reassembled in Geneva on 25 November under the chairmanship of Mr. A. Denis (France), with Mr. M. Perez (Chile) as Secretary and Mr. L. Correa da Silva (Brazil) as Rapporteur. The members of the Symposium who took part in the tours reported their observations in detail and the Symposium recorded a unanimous vote of thanks to the sponsoring steel industry organizations in Czechoslovakia, the Federal Republic of Germany, France, Italy, Poland and the United Kingdom.

A factual summary of the inspection tours appears below.

INSPECTION TOUR IN CZECHOSLOVAKIA

Report presented by Mr. V. M. Subramanian

Group members (16): Messrs. BERRY (United Kingdom), CORREA DA SILVA (Brazil), FISHER (Canada), KUSUMADILAGA (Indonesia), MARQUES (Portugal), MASI (Italy), MATJIK (Indonesia), MISKOVIC (Yugoslavia), MOTTA (Brazil), MYINT (Burma), PALACIO (Peru), SANDBACH (United States), SKELLY (United States), SUBRAMANIAN (ECAFE), TREFIL (Austria), and WELLS (Southern Rhodesia).

Tour leader: Mr. V. M. SUBRAMANIAN.

Sponsoring organization: The Ministry of Metallurgical Industries and Ore Mining, Prague, Czechoslovakia.

Tour officers for host: Messrs. Jiří SKALA, Jan VACL, Frantisek KRUMNIKL and Antonin DITTRICH.

Facilities visited: *Nová Huť Klementa Gottwalda ("MHKG") Works* at Ostrava-Kuncice; *Vitkovicé Zelesárny Gottwalds ("VZKG") Works* at Ostrava; and the *Ejpovice Ore Mines, Krupp-Renn Plant and Research Institute* at Mníšek.

INSPECTION TOUR IN FEDERAL REPUBLIC OF GERMANY

Report presented by Mr. D. F. Anderson

Group members (11): Messrs. ALI (Pakistan); ANDERSON (ECE); ASTROV (USSR); BEALE (United Kingdom); BERGER (United States); BUCK (Canada); BURGESS (United Kingdom); LIORET (France); NADJM (Iran); NEKRASOV (USSR); and VERNER (Czechoslovakia).

Tour leader: Mr. G. F. ANDERSON.

Sponsoring organization: Wirtschaftsvereinigung Eisen und Stahl Industrie, Dusseldorf, Federal Republic of Germany.

Tour officer for host: Mr. E. G. LUEG.

Facilities visited: ***Demag Workshops*** at Duisberg; ***Mannesmann Huttenwerk*** at Huckingen; ***Stahl und Rohrenwerke Reisholz***; ***Max Planck Institute of Research*** in Dusseldorf; ***Hutten und Bergwerke Rheinhausen*** integrated steelworks; and the ***Krupp Apprentice Training School*** in Rheinhausen; ***F. Meyer Stahldraht und Rohrenwerke*** in Dislaken; and ***Gusstahlwerk Witten***.

INSPECTION TOUR IN FRANCE

Report presented by Mr. R. Muller [1]

Group members (15): Messrs. ANDREJEVIC (Yugoslavia); BRANDES (Fed. Republic of Germany); DICK (New Zealand); DOI (Japan); MULLER (ECE); MUSIALEK (Poland); NAKATSUYAMA (Japan); NITZA (Romania); PADBURY (United Kingdom); PESQUERA (Mexico); PRISECARU (Romania); ROMANOTTI (Argentina); TAHER (United Arab Republic); TRIANA (Colombia); and WARGANEGARA (Indonesia).

Tour leader: Mr. R. MULLER.

Sponsoring organization: Chambre Syndicale de la Sidérurgie Française, Paris, France.

Tour officer for host: Mr. J. HACHELIE.

Facilities visited: *Aciéries Réunies de Burbach-Eich-Dudelange (ARBED)*, at Belval, Luxembourg; *Société Métallurgique de Knutange*, at Knutange-Nilvange (Moselle); *Société Lorraine-Escaut*: iron ore mine at Angevillers, ore beneficiating plant at Metzange, coke ovens and roll foundry at Thionville; *Societe Lorraine de Laminage Continu (SOLLAC)*, steel melting plant and continuous hot strip mills; *De Wendel & Cie.*, new blast furnace plant at Jœuf; *Union Sidérurgique Lorraine (SIDELOR)*, sintering plant in Rombas; *Union de Consommateurs de Produits Métallurgiques et Industriels* (UCPMI) at Hagondange (Moselle); *Société des Aciéries de Pompey*, in Pompey (Meuthe-et-Moselle), and the laboratories of *Institut de Recherche de la Sidérurgie* (IRSID) at Maizières-lez-Metz.

INSPECTION TOUR IN ITALY

Report presented by Mr. I. A. Iliuschenko [2]

Group members (19): Messrs. CAORSI (Uruguay); COLLIN (Norway); CSEPES (Hungary); EKECHUKWU (Nigeria); HAJJAJI (Morocco); HESP (Australia); HOUDEK (Czechoslovakia); ILIUSCHENKO (ECE); KENYON (Southern Rhodesia); LATRANYI (Hungary); MAYORCAS (United Kingdom); NICOLACOPOULOS (Greece); N'GUEMA N'DONG (Gabon); PEREZ (Chile); SILVA (Brazil); TUN LIN (Burma); WENZEL (Fed. Rep. of Germany); WIBERG (Sweden); and WINKLER (United States).

Tour leader: Mr. I. A. ILIUSCHENKO.

Sponsoring organization: Associazione Industrie Sidérurgiche Italiana (ASSIDER) Milan, Italy.

Tour officer for host: Mr. F. BOCCALON.

Facilities visited: *Giuseppe & Fratello Redaelli*, a semi-integrated plant at Milano-Rogoredo; *Acciaierie e Ferriere Lombarde-Falck* in Milan; *Società Innocenti Workshops* near Milan;

[1] **Assisted by:** Messrs. NAKATSUYAMA, TAHER, TRIANA and WARGANEGARA.

[2] **Assisted by:** Messrs. HESP, KENYON, MAYORCAS, WIBERG and WINKLER.

Techint Engineering Company, design offices in Milan, *Società Leone Tagliaferri*, electric furnace workshops in Milan; *Instituto di Recherche Breda* in Milan, *Società Cosider*, design offices in Genoa; *Società Italsider's Cornigliano Integrated Steel Works* in Genoa; the *Divisione Siderurgica of Fiat*; the *Fiat Automobile Plant* and their *Apprentice Training School* in Turin. Also the *International Center for Advanced Technical Training* being erected by the Italian Government and equipped jointly with other Governments for the United Nations to provide technical training for personnel from developing countries.

INSPECTION TOUR IN POLAND

Report presented by Mr. B. Leuschner [3]

Group members (18): Messrs. ABRERA (Philippines); ALZUGARAY (Spain); ASTIER (France); CASS (United States); CHOUDHARY (Fed. Rep. of Germany); CORTES (Mexico); GOH (Singapore); GOODWIN (United States); HALLIDAY (United Kingdom); JOYCE (Canada); LAKHDARI (Algeria); LEUSCHNER (ECLA); MAERTENS (Belgium); MITCHELL (United Kingdom); RENO (United States); SHEROVER (Venezuela); STAKHOVITCH (CECA); and WOOD (United States).

Tour leader: Mr. B. LEUSCHNER.

Sponsoring organization: Ministry of Heavy Industry, Warsaw, Poland.

Facilities visited: *Huta Pokój*, integrated plant at Nowy Bytom; *Research Institute for Ferrous Metallurgy* at Katowice. *Huta Lenina* integrated steel works at Nowa Huta near Krakow; *Huta Warszawa*, producing special and alloy steels at Mlociny, near Warsaw.

[3] Assisted by Messrs. LAKHDARI, SHEROVER and WOOD.

INSPECTION TOUR IN THE UNITED KINGDOM

Report presented by Mr. G. F. Mikhalevich

Group members (21): Messrs. AGUIRRE (Chile); BASTOS (Brazil); ILIEV (Bulgaria); KAIGL (CID); KASSEM (United Arab Republic); KHLEBNIKOV (Comecon); KIDDLE (United Kingdom); KRISHNAMACHAR (India); LEHMKUHLER (Fed. Rep. of Germany); LEON (Honduras); LOWNIE (United States); MANIKAM (Ceylon); MAZANEC (Czechoslovakia); MIKHALEVICH (ECE); NIJHAWAN (India); CONJITT (Thailand); PLISHTIL (Comecon); RAIMONDI (Argentina); ROBSON (Madagascar); TEJADA (Bolivia); and WATANASUPT (Thailand).

Tour leader: Mr. G. F. MIKHALEVICH.

Sponsoring organization: British Iron and Steel Federation, London, England.

Tour officer for host: Mr. B. C. J. WATERS.

Facilities visited: *Thomas & Baldwins, Ltd., Spencer Works* at Llanwern, near Newport; *Wolverhampton & Birchley Rolling Mills Ltd, Osier Bed Works*, a non-integrated plant at Wolverhampton; *English Steel Corporation, Ltd., Tinsley Park Works* in Sheffield; *Hadfields Ltd., East Hecla Works* in Sheffield; *Park Gate Iron and Steel Foundry* in Rotherham; *Davy and United Engineering Co., Ltd.* workshops at Sheffield; and *British Iron and Steel Research Association (BISRA) Laboratories* in Sheffield.

V. CLOSING OF THE SYMPOSIUM AND ADOPTION OF ITS REPORT

The Symposium held its closing meeting on 26 November under the chairmanship of Mr. A. Denis (France) with Mr. A. A. Nadjm (Iran) as Secretary and Mr. L. Correa da Silva (Brazil) as Rapporteur. It adopted a provisional report on the discussions at the Prague sessions. The provisional report was afterwards circulated to delegates and their comments have been incorporated into the final report which appears below.

The Symposium was declared formally closed by the Chairman after final statements by Mr. Houdek, permanent Chairman of the Symposium, Mr. Miller, technical director, Mr. Muller, director and Mr. Kaigl, on behalf of the Centre for Industrial Development.

Final report

A. Scope of the interregional Symposium

The scope of the work of the Symposium was indicated at the opening session on 11 November. The importance of introducing or expanding sound iron and steel industry activities in developing countries was emphasized. The United Nations Centre for Industrial Development was deemed correct in judging that a meeting of experts from both developed and developing nations would be useful for a better understanding of the possible solutions of the problems involved. Attention was called to the conditions under which iron and steel industries evolved in the developed countries, and to the lessons therefrom that might be applied in developing countries.

The considerable advance of the steel industry in recent years was outlined, and it was noted that this had resulted in new opportunities for young nations, since that progress had facilitated the establishment of iron and steel plants under technical and economical conditions which a generation ago would have been prohibitive. It was agreed that the Symposium should be mainly concerned with the initial stages of iron and steel-making; namely, the preparation of raw materials and the processing of those materials to the ingot. The problems inherent in those phases of the iron and steel industry, however, made it necessary to discuss a number of general subjects connected with the development of ferrous metallurgical operations in developing countries.

The Symposium directed its attention to the above purposes and conditions, and the subjects that were examined included the following:

(*a*) Review of the current situation of iron and steel-making raw materials, and of the status of the industry in the different regions of the world;

(*b*) Presentation and discussion of technical problems and their solutions, in the light of new modern practices in the iron and steel industry;

(*c*) Consideration of certain general factors of special significance for the iron and steel industry of developing nations.

These topics were systematically considered in the fifteen technical sessions at Prague during the week of 11 to 16 November. This summary outlines the main ideas that were put forward in the prepared papers and during the open discussions which those presentations motivated. The details of the six inspection tours that were made during the week of 18 November to illustrate many of the points referred to in the documentation, are not considered. There were presented and reviewed during the sessions of 25 November.

B. The current situation of iron and steel-making raw materials and the steel industry in the different areas of the world

1. *Resources and exploration of raw materials*

Papers ECA.1, ECAFE.1, ECE.1, ECLA.1 reviewed the raw-materials situation in the various areas. Together, these documents present an up-to-date view of the raw-materials situation in those regions. The progress achieved in the past decade, the new problems which have arisen as old questions have been solved, and the differences among regions can now be better appreciated.

The increasing needs of the developed countries for raw materials afford an excellent opportunity for certain developing countries to exploit their resources and, through the sale and export of raw materials, to purchase and import the equipment necessary for domestic industries. However, raw materials specifications are becoming more and more severe, which makes it necessary to prepare and beneficiate even the traditionally "rich" ores. In many cases these must be treated today to optimize the over-all effectiveness of mining operations and to improve blast furnace productivity.

Capital investments needed for ore exploitation and beneficiation are very high, a problem which developing nations must face. The development of deposits in Canada, Venezuela, Peru, Brazil, Chile, Liberia and other countries may provide examples, or models for study by the developing countries. Transportation facilities are decisive for raw materials exploitation and extraction; this problem needs more detailed consideration than could be given to it within the limits of the Symposium.

2. *Present development and plans — iron and steel industry operations in different areas of the world*

Papers ECA.2, ECAFE.2, ECE.2, ECLA.2 indicated the main characteristics, problems and prevailing conditions of the steel industry in their respective areas. The differences in development among these regions were described in detail and with frequent comparisons. The many opportunities for co-operation which already existed between the developed and developing areas and those that may yet be established, were particularly impressive.

In their efforts towards industrialization, and specifically in the establishment or expansion of steel producing capacity, the developing nations are confronted with difficult problems, many of which are also common among the more advanced countries. The Symposium reviewed the main problems facing the developing nations. Among these the following were indicated: insufficient or inadequate reserves of raw materials, especially coking coal; lack of capital necessary for steel project investments; limited transportation facilities; varying and occasionally unstable economic conditions; lack of trained manpower in sufficient number; need for a broad product-mix in plants of relatively small capacity; difficulty in establishing initial capacity levels consistent with probable early expansion needs. Most of the developing nation representatives viewed an iron and steel industry as a basic requirement for the ultimate industrialization of their countries.

C. Presentation and discussion of technical problems and their modern solutions

1. *Exploration, exploitation and beneficiation of iron ores*

The over-all picture of ore supply for world needs was described as satisfactory despite the existence of deficiencies in certain countries where maximum utilization of low grade ores was necessary. In planning ore mine developments for export it must be remembered that a "buyer's market" might prevail for years.

The exploitation of ore deposits on large, intermediate and small scales was discussed, and the need for beneficiation was found to be a common characteristic for all three levels of operation. The basic problem was that of choosing the most suitable technology, both for mining and for ore treatment.

A thorough presentation of beneficiating practices currently used almost everywhere in the world was given in paper Sect.2. The choice of beneficiating process was shown to be determined by specific ore characteristics and economic factors which must be studied in every case. It was noted that, if necessary, many ores including those of very poor quality, might now be economically beneficiated and undesirable elements eliminated.

2. *Agglomeration of iron ores*

Agglomerating practice, and in particular sintering practice, was the object of several papers and of extended discussion. Sintering and pelletizing were considered as two complementary processes, with the factors for selection between them for a given application being: first, the characteristics of the ore; and second, the blast furnace requirements. The development of pelletizing techniques in recent years, together with the older sintering practice, gives today's steel industry a wide choice of methods for utilizing iron ore fines and "ultra-fines". Both techniques are subject to modification to suit particular local conditions. Further development of the two processes for increased efficiency is expected.

3. *Utilization of non-coking coals*

The papers reviewing the problems and solutions proposed for using non-coking coals indicated clearly that there were many interesting possibilities that might flow from research that was now being carried on with great intensity. At present, the classical coke oven process remains the best means for economical production of coke. But some important recent developments, supported by industrial experience, make possible the production of blast furnace coke from coals of poor agglutinating power, which previously were considered wholly unsatisfactory for coke production. This was seen as a prospect of the greatest importance for developing nations. It was indicated in the papers as well as in the discussions that such coals were already being used for special applications; for example, in electric reduction and low shaft furnaces, in sinter mixtures and in pelletizing.

4. *Blast furnace operations and developments*

The classical coke blast furnace is, and will continue for many years to be, the main facility for the reduction of iron ores, notwithstanding the interesting possibilities that other practices promise, if and when they are developed for commercial operations. This is because the search for new methods for reducing iron ore has been paralleled by remarkable new developments in blast furnace operations, which insure its continued use. The papers and discussions on this subject demonstrate that standard blast furnace practice is experiencing a revolution of its own that will widen its area of application and usefulness. Burden preparation, pulverized coal and hydrocarbon injection in the hearth region, higher blast temperatures, oxygen enrichment, high top pressure and other modifications justify the prediction made that the coke requirements to produce 1 ton of pig-iron may already be reduced to 450 kg, and even lower in the future. It is also considered possible that solid fuels other then metallurgical coke as known today may be used in the blast furnace of the future. There is no need to stress the importance of such developments to all steel producing countries and especially those which are in initial stages of industrialization.

5. *Special reduction processes*

Processes for the reduction of iron ores, other than the coke blast furnace, account for only a relatively small proportion of total world iron production. These procedures may all be considered "special reduction practices", some of which are in effective use for special conditions. Given suitable circumstances, the charcoal blast furnace offers distinct but feasible advantages in some of the developing areas, while the low shaft furnace may be of interest in other particular situations. Where electric power costs are favourable, the possibilities of electric pig-iron smelting units may also be interesting. In the latter case, thermal preheating and prereduction now under development may improve present levels of power consumption and iron producing capacities of the electric pig-iron furnace.

The technological development and industrial experience of many of the so-called "direct-reduction" processes were, in the judgment of the majority of the Symposium members, not yet satisfactory and their economic feasibility was still to be demonstrated. The utmost caution was urged in the selection of such special processes, which should be thoroughly studied in the light of the specific applicable conditions for any given case. It was agreed that certain special reduction processes which had been proved under specific circumstances might be recommended for comparable conditions of raw materials, fuel and energy supply, and market.

6. *Modern steel-making practices*

The new steel-making processes were discussed in great detail, with emphasis on the decisive role of oxygen in modern steel production practice. Capital cost and operating cost data were compared for a large number of the new steel production procedures. It was agreed that the choice of steel-making process depended on the technical, economic and raw material conditions prevailing in a given region, there being no one single process that might be considered suitable for all cases.

Although the oxygen converter stands out as one of the most promising process developments in recent years, improvements in open-hearth practice using oxygen are maintaining the competitive position of that process, especially in the larger shops. The flexibility of the electric steel-making furnace, with regard to size and applicability, gives this process special significance for smaller steel projects, especially where power rates are relatively low.

7. *Continuous casting*

The great technological advances in blast furnace and in steel-making practice are now being complemented by a change in steel-pouring practice which will also be a factor facilitating the development of iron and steel industry activities in developing countries, and in developed areas as well. Over 100 machines for continuous casting are now in operation or under construction, some of them quite large and with novel features. Installations for pouring sections as small as 2″ square and slabs as large as 60″ wide are already in operation. The smaller units are particularly interesting to the newly developing areas, for which the technique is adaptable in small plants with electric furnace or oxygen converter steel-making. Lower investment, reduced operating costs and good quality with simplicity of operation were indicated as some of the attractive features of this newest development. Except for balanced and rimming steels, most types of steel may be produced in continuous casting machines. The further development of the low-head "curved" mould machine, of which a prototype is already in operation at one plant, will broaden the applicability of the process.

8. *Steel quality*

This important topic did not receive as much attention as would be desired. It was nevertheless apparent from the discussions that some of the Symposium members felt that the requirements for steel quality in newly developing nations need not be so stringent as in the more developed ones since steel applications were simpler, at least in the first stages of industrialization. This view was challenged as a false hypothesis that could seriously delay the proper development of a steel industry in any country, newly industrialized or advanced. The need for maintaining high quality standards within the scope of acceptable steel specifications was stressed repeatedly.

It was pointed out that quality depended on the techniques applied in many individual stages of processing, in passing from ore to finished rolled product, the whole process being a complex one which required the greatest attention in plants of all sizes and for steel of all grades.

D. General factors of importance for the establishment of an iron and steel industry in developing countries

1. *Economic considerations*

Although the growth of an iron and steel industry may be closely related to social and economic development, decisions concerning new plants in developing nations cannot be taken on the basis of practical economic considerations alone. These must be tempered with factors which are not normally taken into account in developed nations. Nevertheless, it was agreed that the economic viability of a project must, in the long run, be considered a most important element.

In view of the large investments necessary and the projected growth of the steel industry in new nations during the next ten or fifteen years, the problem of financing is one of the most difficult that has to be faced. This question, although raised a few times during the Symposium, could not be adequately discussed within the established scope of the programme.

2. *Planning of new steel plants in developing nations*

This subject received repeated attention in several of the Symposium's technical sessions. The importance of iron and steel operations and their effect on the economic growth of a new nation may frequently require governmental action to facilitate the establishment of such an industry. This is especially true in regard to services and transportation of raw materials and products. Several symposium members indicated interest in the centralized planning methods employed in the iron and steel industries of certain countries. Others noted that private interest and public support must be solicited and invited to participate in the development and management of the industry.

It was generally agreed that small plants might be wholly justified in developing nations. They could even be justified in developed nations if their production was of a specialized nature, or if they served a small or isolated market.

The need for a wide range of products is almost always present when planning a new plant for young nations. This increases capital charges and operating costs somewhat but cannot always be avoided. The establishment of a steel industry in new countries may require the installation of integrated plants, since the supply of scrap is usually very limited. But this is not always necessary. There can be no rule in such matters and each case must be examined separately. In all cases, however, careful planning of all phases of steel plant design, construction and operation is essential, as indicated in paper SECT.3. A careful selection of experienced advisers from developed countries is recommended. The members of the local staff working with these advisers must also be chosen with care.

One of the questions to be decided when planning a steel plant for a newly developing country is that of the initial capacity to be installed. It is a problem that must be very carefully considered since inadequate judgments may create serious difficulties later. The peculiar conditions prevailing in most new nations must also be carefully weighed and solutions for future expansion planned well in advance. There are already far too many examples of poor planning available, particularly with respect to inadequate market, improper process selection, insufficient transportation and services facilities, and unrealistic financial projections. By emphasizing the need for giving careful attention to such problems, the Symposium members did not intend to paint a picture of insurmountable obstacles; instead such comments were made to underscore the utility of past experiences of developed countries which might become available to the newly industrializing nations.

It was noted that the lack of a great sufficiency of raw materials does not preclude the establishment of an iron and steel industry in developing areas. Examples of countries which depend on imports for their raw materials are numerous and well known. The primary factor for the creation of a steel industry is not the availability of raw materials but the existence of a market. Newly industrializing nations generally have unfavourable terms of trade and thus cannot entirely depend on imports for all their steel requirements, even during periods of overproduction and falling prices in the developed countries.

The possibility of installing second-hand equipment in steel plants in developing areas should be carefully considered, although the choice and the rehabilitation repair of such equipment may require the greatest care. When suitable facilities can be found, capital investment may be reduced considerably.

For developing nations already having a relatively large steel industry, as is the case of India and Brazil, the next stage of steel industry development should include planning means for domestic production of heavy equipment and machinery, including facilities for steel plant operations.

3. *Training and education*

Countries in early stages of industrialization should devote great attention to technical education and training on all levels related to production. This obviously also includes the preparation of personnel for iron and steel operations. The efforts and the success of such programmes in India and in Brazil, the training centre in Milan, Italy, and the experiences outlined in paper B.24, can serve as examples that may be followed with benefit.

It was emphasized, however, that the use of training programmes, especially in foreign countries, must be tempered with the greatest caution in the choice of trainees to avoid the dangers of incorrect attempts to apply inapplicable solutions to local conditions, after returning to their home countries.

4. *Research*

This topic was touched on only briefly during the meetings. The importance of technological research, applied to the solution of existing problems in developing nations, cannot be sufficiently emphasized. The question of clearly defined research programmes deserves full attention in future regional and interregional gatherings, comparable to the present Symposium. The availability of existing research centres in developed countries for research and training activities on behalf of the developing countries, was noted.

5. *Regional integration*

The subject of regional integration is receiving special attention within several newly developing regions. The matter was discussed in a single paper and unfortunately no full discussion was developed. However, the problem was analysed for the Latin American region, and the many advantages and problems of industrial integration were demonstrated. The question clearly requires further discussion in the near future, since the matter of subregional action by newly developing countries appears to be exciting increasing attention, especially in Africa. Examples of the recent meeting in West Africa and the recurring references to a Maghreb association in North Africa were cited.

6. *Standardization and steel standards*

The development of a programme of regional standardization for steel was described in a paper outlining the recent efforts in this field in Latin America. The procedure adopted by the Latin American countries for training of standards engineers, and for the formulation of Pan American steel standards was recommended for consideration by other developing countries. The experiences in a single country were discussed in another paper on the steps taken in India. Both papers stressed the need for a high priority for undertaking logical steel standardization programmes on national and regional bases.

E. THE INTEREST OF, AND ASSISTANCE BY, UNITED NATIONS ORGANIZATIONS

The United Nations, through many of its agencies, has for many years stimulated directly and indirectly the study of steel industry problems in developing countries. Since December 1961, means have been established for a concerted effort to provide every form of industrial assistance to developing countries through the formation of the Committee of Industrial Development and its functional arm, the Centre for Industrial Development.

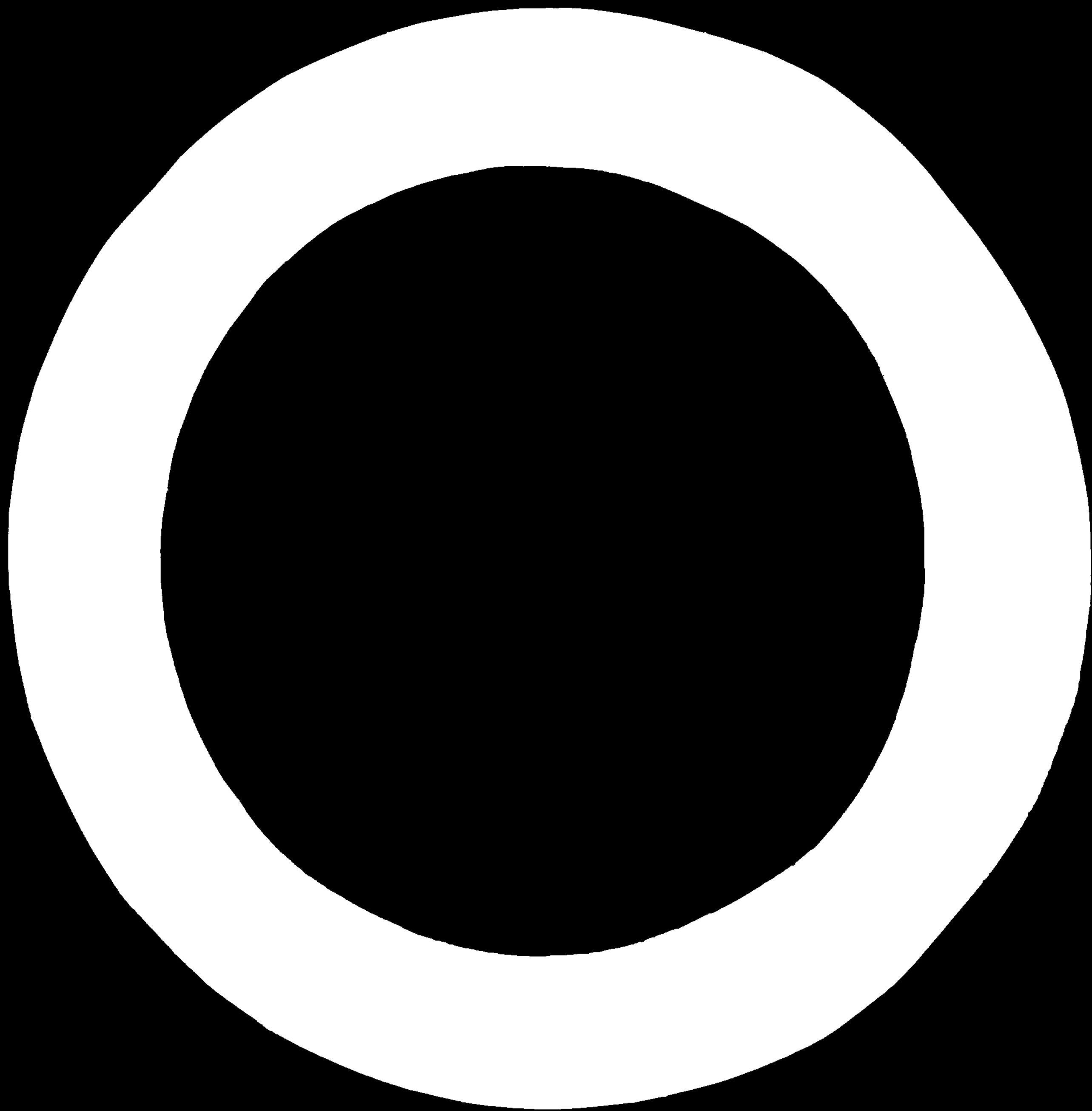
The activities of ECE and of ECLA in the field are well-known and, more recently, those of ECAFE and ECA are following comparable paths.

The ILO Iron and Steel Committee is concerned with a wide range of subjects related to technological developments and their influence on the structure of remuneration, organization of work, vocational training and safety in the iron and steel industry. Information and advice on such questions are available for use as guidelines by governments, employers and workers involved in the transition within the iron and steel industry to new production methods.

Initiated as part of the work programme of the Centre for Industrial Development, this Symposium has brought together steel experts from all over the world to exchange experiences and problems in their respective iron and steel industry efforts. It will be remembered as a landmark in international technical co-operation. Some members expressed the hope that this would be only the first of a continuing series of such meetings.

During the Symposium various announcements and suggestions were made regarding future United Nations activities intended to benefit the development of iron and steel industries in newly industrializing nations. The Symposium was informed that the ECE Steel Committee had included in its work programme a study of the world market for iron ore and of prospective world trade and demand of steel. It was also noted that through this Symposium, the Centre for Industrial Development would be better recognized by all member countries of the United Nations as an agency which was qualified and ready to help young nations with advice on their iron and steel industry problems. There was a suggestion from one participant that the United Nations promote an extensive study of special reduction processes and their possible usefulness for developing nations.

The recent designation by the United Nations of 1965 as the year of "International Co-operation" gives rise to the thought that such a year would be an appropriate occasion for another exercise comparable to this present Symposium, on steel industry questions of equal importance for developed and developing countries. It is the expressed opinion of the Symposium that the high level of the papers presented and the content of the discussions which they engendered at these meetings, demonstrate the utility of future gatherings of this nature to all countries, and especially to the developing nations.



ANNEXES

ANNEX I

Break-down of countries represented at the Symposium

Developing nations* — *Region and country*	No.
AFRICA	
Algeria	1
Gabon	1
Madagascar	1
Morocco	1
Nigeria	1
Southern Rhodesia	1
MIDDLE EAST	
Iran	1
United Arab Republic	2
ASIA AND FAR EAST	
Burma	2
Ceylon	1
India	4
Indonesia	3
Pakistan	1
Philippines	1
Singapore	1
Thailand	2
LATIN AMERICA	
Argentina	3
Brazil	4
Bolivia	1
Chile	2
Honduras	1
Mexico	2
Peru	1
Uruguay	1
Venezuela	1
EUROPE	
Greece	1
Portugal	1
Spain	1
Yugoslavia	3
TOTAL 29 countries (58 per cent)	46

Developed nations* — *Region and country*	No.
ASIA AND FAR EAST	
Australia	1
Japan	2
New Zealand	1
EUROPE	
Austria	2
Belgium	1
Bulgaria	4
Czechoslovakia	4
Federal Republic of Germany	7
France	6
Hungary	2
Italy	3
Netherlands	1
Norway	1
Poland	2
Romania	2
Sweden	2
Switzerland	1
United Kingdom	11
USSR	2
NORTH AMERICA	
Canada	3
United States	10
TOTAL 21 countries (42 per cent)	66

ORGANIZATIONS

Name	*No.*
CECA	2
COMECON	2
ILO	2
OAS	1
4 organizations	7

TOTAL ATTENDANCE	126** from 50 countries

* A "developed" country is defined arbitrarily as one with an annual *per capita* steel consumption of 100 kg or more. Basis for division: *Estimates by Centre for International Studies of Massachusetts Institute of Technology, for 1961.*

** Includes secretariat staff of 9.

Annex II

List of participants

(Names of Symposium officials for the United Nations and related organizations are marked with an asterisk)

Abrera, Bernardo P.
General Manager,
National Shipyards and Steel Corporation
Manila, Philippines

Aguirre Tupper, Fernando
Secretary General,
Instituto Latinoamericano del Fierro y el Acero (ILAFA)
Santiago, Chile

Ali, Mir Asad
Deputy Director (Steel),
Department of Investment Promotion Supplies
Government of Pakistan
Karachi, Pakistan

Allard, Marc-Louis
Directeur Général,
Institut de recherche de la sidérurgie (IRSID)
Saint Germain-en-Laye, France.

Alzugaray, Juan José
Ingénieur industriel,
Altos Hornos de Vizcaya
Bilbao, Spain

* **Anderson**, Dieter F.
Economic Affairs Officer,
United Nations
Economic Commission for Europe
Geneva, Switzerland

Andrejevic, George
Secretary-General,
Yugoslav Iron and Steel Federation
Beograd, Yugoslavia

Astier, Jacques Emile
Ingénieur en chef,
Institut de recherche de la sidérurgie (IRSID)
Maizières-lez-Metz, France

Astrov, Eugene Ivanovitch
Central Research Institute of Iron and Steel
Moscow, USSR

Balla, Ladislav
Chief of Section,
Mining and Non-Ferrous Metallurgy
Ministry of Metallurgical and Ore Mining Industries
Prague 2, Czechoslovakia

Barnaba, Amor Teo
Manager, Documentation Service,
COSIDER
Genoa, Italy

Bastos, Eurico Alves
Superintendent of Operations,
Companhia Siderurgica Nacional
Volta Redonda, Brazil

Beale, Colin Ogden
Assistant Research Manager,
Head Wrightson and Co., Ltd.
Teesdale Iron Works
Stockton-on-Tees, United Kingdom

Berger, J. Alfred
Chairman of Department and Professor of Metallurgical Engineering,
University of Pittsburgh
Pittsburgh, Pennsylvania, USA

Berry, Richard William
Deputy Head,
Technical and Development Department
British Iron and Steel Federation
London, S.W.1, United Kingdom

Bichler, Antonin
Engineer,
Steel Research Institute
Trinec, Czechoslovakia

Blaszezak, Jozef
Ministry of Heavy Industry,
Warsaw, Poland

Brandes, Gunther
Director,
Lurgi Gesellschaft für Chemie und Huttenwesen m.b.h.
Frankfurt/Main, Federal Republic of Germany

Buck, W. Keith
Chief,
Mineral Resources Division
Department of Mines and Technical Surveys
Ottawa, Canada

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ANNEX III

List of papers presented at the Symposium

COMM. 1	Statement by Commissioner Abdel-Rahman
SECT. 1	"The Modern Iron and Steel Industry", by Centre for Ind. Devel.
SECT. 2	"Raw Materials and their Preparation", prepared for Economic Commission for Europe
SECT. 3	"Problems Arising from the Establishment and Development of the Iron and Steel Industry in Developing Countries", by the United Nations Economic Commission for Europe
ECA 1	"Raw Materials in Africa for Iron and Steel Manufacturing", by the United Nations Economic Commission for Africa
ECAFE 1	"Availability of Raw Materials for Iron and Steel-Making in the ECAFE Region", by the United Nations Economic Commission for Asia and the Far East
ECE 1	"Trends in Production and Consumption of Iron and Steel Making Raw Materials in Europe and the United States", by the United Nations Economic Commission for Europe
ECLA 1	"Steel Making Raw Materials in Latin America General Situation" by the United Nations Economic Commission for Latin America
ECA 2	"The Iron and Steel Industry in Africa", by United Nations Economic Commission for Africa
ECAFE 2	"Review of the Iron and Steel Industry in the ECAFE Region", by United Nations Economic Commission for Asia and the Far East
ECE 2	"Present and Future Trends of Production and Consumption of Pig Iron and Crude Steel in Europe and the United States"
ECLA 2	"The Iron and Steel Industry of Latin America", by United Nations Economic Commission for Latin America
A 1	"Exploration of a Small Iron Ore Deposit", by J. Caorsi (Uruguay) and O. Boesi (Uruguay)
A 2	"Ore Exploration and Exploitation Intermediate Scale", by R. Wasmuht and R. Tschoepke (Fed. Rep. of Germany)
A 3	"Ore Exploration and Exploitation on a Large Scale", by H. Reno (USA)
A 4	"Standard Methods of Beneficiation and Concentration Blending, Separating, Sizing and Agglomeration", by N. Nakatsuyama (Japan)
A 5	"Pelletizing", by J. A. Astier (France)
A 6	"Krupp-Renn Experience in Czechoslovakia", by J. Mach (Czechoslovakia) and B. Verner (Czechoslovakia)
A 7	"Sintering — A General Review", by H. Lehmkuhler (Fed. Rep. of Germany)
A 8	"The Production of High Quality Sinter", by J. E. Greenswalt (United States)
A 9	"Sintering Practice on a Large Scale", by A. Rudkov (USSR)
A 10	"Sintering Practice in Continuous Strand Plants", by G. Brandes and L. R. Choudhary (Fed. Rep. of Germany)
A 11	"Sintering Practices Operating Results", by P. Maertens (Belgium)
A 12	"Small Steel Plants Their Influence on Developing Countries", by M. N. Dastur (India)
A 13	"The Canadian Steel Industry — a Pattern of Growth", by W. K. Buck (Canada) and R. B. Elver (Canada)
A 14	"Growth Pattern of the Iron and Steel Industry in India's Economic Development", by B. R. Nijhawan (India)
A 15	"Problems of Steel Plant Expansion", by W. Musialek (Poland)
A 16	"Economic Considerations for Steel Plants in Developing Countries", by W. T. Hogan (United States)
A 17	"The Use of Non-Coking Coals for Iron-Making Operations", by R. Loison (France)
A 18	"Substitutes for Coking Coals in the Blast Furnace", M. Fine, J. de Carlo and E. Sheridan (United States)
A 19	"Substitutes for Coking Coals in Iron Ore Reduction", by H. R. Brown (Australia) and W. H. Hesp (Australia)
A 20	"Electric Energy Requirements for Steel Plants", by H. W. Lownie, Jr. and R. E. Presnell (United States)
A 21	"Electric Pig Iron Smelting", by M. Rakar and J. Stare (Yugoslavia)
A 22	"Electric Steel Melting" by G. Scotti (Italy) and F. Grossi (Argentina)
A 23	"Electric Furnace Steel Production in Peru", by E. Palacio (Peru)
A 24	"Iron Ore Exploration and Exploitation on a Large Scale", Liberia, by A. Nomalu Massequoi (Liberia)
A 25	"Progress in Electric Smelting Furnaces", by F. C. Collin (Norway)
B 1	"Technical Progress in the Production of Pig Iron in Blast Furnaces", by V. G. Voskoboynikov (USSR)
B 2	"Charcoal Blast Furnace Operations", by A. Constantine (Australia)
B 3	"General Review of Direct Reduction Processes", by F. N. Wiberg (Sweden)
B 4	"Comparative Evaluation of Direct Reduction Processes", by E. Poblete (Chile)
B 5	"The SL direct Reduction Process", by D. J. Hains (Canada)
B 6	"The Hyl process", by J. Celada (Mexico) and J. Skelly (United States)
B 7	"The Echeverria Ore Reduction Process", by G. Cedervall (Switzerland)
B 8	"The Strategic-Udy Process", by K. Sandbach (United States)

B.10	"Comparison of Steel Making Processes", by the United Nations Economic Commission for Europe
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B.12	"Oxygen-Lime Steel Making Practices", by B. Trentini (France)
B.13	"Problems of Quality in Steel Production", by J. Pearson (United Kingdom)
B.14	"Steel Standards and Standardization on Country-wide Basis", by B. S. Krishnamachar (India)
B.15	"Steel Standards and Regional Standardization", by F. Aguirre (Chile) and A. Gomez (Chile)
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B.17	"Continuous Casting — Present and Future Prospects", by E. I. Astrov (USSR)
B.18	"The Continuous Casting of Round Sections", by B. Tarmann (Austria) and W. Poppmeier (Austria)
B.19	"Technical and Economic Feasibility Planning for a Small Iron and Steel Plant", by I. D. Dick (New Zealand) and T. Marshall (New Zealand)
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B.21	"Project Planning and Construction - Large Scale", by M. Gonni (Italy)
B.22	"Problems Involved in Development of a Steel Plant", by M. Allard (France)
B.23	"Regional Integration of the Steel Industry in Latin America", by F. Aguirre (Chile)
B.24	"Training of Engineers and Operators for New Steel Operations in Developing Countries", by J. A. Berger (United States)
B.25	"The Purofer Direct Reduction Process", by Ludwig Von Bogdandy (Fed. Rep. of Germany)
B.26	"The Kaldo Process", by F. Johansson (Sweden)
B.27	"The Iron and Steel Industry of Southern Rhodesia", by W. Wells (Southern Rhodesia)
B.28	"The Use of Charcoal in Blast Furnace Operation", by Food and Agriculture Organisation of U.N.
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DS-2	Discussion summary, "Problems Arising from the Establishment and Development of Iron and Steel Industries in Developing Countries"
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SUMMARY I	Final summary report

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