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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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REPORT OF THE SECOND INTERREGIONAL IRON AND STEEL SYMPOSIUM

MOSCOW, 1968

UNITED NATIONS

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
VIENNA

REPORT OF THE SECOND INTERREGIONAL IRON AND STEEL SYMPOSIUM

held in Moscow, 19 September - 9 October 1968

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Foreword

1. The First Interregional Symposium on the Iron and Steel Industry was held in Prague and Geneva in November 1963. The proceedings of this symposium were published in 1964.1/

2. Since its inception in January 1967, the United Nations Industrial Development Organization (UNIDO) has paid particular attention to the development of iron and steel industries in developing countries. Experts have been supplied through UNIDO to assist developing countries in a wide range of tasks, from the development of ore bodies to setting up quality control systems for rolling steel plates. In the non-operational field, UNIDO organizes supporting activities such as studies, expert group meetings and symposia. The Symposium on Industrial Development held in Athens in December 1967 paid considerable attention to the iron and steel sector. The problems facing developing countries in developing their iron and steel industries, however, require detailed consideration. UNIDO therefore made the necessary arrangements to include the Second Interregional Symposium in its programme of supporting activities.

3. The Second Interregional Symposium on the Iron and Steel Industry on "Techno-economic Principles on the Development of Iron and Steel Industries in Developing Countries", organized by UNIDO in co-operation with the Government of the Soviet Union, was held in Moscow from 19 September to 9 October 1968.2/

4. The purposes of the symposium were:

(a) To assist developing countries with the experience of industrially developed countries in the establishment and development of their iron and steel industries;

(b) To exchange information between countries on recent technological improvements in the iron and steel industry and also on the present

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1/ Proceedings, United Nations Interregional Symposium on the Application of Modern Technical Practices in the Iron and Steel Industry to Developing Countries, 155 pp., United Nations Publication, Sales No. 64.II.B.7.

2/ Selected proceedings are being prepared for publication in 1970.

status, potential possibilities and long-term plans for the development of the iron and steel industry in developing countrie as well as the present and future trends in the world steel trade;

(c) To discuss the prerequisites for the development of the iron and steel industry on a national and regional basis as well as to determine the optimum capacity of iron and steel plants, economic analysis, reconstruction and modernization in the iron and steel industry.

5. The conclusions and recommendations of the symposium are presented in Chapter I. The report is organized according to the order of presentation and discussion of papers at the symposium. The papers were divided into five main parts, which are discussed in Chapters II-VI. (Annex 4 lists papers by these five subjects of discussion.) Chapter II examines the present status, potential and long-terms plans of the iron and steel industry. Chapter III reviews the technological developments that have taken place in all the branches of iron and steel production. Chapter IV examines the prerequisites for the development of the iron and steel industry on a national and regional basis. Chapter V assesses the optimum capacity and stages of construction of iron and steel plants and their parts. Chapter VI evaluates the role of economic analysis and examines the reconstruction and modernization of the industry.

6. The symposium devoted a major part of its time to the discussions reported in Chapters IV, V and VI, which were of particular importance to developing countries. In conjunction with the technical meetings visits were made to the Novo-Lipetsk, Krivoi Rog, Zaporozhye and Cherepovets integrated iron and steel plants in the USSR. The symposium also visited the Moscow Institute for Steel and Alloys, the State Design and Projecting Institute for the Iron and Steel Industry and the Central Research Institute for the Iron and Steel Industry of the USSR.

7. The symposium was attended by 148 participants from 43 Member States and nine international organizations. Sixty steel industry specialists from 32 developing countries participated together with experts and consultants from iron and steel works, research organizations, process and facility designers and equipment suppliers from developed countries. In addition, some 48 observers from the iron and steel industry of the USSR attended the symposium. Lists of participants and observers are given in Annex 1.

8. The symposium was serviced by UNIDO secretariat and members of the Ministry of Iron and Steel of the USSR. A number of leading experts served as discussion leaders and rapporteurs at the technical meetings. The report of the symposium was drafted by a Report Committee comprising the discussion

leaders, the rapporteurs, the participating members of the UNIDO secretariat and certain specialists from developing countries. The report was discussed, modified and finally approved by the whole symposium.

9. The symposium was opened by Mr. E. Ward, Assistant Director of the Technical Co-operation Division of UNIDO. The messages from the Minister of Iron and Steel Industry of the Soviet Union, Mr. I. P. Kazanez and from Mr. I. H. Abdel-Rahman, Executive Director of UNIDO were followed by welcome addresses of Mr. I. V. Arkhipov, Deputy Chairman, State Committee for External Economic Relations and Mr. I. G. Isaev, Deputy Mayor of Moscow.

10. Mr. V. V. Lempitski, USSR, was unanimously elected Chairman of the Symposium. Mr. I. Chowdry, Pakistan, and Mr. S. M. Taher, United Arab Republic, were elected Vice-chairmen. Discussion leaders of the symposium were: Mr. L. C. Correa da Silva (Brazil), Mr. V. I. Javoyski (USSR), Mr. M. N. Dastur (India), Mr. B. Tarmann (Austria) and Mr. O. Fiala (Czechoslovakia). Technical rapporteurs were as follows: Mr. B. Malinin (USSR), Mr. J. Astier (France), Mr. A. Gomez (Chile), Mr. J. B. Austin (United States) and Mr. P. A. Shirjaev (USSR). The secretariat of the Symposium consisted of the following: Messrs. E. E. Ward (UNIDO) and I. N. Golikov (Ministry of the Iron and Steel Industry, USSR) as directors; M. A. Maurakh (UNIDO) and N. N. Timoshenko (Ministry of Iron and Steel) as co-technical directors; and B. Crowston (UNIDO) as technical secretary.

11. The technical meetings of the symposium, which closed with statements of Mr. E. Ward and the Chairman of the Symposium, were followed by plant study tours of steel works and metallurgical institutions in Czechoslovakia, France, India, Poland and United Kingdom.

Explanatory notes

References to "dollars" indicate United States dollars, unless otherwise stated.

References to "tons" indicate metric tons, unless otherwise stated.

1 atm = 1 atmosphere

1 in = 2.54 centimetres

Processes

DSR process = Direct Strand Reduction process

LD process = Linz-Donawitz process

SL/RN = Steel Company of Canada (S), Lurgi Gesellschaft für Chemie und Hüttenwesen mbH (L), Republic Steel Corp. (R) and National Lead Company (N)

United Nations Organizations

ECA = United Nations Economic Commission for Africa

ECAFE = United Nations Economic Commission for Asia and the Far East

ECE = United Nations Economic Commission for Europe

ECLA = United Nations Economic Commission for Latin America

ILO = International Labour Organisation

Other organizations

ECSC (CECA) = European Coal and Steel Community

EMAB = Economic Mutual Assistance Board, USSR

OECD = Organisation for Economic Co-operation and Development

BISRA = British Iron and Steel Association, now The Inter-group Laboratories of the British Steel Corporation, England

IRSID = Institut de Recherches de la Siderurgie (French Iron and Steel Research Institute), France

NML = National Metallurgical Laboratory, India

TSNIICHERMET = Central Research Institute for Ferrous Metallurgy, USSR

CHAPTER I

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

12. The following main conclusions, based on the information presented in the papers and the points raised during the discussion meetings, were approved by the participants of the symposium.

Present situation

13. The situation in the world market for iron and steel products during the past five years was described as being one of over-capacity with fierce competition and a depressed price level. Expansion of capacity during the period reviewed (1963 - 1968) was mainly in the industrialized countries.

14. The comparatively high growth rates of iron and steelmaking capacity in developing countries are due to the low initial level. The absolute increase in capacity was very low. The failure of developing countries to expand capacity and production was partly due to a lack of capital resources, but also to the absence of comprehensive development programmes in many countries.

15. The symposium noted with interest the papers presented on the subject of assessing statistically present and future steel demand, and its product and sector patterns. Although large-scale, fully integrated iron and steel plants are economically advantageous, under particular circumstances in some developing countries smaller-size plants may be established, which could operate economically in a restricted market, producing a limited range of products. Reference was made in this context to the beneficial effect of operating steel industries in markets that have been enlarged through economic association of different countries, like those already existing in eastern and western Europe, and in some of the developing regions.

16. During the last five years, raw materials for iron and steelmaking, in particular iron ore, have become increasingly available at lower cost almost

everywhere. The cases of Italy and Japan suggest that it is possible to operate economically steel industries, having hardly any domestic raw material resources, if the strength and volume of demand prescribes this.

17. Since the First Interregional Symposium on the Iron and Steel Industry in 1963, many iron and steel plants have been established in developing countries. Although, from a micro-economic point of view, they may not always operate at a profit, they may be justified from the point of view of macro-economics. There was agreement, however, that the aim should always be to achieve economical operating conditions as soon as possible.

Recent technological developments

18. Sintering remains the predominant and most versatile process of preparation of the blast furnace charge. During the last five years, however, pelletizing has gained importance especially for fine concentrates.

19. During recent years, there has been considerable advance in the development of direct reduction processes. At the present time the HYL process is in commercial operation. A number of SL/RN plants are under construction. It was felt that the results of the operation of these plants when they go into production will be of considerable interest for developing countries.

20. Countries that possess ores with low Fe contents may now consider the following new methods of iron ore dressing:

(a) A magnetic flcatation flow sheet for producing high-quality concentrate;

(b) New methods for beneficiation of oxidized quartzites by magnetic roasting;

(c) Magnetic separation in multi-gradient separators;

(d) Floatation and magnetic floatation flow sheets with separation of tailings out of the first stage of magnetic separation;

(e) Pelletization of concentrates or natural rich ore fines such as blue dust, including self-fluxed pellets.

21. All types of energy resources are being used for iron and steelmaking - as for example, charcoal, lignite, bituminous coals, non-coking coals, natural gas, fuel oil and electricity.

22. A recent development in blast furnace operation is the automation of charging and other operating techniques. This can result in closer physical and chemical control of pig-iron, economies of blast furnace operation and optimization of subsequent steelmaking.

23. The oxygen converter is now established as a most versatile steelmaking process. It was felt that rotary vessels may have some advantages but only under specific conditions. For melting of scrap, the electric arc furnaces are being increasingly adopted. Oxygen converters and electric arc furnaces will be the main steelmaking processes in both developed and developing countries in future years.

24. There was considerable amount of interest in the continuous steelmaking processes. It was agreed that such processes, however, will have to be further developed and proved by the advanced steelmaking countries before they can be recommended for adoption in developing countries although such processes would be economically attractive for developing countries.

25. Considerable progress has been made in continuous casting in recent years and many of the problems of the continuous casting process have been primarily solved.

Requirements for creation and expansion

26. The most important factors for the creation and development of the iron and steel industry were considered to be the present and future steel supply and demand, the availability of raw materials, of qualified manpower and the financial resources for the investments.

27. With regard to the demand, it was emphasized that while a high correlation between income levels and steel consumption per capita existed, this did not seem to be true in the case of developing countries since numerous extraneous factors intervene. Specifically, the steel demand of a particular sector is not always affected by the developments in other sectors of these economies. It is sometimes more rewarding to make a detailed study of the imports in order to assess the size of the market before steel capacities are expanded.

28. In 1953 steel imports accounted for slightly over 70 per cent of the steel consumption of the developing countries. This decreased to approximately 45 per cent about twelve years later. This process of import substitution, however, has been slowing down.

29. The influence of location on small integrated and non-integrated plants was important but not quite as crucical as in the case of larger, fully integrated plants.

30. Plants in the small capacity ranges are often more susceptible to economies of scale than plants in the large capacity range. When planning small plants, therefore, careful consideration should be given to this factor.

31. With regard to the degree of vertical integration of plants in developing countries that have relatively small markets, as a first step, the possibility of beginning with a rolling mill to produce bars and rods to supply the bulk for the requirements in these markets may be examined. In the next stage, the rolling mill can be integrated with electric melting and later the possibility of reduced iron ore as a feed stock for steelmaking in electric arc furnaces may also be considered. This material may have greater price stability than scrap and also contain very small amounts of contaminants.

32. As a means of enlarging markets in the developing countries it was felt that there could be substantial scope for this by regional economic collaboration. It was generally recognized, however, that there would be obstacles in the way of realizing such integration, particularly problems related to infrastructure conditions, monetary policies and exchange systems.

33. The possibilities of regional collaboration for scientific and technical research were discussed. Two alternatives were suggested, either the centralization of these activities in one regional establishment or the co-ordination of the tasks that could be performed at several institutions to achieve a common programme and objectives.

34. Regional co-operation in the standardizing of steel products was found most desirable because of the considerable savings that can be obtained by the standardization of types and sizes of steel. It was agreed that special efforts must be directed towards this end.

Improvements in design

35. The design of newly erected blast furnaces has been improved mainly through the increase of their useful volume and by providing for the intensification of the operation of the furnace and ancillary facilities.

36. In developing countries where there is no coking coal available, blast furnaces based on charcoal may still be installed, provided a constant supply of charcoal and suitable quality ore are available and low outputs of pig-iron (300-400 tons per day) are required. In addition, processes such as the low-shaft furnace and electric blast furnace for ironmaking may be considered.

37. The operation and output of existing and also of newly erected blast furnaces may be improved by increasing the temperature and volume of the blast, the injection of natural gas, fuel oil and coal slurries and by the enrichment of the blast with oxygen and other modifications. These requirements may also be used for the charcoal blast furnace.

38. Recent design improvements of oxygen converters have been mainly in the vessels and ancillaries, such as air-cooled trunnion rings, multihole lance operation gas collection cooling and clearing instrumentation and automation.

39. By eliminating the ingot phase and its requirements for a costly primary mill, continuous casting offers, at low capital cost, the possibility of establishing an efficient operation with considerable flexibility in output capacity. An equally important application is in those steel works where melting capacity exceeds the existing blooming or slabbing facilities, or where it is desired to expand the output of a steel works beyond the capacity of an existing primary mill. This is likely to be of particular significance in a rapidly growing steel industry. Continuous casting can therefore be used either in replacement of, or as complement to, the primary mill and is accordingly of potential interest to both small and large steel-producing units.

40. Two recent developments of continuous casting are of significance and they should be considered in the design of new casting machines. These are continuous/continuous (sequential) casting and submerged snorkel pouring. To facilitate continuous/continuous (sequential) casting strict scheduling of operations is required. At present snorkel pouring is limited to medium and large mould sizes larger than a 144 mm^2.

41. A complementary process to continuous casting is the Direct Strand Reduction (DSR) process, which incorporates a rolling operation directly on the continuous casting machine. The main advantage of this process is that machine through-put is increased by casting l rger sections, which are subsequently reduced to the final billet size. In addition, there is an increase in the reliability of operation and the range of size of the final product.

42. A number of varieties of low capacity rolling mills for billets, sections and tubes, are available for developing countries. For flat product rolling, however, the problems of scale are much more acute and the choice of type and design of low capacity flat product mills is limited. The planetary mill for hot strip can operate at very low levels of output.

Economic analysis and improved operating techniques

43. An economic analysis of new or existing steelmaking facilities should be based on the following main factors, which might serve as a foundation for the future development of the iron and steel industry:

(a) A long-term analysis, which would take into account a particular local and regional market situation, the available raw materials, energy, labour and finance. Economy of scale is only one decision factor, which should not be unduly emphasized.

(b) The analysis must also evaluate the best possible technologies and methods. It should take into account factors such as investment, new technologies, mechanization and automation. In that way, economic analysis plays an active role in the technological development.

(c) Economic analysis can also be used as a practical instrument for the management and operation of a steel plant. This approach is particularly useful in determining preventive maintenance and avoiding serious breakdown.

(d) An economic analysis can enable a classic approach to be made to evaluate the results obtained by an individual plant or by the steel industry as a whole.

44. The assessment of production by the use of techno-economic indices is a useful guide for the control of operations and future investment. They will become increasingly important to developing countries when improving and expanding their steel production. Each plant, however, has to study its own economic conditions and formulate standard costs, which should be reviewed each year to help the particular plant reach the designed level of performance.

45. The use of computer control may have far-reaching benefits in the revision of standards. It may enable a more efficient utilization of raw materials, a closer control of the process and thus a more consistent quality of product obtained. These wider considerations should be included in any assessment of the possible application of computers.

Recommendations

46. In the course of the symposium recommendations were made for possible action to be taken by UNIDO, in co-operation as necessary with other United Nations bodies. Specifically, the symposium recommended:

(1) That UNIDO study the possibility of setting up regional centres for research in iron and steel technology;

(2) That UNIDO endeavour to facilitate the distribution of technical literature, particularly in the form of abstracts and bibliographical material, to developing countries;

(3) That UNIDO study the pattern of world steel prices and the relationship between international and domestic price levels in the developed countries, as well as in the developing countries in order to examine how the situation affects the growth of the steel industries in the developing countries;

(4) That UNIDO expand its technical assistance activities in this field in order to enable the developing countries to ensure that the terms of financial aid are reasonable;

(5) That UNIDO pools the experience gained in the solution of problems in the iron and steel industry so that it could be drawn upon and added to by the developing countries;

(6) That UNIDO make detailed studies on the question of technical and managerial training for the iron and steel industry;

(7) That UNIDO investigate the possibilities of developing design and engineering services and equipment manufacturing industries in developing countries;

(8) That UNIDO study the possibilities of regional co-operation for the development of the iron and steel industry;

(9) That UNIDO inform developing countries about the new methods and means of producing iron and steel developed by research institutes in developed countries and about the possibilities of applying these new techniques as soon as they become well established.

(10) That UNIDO might direct part of its future efforts towards improving the transfer of experience relevant to the operation of steel plants producing between 50,000 and 500,000 tons per annum, which are required in many developing countries to satisfy regional markets, by:

(a) Improving the transfer of technical information on metallurgical equipment available, such as small-scale blast furnaces, small-scale coke ovens using new techniques, such as formed coke, continuous coking, charcoal blast furnaces etc;

(b) Including the development of new processes, especially suitable to operation at this level of output, particularly continuous processes;

(c) Analysing the installation and operational characteristics of small steel plants existing in North America with capacities of less than one quarter of a million tons per annum and by informing developing countries of these characteristics;

(d) Assessing of the applicability to smaller plants of the modern management and technical control techniques acquired in large plants;

(e) Assisting developing countries to set up iron and steel pilot plants using equipment suited to the needs of small integrated iron and steel works, and utilizing the kinds of ores and fuels available in developing countries.

(11) That the activities of the United Nations organizations in providing experts to assist developing countries with the creation and expansion of their iron and steel industries should be continued and intensified. It was also agreed that the studies and meetings undertaken by the United Nations to improve the dissemination of

economic and technical information on the iron and steel industry and its markets should be intensified;

(12) In recognition of the papers, discussions and visits made in the course of the Second Symposium; and considering that the First and Second Interregional Symposia on the Iron and Steel Industry resulted in the promotion of economic and technical aspects of the iron and steel industry (especially in the field in which the developing countries are particularly concerned); and also that the union of such a highly specialized group from many nations contributed to technical and economic development (both in terms of increasing industrialization and furthering friendship between different nations); it was recommended that UNIDO organize the Third Interregional Iron and Steel Symposium in four to five years, and depending on careful study by UNIDO, endeavour be made to organize the next symposium in a developing region. It was further recommended that the next symposium emphasize finishing and subsidiary activities of the iron and steelmaking, i.e. quality control, production of alloy steels, casting, rolling and fabrication, research and development, engineering and design and the application of the iron and steel products.

CHAPTER II

PRESENT STATUS, POTENTIAL POSSIBILITIES AND LONG-TERM PLANS FOR THE DEVELOPMENT OF THE IRON AND STEEL INDUSTRY AND THE WORLD STEEL TRADE

47. The first meeting of the symposium set the broad perspective and provided the economic background for the subsequent discussions on the more detailed problems facing the developing countries in setting up or expanding their iron and steel industries. Thus, a picture was provided of the developments in, and the present situation of, the world market for iron and steel, and of the state of development and prospects of the iron and steel industries in the developing regions.

48. During the second meeting a detailed report on the activities of the Permanent Commission on Ferrous Metallurgy of the Council for Economic Mutual Assistance was presented. Consideration was also given to the availability of iron and steelmaking raw materials, particularly iron ore, and a general review was made of the parameters to be taken into account in the planning and successful operation of iron and steel industries in developing countries. This was followed by a more specific assessment of the problems involved in and methods to be used for making forecasts of iron and steel demand in the developing countries.

49. A review was also made of the important role played by the technical press in disseminating information essential for the development of the iron and steel industry. The symposium was also informed of the activities in the field of the iron and steel industry carried out by the various United Nations bodies.

50. Some of the main conclusions of the papers presented during this discussion[3/] are set out in the following paragraphs.

3/ See Annex 4, nos. 1-11.

"World production, trade and prices of iron and steel"
(document ID/WG.14/20)

51. This paper analysed the discrepancy between the growth of steel demand and of steelmaking capacity, which has, for a number of years, characterized the steel market in many countries and particularly the international market. It has left its impact not only on the steel economy of the industrialized, but also on that of the developing countries. A brief analysis of recent developments in the world steel market was therefore made in the paper and the principal problems were shown.

52. Since the bulk of steel production originates in industrialized countries and is also consumed there, the development of steel industries in the developing countries is influenced to a noticeable degree by the situation in industrialized countries. The share of developing countries in the world steel consumption has increased only very slowly, from 5.1 per cent in 1950, to 6.4 per cent in 1960 and to 7.2 per cent in 1965. The rate of growth (compound) between 1950 and 1965 was 8.2 per cent per annum. The share of developing countries in the world steel production grew from 1.5 per cent in 1950 to 3.8 per cent in 1965; the absolute tonnage increased at an annual rate of 12.7 per cent, a rate that merely reflects a very low initial level. The low level of steel demand in developing countries is ascribed in the paper to the lack of foreign exchange to pay for steel imports, to the shortage of capital for the establishment of domestic steel production, and the absence of steel-transforming industries or of construction projects that would use large amounts of steel. In general, the retarded economic development of these countries has also led to stagnation or insufficiently rapid growth of steel-producing and steel-consuming industries.

53. An analysis of price and international trade data shows that even the sharp fall in steel prices observed in the international markets (price decreases for some products were, after 1957, between 30 and 50 per cent) has not brought a very marked increase in the steel imports of developing countries, for the reasons given above. While imports of steel into developing countries increased between 1960 and 1965 only at an annual rate of 4 per cent, imports into the industrialized countries grew at 10 per cent a year during the same period. This is ascribed partly to a growing exchange of skills among industrialized countries (i.e. a growing international division of labour), but mainly to the fact that prices in international trade were lower than those the main producers charged in their domestic markets.

54. The second part of the paper discussed the principal characteristics of the iron and steel industry, beginning with an analysis of data on iron and steel use. While a clear relationship can be shown to exist between the level of economic development and the level of steel use in developed economies, it is more difficult to establish a similar relationship for the less advanced countries. Likewise, while it is possible to show a typical sector and product pattern of steel consumption for industrialized countries, for the developing countries these patterns seem to vary with the type of economy: agricultural, mining, petroleum. The broad lines of development in the product pattern of output were also described from the experience obtained by certain developing countries.

55. The paper also discussed the impact of technological developments on the production of iron and steel. The trend towards using and developing equipment of large capacity (economies of scale), which has led in industrialized countries to the creation of large integrated plants, serving large markets, has been in certain cases a barrier to establishing iron and steel works in developing countries. Steel works require - at least in the early stages of development - metallurgical equipment (particularly rolling mills), which can economically produce a variety of forms and qualities, in relatively small tonnages. Further research is needed to overcome this difficulty. It was also stressed that, on the other hand, regional groupings and the creation of common markets permit the use of modern large-capacity equipment and provide advantages through production of large quantities of steel. Attention was also drawn to economies in investment expenditure achieved by building large plants instead of several small units.

56. The main secondary effects, both positive and negative, of establishing an iron and steel industry in developing countries were also briefly discussed. Mention was made of the generation of employment and hence of income, the savings in foreign exchange, the creation of ancillary services and industries as well as the expansion of the steel-using sector through the regular availability of iron and steel products. Attention was, however, drawn to the possible negative effects on the balance of payments (temporary burden through import of plant and equipment; more regular burden through import of coking coal) and to the problems of securing adequate means of finance. Finally, mention was made of various protective measures used in particular by the new steel-producing countries to stimulate domestic development.

57. The third part of the paper provided suggestions for expanded regional co-operation and for the integration of smaller steel markets of developing countries. The fourth part showed likely trends of world crude steel production in 1970, according to which the developing countries, taken as a whole, are expected to increase their output from, at present, 17 million tons to over 35 million tons, which corresponds to an annual growth rate of 16 per cent. For the period 1970 - 1975 a rate of increase of the order of 13 to 14 per cent a year may be expected, i.e. nearly a doubling of capacity during the five years. This would involve a considerable economic effort, particularly if account is taken of the required corresponding investment in consuming sectors.

58. The paper concluded that it is hardly possible to make general recommendations for government policies to be pursued in setting up iron and steel works or expanding existing installations. The reason is that, particularly during the early stages of economic and industrial development, any steelmaking operation is determined, as far as its size and production programme is concerned, by its market, i.e. by the kind, rate of growth and volume of demand. It is evident, therefore, that detailed pre-investment surveys are required to assess the volume and product pattern of existing demand and the required corresponding investment in ancillary and steel-using sectors. Experience shows that new steel industries have always been most successful when established as part of a comprehensive industrial development programme.

<u>"Present status and future of the iron and steel industry in African countries"</u>
<u>(document ID/WG.14/8)</u>

59. This paper provided an account of the present and prospective levels of consumption of iron and steel products in the various African countries, and corresponding to this, the present and prospective level of production. The development of the industry was discussed in terms of the availability of the factors of production, of the effects on trade, of the level of costs and of the investment involved. Account was also given of the organization of the industry and of the impact of government policies.

60. The current consumption *per capita* of iron and steel products in African countries is very low, amounting to less than 10 kg in half of the forty countries concerned as compared with 250 to 300 kg in developed countries. This is a consequence of the low level of income and also in many cases of the virtual absence of an engineering industry. As most of the countries are also

small from the point of view of the population, at present only seven of them have a consumption of iron and steel in excess of 100,000 tons per annum.

61. The pattern of consumption in Africa is very different from that in developed countries. Galvanized sheet and hot-rolled sheet or tubes are important while, because of the low engineering demand, the consumption of cold-reduced sheet and of castings is proportionally very low. Reinforced concrete construction is favoured as compared with sections. In Libya, Algeria and Nigeria the petroleum industry is a major user of steel in the form of pipe-lines.

62. Because of the great economies of scale in integrated iron and steel production, such plants exist only in the larger markets, i.e. South Africa, the United Arab Republic, and, more recently, Algeria and Tunisia, but other activities such as scrap melting and rolling of bar and light sections and tube welding, galvanizing and wire drawing are carried out in several countries. With regard to future developments, while the larger countries may continue with little disadvantage to plan their industry on a national basis, it is important that all the smaller countries and some of the larger ones without suitable raw materials should co-operate in the development of the industry so that plants of an economical size supplying a multinational market and based on the best available raw materials could be established. For this purpose, the Economic Commission for Africa has made projections for the establishment by 1980 of subregional plants in the east, west and central subregions and for some degree of specialization and integration in the north subregion. Such plants apart from heavy-plate seamless tubes and sections would supply about 90 per cent of requirements.

63. As far as costs of production are concerned an iron and steel works established at a suitable location in Africa would have an advantage of having access to iron ore which, however, would be partly offset unless it had access also to cheap coking coal as in southern Africa. Its advantage with regard to cheap labour would be entirely offset initially in the east, west and central African subregions by the need to employ highly paid expatriate staff. The main disadvantage is the higher cost of erecting the works that, even at a coastal site, would be some 25 per cent above European levels. These disadvantages are considerably increased if small capacity plants are erected. With reasonable capacity, however, steel can be produced at prices competitive with imports and give a reasonable return on capital.

64. The total investment needed to provide 75 per cent of African iron and steel requirements by 1980 would be of the order of $4 thousand million. If,

instead of large subregional works a number of smaller works were established, the investment would be reduced, but the capital cost per ton would be about one third higher and the total production would be reduced.

"Present status and future of the iron and steel industry of the Asian countries"
(document ID/WG.14/9)

65. In reviewing this paper, it was shown that in 1966, the average steel consumption *per capita* in the ECAFE region (excluding China Mainland) was about 49 kg or about 28 per cent of the average world steel consumption *per capita*. In crude steel production, the share of the ECAFE countries (excluding China Mainland) in the total world output in 1966 was about 13 per cent. The high share of the ECAFE region in total world production was contributed mainly by the three large steel-producing countries in the region (China Mainland excluded): Japan contributed about 10 per cent and India and Australia combined about 2.5 per cent. The share of the other countries was insignificant (less than 0.4 per cent).

66. In the countries producing over 1 million tons (Australia, India and Japan) steel production increased from 29 million tons in 1960 to 53 million tons in 1965, an increase of 80 per cent. Steel consumption rose 50 per cent, from 28 million tons in 1960 to 42 million tons in 1965. The average consumption of steel *per capita* in these countries in 1965 was 71 kg. In Japan, production in 1965 exceeded consumption by about 42 per cent. In India and Australia, production rose to 83 and 92 per cent of consumption respectively.

67. Apart from the high level of production and consumption in the large steel-producing countries, there was also a steady increase in crude steel production in the small steel-producing countries of the group producing less than 500,000 tons. Consumption *per capita* in this group during the period 1960 to 1966 increased by about 20 per cent. In absolute tonnage terms consumption increased from 3.7 million tons in 1960 to 6 million tons in 1965, an increase of about 62 per cent. Production, however, has lagged far behind consumption. In 1960, production accounted for only about 9 per cent of consumption and in 1965 the proportion was about 13 per cent.

68. The progress made so far in the iron and steel industry in the small steel-producing countries has been small and, therefore, it has not had a significant impact on the general economic welfare of the large masses of people in the region. The most significant progress has been made particularly in Japan, and also in Australia and India. Although India's production

in terms of *per capita* output seems insignificant, the percentage increase over the previous years has been considerable and has contributed much towards India's growing industrial potential.

69. The estimated apparent steel consumption in the small steel-producing and non-steel-producing countries in the ECAFE region in 1970 will be about 9.9 to 10 million tons, of which about 4.4 million tons will be supplied from domestic production and the balance of 5.6 million tons from imports. On this basis, the total steel consumption will be about 42 million to 45 million tons in 1985 for the less developed countries in the region.

70. The total apparent steel consumption for the ECAFE countries for 1970 is estimated to be 87 million tons, the consumption in the large producing countries being 77 million tons and in the small producing and non-producing countries about 9.9 million tons. In 1964 direct steel imports cost the ECAFE countries $1,009 million. Including the value of indirect steel imports of machinery, engineering equipment etc. the cost was approximately $5,280 million.

71. There are many difficulties to be met and problems to be solved before iron and steel production units can operate satisfactorily in some of the ECAFE countries. The problems include the limited size of markets, the shortages of foreign exchange and trained personnel, transport and power. A realistic approach to the problems hindering the growth of steel industry in this region would be to study the situation on a regional basis. Efforts might be made to pool resources, capital and markets and thereby achieve economies of scale. Interregional co-operation would improve prospects for the region as a whole.

72. The Asian Conference on Industrialization, at its meeting in Manila in December 1965, envisaged a large iron and steel development programme in the small steel-producing and non-steel-producing countries of the region for the next 15 to 20 years. Targets for steel production were set at 4.5 million tons in 1970 and 43 million tons in 1985. It also emphasized the need for regional co-operation for accelerating the development of the steel industry in the region.

73. As an initial step towards the implementation of the programme the Asian Industrial Development Council (AIDC) has begun to investigate the possibilities of harmonizing and co-ordinating the plans for steel development in some of the small steel-producing countries in South-east Asia.

"Present status and future of the iron and steel industry of the Latin American countries"
(document ID/WG.14/42)

74. This paper described the growth in apparent consumption of rolled steel products in the Latin American countries during the period 1955 to 1965, estimated the possible demand for these products in 1970, 1975 and 1980 and outlined the plans of steel enterprises for expansion. The document indicates that over the ten years reviewed, the steel production growth rate averaged 12.7 per cent annually. Some of the changes that have taken place in the structure of the industry are mentioned. An analysis is included of installed capacity of integrated plants and of prospects for more effective utilization through the intensified application of advanced techniques.

75. With respect to raw materials, mention is made of the abundance of high-grade iron ores in the region and of the insufficiency of coking coal, which most integrated plants are obliged to import for mixing with locally mined coal. The paper deals also with interregional trade in rolled steel and concludes by giving information on the capital structure of integrated iron and steel enterprises and the sources of their principal foreign credits.

"The effect of regional co-operation on the development of the iron and steel industry under the Economic Mutual Assistance Board"
(document ID/WG.14/2)

76. The Council for Economic Mutual Assistance is an international economic organization, the aim of which is to promote through the co-ordinated efforts of its member countries: the development of their national economy; accelerated economic and technological progress; the raising of the level of industrialization in countries with less developed industry; the steady development of higher labour productivity; and the continual improvement of the welfare of the people of member countries of the Council.4/

77. The Council for Mutual Economic Assistance is an open organization, which may be joined by countries that share the aims and principles of the Council and agree to assume the obligations set forth in its Charter. In 1964 an

4/ The following member countries take part at present in the work of the Council for Economic Mutual Assistance: Bulgaria, Czechoslovakia, Eastern Germany, Hungary, Mongolia, Poland, Romania and the USSR.

agreement was concluded between the Council for Mutual Economic Assistance and the Government of Yugoslavia concerning that country's participation in the work of the Council's organs.

78. For the purpose of promoting further expansion of economic ties between member countries of the Council and achieving broad economic, scientific and technological co-operation in various branches of their national economies, a number of standing commissions have been established by decisions adopted at sessions of the Council. The Standing Iron and Steel Commission was established in 1956. This Commission approves recommendations made to member countries of the Council; or refers to sessions of the Council; or to its Executive Committee; or to proposals on the improved utilization of economic and natural conditions in member countries with a view to achieving the most effective development of the iron and steel industry of those countries. It co-ordinates plans for the development of the industry, on specialization and co-operation in production, on the most efficient utilization of production capacity, raw materials resources, materials and production in the iron and steel industry. In addition, the most effective utilization of basic capital investment, questions of multilateral scientific and technical co-operation and the co-ordination of scientific and technical research, the unification of basic parameters and standards in the industry, and other questions of interest to the member countries of the Council are examined.

79. Over the period of its existence, the Standing Commission has worked out and adopted recommendations to member countries of the Council on a large number of questions connected with the development of their iron and steel industry and it is carrying on extensive work on the co-ordination of their iron and steel development plans.

80. The technical level of the iron and steel industry has risen in countries that are members of the Council, and the range of products has been considerably widened. The increase in the production of iron and steel has promoted the successful development of the economies of these countries. The share of the participant countries of the Council for Economic Mutual Assistance in the world production has increased from 24.8 per cent in 1960 to 27.5 per cent in 1967. In Bulgaria, which has a modern ferrous metallurgical industry, the production of steel *per capita* was 0.7 kg in 1950, 149 kg in 1967 and the estimate for 1970 is 270 kg.

"Availability of iron ore and resources for iron and steelmaking"
(document ID/WG.14/21)

81. The paper shows that world production of iron ore has risen from 244 million tons in 1950 to 617 million tons in 1965; and while only 17 per cent of that production entered into international trade in 1950, the proportion reached 34 per cent in 1965. The iron ore industry has undergone considerable change during the past two decades, not only in the technology applied in mining and processing iron ore, but also in its structure and in the product and geographical pattern of its output.

82. The present situation of the industry is described in the paper as one of over-capacity at mines. The general trend is reflected very well by the price of Swedish ores (Kiruna D, CIF Rotterdam). These ores were 35 per cent cheaper in 1967 than in 1957.

83. Having shown in an early section the developments and problems of the market, the paper continues with an analysis of the characteristics of the iron ore industry and its markets. Iron ore reserves are discussed and a review is made of the developments in iron ore production and the changes in its geographical pattern. The trends in consumption of ore are also analysed. The paper shows furthermore that the iron content of ores entering into international trade has increased faster than that of ore production in general. In other words, in order to keep the transport cost per recoverable Fe-unit as low as possible, leaner types of ores are consumed within a closer distance of the originating mines, whereas ores of higher grades are shipped over long distances. The increasing importance of iron ore resources at greater distance from the principal consuming centres is brought out: the number of ton-kilometres of ore carried in sea-borne trade has grown between 1950 and 1964 by 11.2 per cent annually, whereas the tonnage of ore carried during the same period increased by 9.2 per cent per year. At the same time the share of developing countries in world exports has increased from over 30 per cent in 1950 to 46 per cent in 1964.

84. After a brief analysis of price trends, bringing out the almost general deterioration of export prices after 1960, some of the prospects of the iron ore market are discussed, based on a recent study on "The world market for iron ore" (ST/ECE/Steel/24), prepared by the Economic Commission for Europe. An assessment of the plans for the expansion of mines throughout the world shows that in 1970, after deduction of domestic requirements, the quantity available for exports would be about 60 per cent higher than in 1964. This would mean that in the world the quantity required for imports and that

available for exports should not be too far apart. It is expected that the present export surplus which has contributed to the depression of prices will diminish, if it is not expanded at a rate above the estimated 7 to 8 per cent growth in import requirements. Between 1970 and 1975, world iron ore consumption is forecast in the ECE study to grow at about 4 per cent a year, whereas import requirements may grow at a rate of 2 to 2.5 per cent annually during the same period. Taking into account the known reserves of iron ore, the time required to equip new deposits and the ore producing countries' own ore needs, it would appear that the export potential for iron ore could grow by a maximum of 3 per cent between 1970 and 1975. At this rate of growth the resulting export capacity would only be about 10 per cent higher than import requirements.

"The iron and steel industry and industrialization of the developing countries"
(document ID/WG.14/62)

85. This paper stresses the role of iron and steel industry in developing regions and countries in promoting economic growth in general, and in catalysing the growth of industries dependent on iron and steel such as the engineering and consumer industries. The fact that the establishment of an integrated iron and steel industry in any location, especially in a developing country, requires specific parameters and prerequisites to be met, is discussed. The necessity of regional self-sufficiency in iron and steel end-products related to diversification of the steel industry, on non-integrated basis is also brought out. General statistical background data on the subject are furnished.

86. References are made in the paper to agglomeration and pelletizing of iron ores in general and the part it plays in developing countries in particular. Iron ores processing for home industry or export can save or earn foreign exchange for developing countries and its establishment should be encouraged. Reference is made to the cost of these operations *vis-à-vis* the technological processes involved.

87. The important role of the United Nations Industrial Development Organization (UNIDO) as an instrument for promoting the growth of the iron and steel industry, covering technical feasibility, pre-investment studies, economic appraisals and over-all evaluations, is discussed in this paper. Collaboration between UNIDO, Regional Economic Commissions and related United Nations bodies is stressed for undertaking the above studies and also for pursuing regional assessment of resources of raw materials, market potentialities and the optimum

techno-economic integration required. If these projects are undertaken through UNIDO assistance, it may be easier to settle difficult questions such as whether a developing country or region should set up an integrated iron and steel industry or alternatively a network of its constituent production facilities on reverse non-integration basis, e.g. merchant and light section mills or cold mills for flat production based on imported semis. Each case, however, is important enough to be judged on its own techno-economic merits.

88. In some quarters, a view is tenaciously held and persistently advocated that the developing countries could import all their iron and steel needs from advanced countries instead of endeavouring to be self-sufficient. The fallibility of such reasoning is pointed out. The savings in foreign exchange resulting from the home production of indigenous steel on integrated or non-integrated constituent basis cannot be overlooked, but the indigenous steel production costs, however, should indeed lead to rational decisions. The process of such reasoning and of the growth of the steel industry in developing regions are of relatively recent origin and the chain reaction growth is very much in evidence today both in developing countries and in those highly advanced. The pivotal role of UNIDO in bringing the two together has been fruitful since its recent formation and will be of increasing importance in the years ahead.

"Forecasting iron and steel demand in developing countries" (document ID/WG.14/12)

89. This paper shows that the process of development involves not only an acceleration in the rate of growth of an economy but also, in the case of developing countries, a considerable change in structure including in particular a rapid expansion of the metal-using industries. It is therefore not appropriate to attempt to forecast future iron and steel demand by a prolongation of previous rates of increase or by linking it to a single index such as that of industrial output generally. On the other hand, the statistical and planning apparatus in most of these countries is not adequate to employ the end-use method used in highly developed countries, namely the construction of an elaborate sectorial forecast of the economy and its evaluation in terms of steel content.

90. It is therefore suggested that the most suitable procedure in most cases is to relate the demand for iron and steel to the development of the economy as indicated by the gross domestic product and capital formation, the latter being important as the major steel-using sector and as a determinant of the

rate of growth. It may be assumed that these two factors will always be available even in the most elementary forecasts. This procedure will give an estimate of total, direct and indirect demand for iron and steel and it is necessary in developing countries to subtract indirect consumption, i.e. imports of machinery and transport equipment and conversely in developed countries usually to add exports. The basis for estimating these imports is the proportion of engineering requirements likely to be met by the domestic industry.

91. The procedure is described in detail for African countries. It is shown that there is a close relation between increases in total iron and steel consumption and increases in the gross domestic product when adjusted by its capital formation content. It is also shown that the division of consumption between construction and engineering uses is remarkably constant so that projected consumption can be estimated in these two categories. For determining the proportion of engineering demand that should be met by local industry, a further breakdown of engineering demand is suggested as part of an engineering study or alternatively standard proportions are proposed. Non-ferrous metal consumption, which is an integral part of engineering production, is estimated at the same time. For the division of consumption into types of steel it is suggested that the proportions obtained in the engineering industries of developed countries may be used in the engineering sector but that, in the construction sector, the division should reflect local conditions.

"Interrelation between iron and steel industry and industries of consumers of its products"
(document ID/WG.14/69)

92. The paper sets forth the inter-industry relations of the iron and steel industry on the basis of the input-output balance of the national economy of the USSR and of the section of this balance relating to the iron and steel industry. The calculation of this balance and of its iron and steel industry section was made in the Economic Research Institute of the State Planning Committee of the USSR on the basis of the 1965 data and the plan for 1970.

93. These data give a possibility not only of revealing the existing inter-industry relations referring to consumption of the products of the iron and steel industry, but also of determining the changes that are taking place in the current five-year period, under the influence of the technical progress both in the iron and steel industry and in the industries, consumers of its products. The paper comprises the factors that influence most essentially the changes of the inter-industry relations of the iron and steel industry.

94. As the inter-industry relations are determined by the method of the input-output balance, the paper contains brief information about the input-output balance, and it is shown what place the iron and steel industry takes in the national economy as to the production output, availability of the basic productive funds, investments and number of people engaged. The data on the share of the iron and steel industry in the creation of the national income (directly and by means of the branches that consume its production) are also of great interest.

95. In order to show the relations of the iron and steel industry with reference to the consumption of its total production and to show the place this production takes in the gross national product of the country, these relations are expressed in terms of money. At the same time, the consumption of the main products of the iron and steel industry by different branches of the national economy is expressed in real terms.

96. The most important products indicated in the report are: iron ore, sinter, iron, steel, electric ferroalloys, rolled products, steel pipes, coke and hardware. The consumption of the above products by different branches of the national economy and the share of each branch in the total consumption of the above products are shown. The production relations of the iron and steel industry are characterized by the consumption of its products per unit of products of other branches and per total output of these branches. Both the relation of the distribution of products of the iron and steel industry and that of the consumption of the products of other industries by the iron and steel industry are shown. In this connexion, the paper contains a section dealing with the analysis of the inter-industry relations of the iron and steel industry and the consumption of products of other industrial branches by the industry, with the interrelations of the production expenditures.

97. The inter-industry relations of the iron and steel industry with regard to the consumption of the products of other industrial branches, are slightly more stressed in the paper than those referring to the distribution of its own products which have quite a marked effect. The iron and steel industry consumes a comparatively wide range of products manufactured by many industrial branches. The expenses of the industrial branches for manufacturing 1,000 roubles of production of the iron and steel industry and for manufacturing one unit of the above nine products are also shown.

"The value of the technical press in the development of a steel industry and its technology"
(document ID/WG.14/54)

98. The paper stressed that one of the purposes of the symposium was to exchange information between countries on recent technological improvements in the iron and steel industry. The raison d'être of the technical press in any country is the exchange and dissemination of information on technological improvements. The parallel aim is achieved with trade journals, the major functions of which are the exchange and dissemination of information on commercial questions of interest to an industry.

99. The paper examines both the technical and trade press publications of several developed countries to show how these publications reflect the technical and economic principles affecting their steel industries. It is hoped that this paper on the techno-economic steel industry press in developed countries results in suggesting guidelines as to how an effective press may grow in the developing countries.

100. One should bear in mind that the technical press of a highly developed country like the United States is specialized over many fields. In order to examine the whole spectrum of technical and economic articles regarding the industry, it is necessary to take into consideration many publications not apparently related to the steel industry. Thus, in addition to publications on steel production and engineering, there are others on steel distribution, design, fabrication and materials application. Likewise, there are trade papers on labour, finance and other important aspects of such a basic industry as steel. Typical examples of both the publications and selected articles relating to the steel industry are examined.

101. The steel industry technical-trade press in developed countries (especially of the United States and the United Kingdom) is described. The description shows broadly what publications are available, what aspects of the industry they report on, and how the steel industry personnel benefits. Finally, an analysis is made of the possibility of a discussion of the steel industry problems of the developing countries in the technical press of the developed countries.

"Review of the activities of the United Nations in the iron and steel industry in developing countries"
(document ID/WG.14/66)

102. The review assesses both the operational and non-operational acrivities of the United Nations in the iron and steel industry during the period after the First Interregional Symposium on the Iron and Steel Industry in Prague and Geneva in 1963. This symposium examined the application of modern technical practices in the iron and steel industries of the developing countries.

103. Since the First Interregional Symposium over 70 experts and a number of consulting bodies have been sent to developing countries. Projects have ranged from pre-investment studies to assistance on the quality of rolled steel plates. These are listed in the paper according to their respective regions of location and date of origin.

104. A bibliography has also been compiled of the publications of the non-operational activities of the United Nations relating to iron and steel activities issued as a result of studies, symposia and expert group meetings under the auspices of the United Nations Regional Economic Commissions, the International Labour Organisation and the Centre for Industrial Development, and, more recently, the United Nations Industrial Development Organization. These documents are listed according to the organization and date of issue.

105. Most of the questions affecting the development of iron and steel industries are reflected in the studies listed in the bibliography. The publications relating to the availability of raw materials are specified and assessed. A suggestion is made that more attention be paid to examining energy and water supplies to steel works. The studies carried out relating to consumption and demand are also specified and assessed, together with other important topics, such as regional and interregional co-operation, trade in steel, the role of small steel works and non-traditional methods of production.

106. The UNIDO in-plant training programme for iron and steel engineers and technologists from developing countries at the Zaporozhye iron and steel plant in the USSR is described. This programme consists of practical training in all departments of a large integrated iron and steel plant.

107. The recommendations made at the International Symposium on Industrial Development held in Athens in December 1967 in the field of iron and steel are reviewed. These recommendations will, if followed, expand the activities of the United Nations in this field. The specific recommendations made to UNIDO for its future activities in iron and steel are outlined.

108. The list of the United Nations operational activities and bibliography of studies arising from the non-operational activities in iron and steel together with the review of training programmes and fields of future UNIDO activities will assist both developing and developed countries in understanding more fully the work of the United Nations in this particular industrial sector.

Discussion

109. The discussion of the papers describing the present state of the industry centred on the problems involved in the establishment of the iron and steel industry in developing countries. Although there have been quite dramatic increases in the steelmaking capacity in certain developing countries, the over-all share of developing countries of world steel capacity has not increased.

110. The idea was expressed that developing countries should build up their steel industries at the fastest possible rate, even if sacrifices were temporarily imposed. It was noted that benefits to the over-all economy are often obtained from steel-producing units which are not profitable themselves.

111. The present over-capacity of the world's iron and steel industry lead to intense over-capacity in the world's steel markets and resulted in depressed price levels. The apparent discrepancy between the domestic and international price levels was noted and it was recommended that this question be examined by UNIDO.

112. Attention was called to the problems of transfer of technical information. This is particularly important to developing countries. It was suggested that UNIDO facilitate the distribution of such information, paying particular attention to the secondary information, which is most widely used in the USSR and abstracts of world wide technical information, which are published in the United Kingdom, the United States and other countries.

113. It was stressed that the regional, economic and technical co-operation of the type undertaken by the steel industries of developed countries in organizations, such as the Council for Mutual Economic Assistance and the Economic Commission for Europe was of interest to developing countries.

CHAPTER III

TECHNOLOGICAL IMPROVEMENTS IN THE IRON AND STEEL INDUSTRY

114. The papers discussed under this heading reviewed recent developments in ore preparation, iron and steelmaking.

"New methods of beneficiation and agglomeration of iron ores and concentrates for the blast furnace process; their efficiency" (document ID/WG.14/70)

115. The paper reviewed the new methods of beneficiation and agglomeration of iron ores and concentrates for the blast furnace in the USSR and discussed the developments towards improvement of the grades and physical properties of agglomerated raw materials.

116. The existing methods of beneficiation allow production of concentrates with 64 to 66 per cent Fe. By the use of multi-staged and combined flow sheets with ore and pebble grinding of magnetite quartzites and by floatation of the magnetite quartzites, concentrates containing 66 to 71 per cent Fe are produced at Krivoi Rog. In 1967 a magnetic floatation flow sheet was developed. The magnetic separation concentrate with Fe content of 64 to 65 per cent is treated by reverse anionic floatation, the tailings of which are reground with subsequent repeated magnetic separation. With these flow sheets it is possible to produce concentrates containing 71.5 per cent Fe with 81.2 per cent recovery and 41.9 per cent yield.

117. The paper then deals with interesting developments in magnetic roasting of oxidized quartzites. Magnetic roasting was started in 1962 at the Central Mining and Beneficiation Combine, Krivoi Rog using rotating kilns. The development of vortex chambers and fluidized bed furnaces may improve magnetic roasting and by this method it should be possible to decrease substantially investment and production cost. Other flow sheets for beneficiation of oxidized quartzites include floatation combined with gravity and high intensity magnetic

separation. Combined methods with floatation make it possible to produce richer concentrates from oxidized quartzites.

118. Laboratory and pilot plant tests have recently been conducted for beneficiation of hematite-magnetite ores (55 to 56 per cent Fe and 16 to 17 per cent SiO_2). A three-stage flow sheet for magnetite separation with two stages of grinding has been developed. Magnetic separation in multi-gradient separators allows stage-by-stage beneficiation flow sheet for oxidized ores, to give up the use of reagents, and to improve the conditions of concentrate filtration.

119. In regard to agglomeration methods, the most commonly used in the USSR is sintering, for which there is a capacity of over 120 million tons per year. Briquetting did not find commercial application in the USSR. In recent years pelletizing has been widely developed. Much attention is paid to the production of self-fluxed pellets. Natural gas is used for pellet firing. Limestone and betonite are used for binding.

120. There are two commercial pelletizing plants producing self-fluxed pellets in the USSR, one in Sokolovsk-Sarbaisk Mining and Beneficiation Combine with an annual capacity of 8.4 million tons of pellets of 1.15 basicity, and the other at Krivoi Rog with an annual capacity of 6.8 million tons per year. The problem of full scale production of hard self-fluxing pellets of uniform quality has not yet been solved.

"Application of low-shaft furnaces for ironmaking with sub-standard raw materials" (document ID/WG.14/22)

121. The paper gave an exhaustive account of operating experience with a variety of sub-standard materials over a decade on pilot plant low-shaft furnace at the National Metallurgical Laboratory, Jamshedpur, India. In regard to the ore size, they have confirmed an optimum size of 5 to 23 mm. The flue dust losses increase with smaller size and are even greater when using non-coking coals instead of small-size coke. The use of small-size coke below 30 mm seems to give the best results with smooth furnace operating conditions. The fuel rates obtained are from 1.2 to 1.6 tons of fixed carbon per ton of iron, which is about 1.5 to 1.9 times the fuel consumption achieved at regular blast furnaces.

122. The direct use of lump coals gives rise to operating problems and almost 50 per cent higher fuel rate compared to small-size coke and therefore the laboratory does not recommend the use of non-coking coals. It has shown,

however, that low temperature carbonization coke made out of certain non-coking coals (Talcher) gives satisfactory results. However, low-temperature carbonization coke from other deposits such as those from the Wardha Valley has not been found suitable.

123. The conclusion is that while iron can be made in low-shaft furnaces from sub-standard raw materials, this would be at high cost because of low productivity, high fuel consumption and high depreciation charges. For these reasons, these furnaces cannot be placed where blast furnaces already exist or where conditions for installation of a blast furnace prevail. However, they could be considered only in situations where the production is contemplated from local or regional sub-standard materials.

"The Liège experimental furnace"
(document ID/WG.14/1)

124. This paper stated that the low-shaft furnace can be used as an experimental furnace to study the process of the large blast furnaces. It is suggested that a developing country should install a low-shaft furnace for initial iron production, obviously under specific conditions, and later convert it into an experimental furnace.

125. The paper also confirms the superiority of small-size coke over semi-coke and coal. The lower top gas temperature of 100°C at the Liège small blast furnace, as compared to 400°C of NML furnace, is possible because of the greater height (4 m as against NML's 2.6 m) of the Liège furnace. While the National Metallurgical Laboratory does not recommend the use of non-coking coals directly, the Liège experience shows no difficulty in using steam coal. It is emphasized in the paper that the process can be understood better through basic research, which is vital for technological applications in the large blast furnace. The need for elimination of even small quantities of fines from agglomerated burdens is apparent from the experience of the Liège furnace. The trials with auxiliary fuel injection, oxygen enrichment of blast, and high blast temperature has given some positive conclusions regarding their impact on the furnace operation from which the operative economics could be worked out. Trials have established that the best results are obtained from pellets when used in the furnace with highly basic agglomerates. Pellets with high growth rate have adverse effects on furnace operation.

126. The conclusion drawn, based on trials regarding the reducibility of the agglomerates - that at normal gas flow rates, 50 per cent reducibility of agglomerates gives very high carbon monoxide utilization values and higher reducibility does not contribute to carbon monoxide utilization any further - will be of practical value to blast furnace operators for an effective use of the available raw materials. The interesting trials with pre-formed coke achieved a very high production rate of 9.8 tons/m^3 of useful volume per day. It is considered quite possible to increase regular blast furnace output by 30 per cent.

127. The installation of low-shaft furnace for such experimental purposes, with a view to making basic contributions to the understanding of the regular blast furnace operations, can certainly be justified.

"Modern technology of oxygen-blowing steelmaking processes"
(document ID/WG.14/59)

128. This paper examined the vast unexplored area of oxygen steelmaking. While an open-hearth furnace has already been fully exploited, the potentials of oxygen steel have yet to be developed. The LD process is dealt with in detail, and the other processes developed subsequently, namely the Kaldo and the Rotor as well as the most recent ones, the Tandem and the LD-Kaldo are briefly reviewed.

129. The average vessel size has increased to 113 tons in 1967. It is interesting to note that the United States has the largest average vessel size, of 159 tons, while Japan, which produced the highest tonnage of LD steel in 1967, has an average vessel size of only 86 tons. While there are several 200- to 300-ton vessels in the United States and other countries, Japan has not made vessels larger than 200 tons even in the plants recently built or under construction. This hesitancy is somewhat paradoxial, in view of the fact that Japan is installing extremely large blast furnaces for ironmaking. Nevertheless, they have developed such operating techniques that the productivity rates of their 150- to 200-ton vessels are as high as those of the larger vessels in other countries.

130. The performance and, even more important, the versatility of the LD process in handling all types of hot metal and producing various types of steel, including alloy and special steels has been to a large extent due to developments in lance design and blowing technique. The paper highlighted these aspects by discussing the recent developments at great length. The application of multi-hole nozzles to LD converters was started in Japan a few years ago to

obtain a quiet blowing free from slopping when the OG process (gas cleaning and collecting) was adopted. In addition to meeting the OG process requirements, it has brought about several other advantages such as: higher yield; lower converter delays due to less spillage, less converter nose build-up and less skulling of lance; higher blowing rates resulting in substantial reduction in blowing time thereby increasing productivity; and increased lining life. These advantages have practically ousted the one-hole lance, particularly in large vessels. Even 4-hole and 6-hole nozzles are successfully used.

131. A nozzle, developed by ARBED, Luxembourg, for the LD-AC process, called the ATR lance is of particular interest. While the normal powdered lime lance has multi-hole nozzles inclined towards or running parallel to, the middle axis, the ATR lance has a main jet in the centre to supply primary oxygen and an outside nozzle ring through which secondary oxygen enters obliquely into, and rarefies, the main jet depending on the pressure conditions. The nozzle affords great flexibility for hard or soft blowing by adjusting the flow and pressure of the secondary oxygen. In addition to rarefying the main oxygen jet, the secondary oxygen with its tangential impingement on the main jet, appears to cause the main jet to rotate also. The advantage of such a rotating oxygen cone for regulating the reactions are yet to be fully investigated.

132. The most important aspect of the LD-AC process for treating high phosphorus hot metals is to create initially as foamy a slag as possible with a high FeO content to enable dephosphorization to start early. The ATR lance has proved highly satisfactory in this respect for Thomas iron. It can also be used with advantage to blow basic iron with one slag process effectively to regulate blowing conditions without changing lance height.

133. The paper mentions some of the interesting means of understanding the behaviour and degree of foamy slags by measuring the radiation intensity of the flame at vessel mouth, the stack temperatures of the waste gases and the noise level in the upper part of the vessel by arranging special devices outside the vessel in the area of the cone, and the extent of rise of the foamy slag inside the vessel by means of water-cooled probes.

134. Another lance, developed a few years ago in Austria, is a simple ring nozzle for LD-AC, where the lime powder is introduced through a central tube in the lance and the oxygen is carried in an outer tube and the mixing of the powdered lime with the oxygen takes place at the tip of the nozzle head.

135. Even a simpler system, known as the Strico process, also called the whirlwind system, has been developed in Austria in co-operation with Messrs. Strico. This has a separate lance, independent of the oxygen lance, for introducing powdered lime. This system has been used for charging the dry converter dust obtained from the electric filter. This has also been found suitable for injecting carbide powder to improve carbide efficiency in scrap melting, particularly in large vessels.

136. It therefore appears to be advantageous to include a simple pneumatic dust supply according to the whirlwind system in planning future LD steel plants, as this can be used for charging the dry LD dust, for powdered lime injection as well as for injection of powdered carbide. While this may add somewhat to the cost, there is no doubt that it would offer a great flexibility to charge different types of powder as and when required whereas the other types of integral lances can be used only for one purpose.

137. The paper mentioned other improvements achieved in the field of control of LD process. The optical method of observing the flame to determine the final point of soft steels (very low carbon) has enabled improvement in yield by adhering more exactly to the blowing conditions at the end of the process to control the FeO content in the slag and to improve the quality by eliminating overblowing of soft heats.

138. The method of catching the carbon for high carbon heats has been developed on a large basis and is still being used today. This is because of the difficulty in hitting the correct carbon by recarburizing in the ladle. Today, however, carbon carriers are blown pneumatically through a tube into the ladle during tapping and it is possible to hit the carbon without difficulty. This way the disadvantages of the catch carbon method would be removed by promoting instead the method of recarburization.

139. An LD plant in Austria has developed the method of recarburizing by charging a certain amount of hot metal into the steel stream in the ladle while tapping the heat, after blowing down to 0.08 or 0.10 per cent carbon. This method may be beneficial in plants where high quality iron with low silicon, sulphur and phosphorus is available, but may not be feasible in plants that do not have such hot metal. Also, in a large production shop with more than one converter in operation, there may be operational difficulties and interferences in using this method as a regular practice.

140. Various practices developed to produce special steels in an LD converter were then discussed. During the initial years special steels, with a total alloy content not exceeding 5 per cent, were blown. The range of special and alloy steels, including stainless steel, produced in LD has now increased. In addition to improvements in converter practice, vacuum degassing facilities and alloy bearing hot metal charges have substantially contributed towards production of alloy and special steel including stainless steel in the LD.

141. Finally the paper briefly reviewed other oxygen steelmaking processes such as the Kaldo, the Rotor and the LD-Kaldo process. To this may be added the new development known as the "Rotovert", which is a vertically rotating converter (32-40 rpm) in which the molten metal rises up the sides of the vessel as a result of the centrifugal force. This is being developed by Swedish and Italian teams on a 5-ton converter. In general, these rotating vessels offer possible advantages of increased yield, higher scrap charge, closer control of slag, better regulation of carbon drop, a more uniform metal temperature and also a more homogeneous steel. In spite of these advantages only ten Kaldo plants have been built since the first installation of Kaldo in 1956. The Rotor emerging from Oberhausen has been abandoned where it originated. At ISCOR, in South Africa, considerable changes to the plant and the operating practices have been made to overcome various problems. The major disadvantages of these processes are the high maintenance cost of the rotating vessels, refractory problems, lower productivity and higher investment.

142. On the basis of experience gained in the Rotor operations, ISCOR developed the Tandem process. A production rate of over 100 tons per hour is possible from a 300-ton tandem furnace (tapping 150-ton heats). But this would be still far below the 400 tons per hour rate of a 300-ton LD.

143. As regards the LD-Kaldo, this has been recently developed by Cokerell-Ougree, Belgium, to combine the advantages of the two processes, i.e. LD and Kaldo. They have installed in their Marchinne plant a 35-ton LD-Kaldo unit, which went into operation in 1965.

144. The developments in lance design, blowing techniques and operation controls have already enabled the LD process to handle all types of hot metal and produce various grades of steel, including a large variety of special and alloy steels, as well as stainless steel. It has fully taken over the functions of the open hearth and the Bessemer, both in regard to the various types of hot metal handles and the different types of steel produced by these processes, and

also the functions of the electric arc furnace in respect of certain grades of special and alloy steels. The objects with which the other oxygen steelmaking processes such as Kaldo, Rotor and the LD-Kaldo were started have already been achieved by the various developments in the LD process. Therefore, as in any steelmaking process that comes to stay, the supremacy of the LD in terms of investment, operating costs, product quality and versatility has been clearly established over the other oxygen steelmaking processes. According to the present trends, it appears that new steel production capacity being installed will be divided between the LD and electric furnace.

"Electric arc furnace steelmaking for developing countries"
(document ID/WG.14/24)

145. This paper considered the role of the electric arc furnace, with particular reference to developing countries. While the open hearth has been shown to be outpaced rapidly by oxygen steel, the share of the electric furnace in the total world steel production has been steadily rising. The electric furnace has already made substantial inroads into the field of plain carbon tonnage steels, which account for 62 per cent of the total electric furnace production in the United States and about 65 per cent in Japan in 1967.

146. In the next 15 to 20 years it appears that the oxygen converter and the electric furnace may be the only two principal steelmaking processes in most countries with the LD converting the bulk of liquid iron to steel, and the electric furnaces taking care of bulk of the scrap. In developing countries such a two-process situation would come even earlier because they generally have the opportunity of starting with the oxygen converter for integrated operations with an arc furnace for scrap based small-scale production. The industrialized countries on the other hand often have the problem of retiring their existing open hearths. Arc furnace steelmaking has become even more attractive to developing countries in conjunction with continuous casting.

147. The paper briefly reviews the various technological developments that are further widening the scope and usefulness of the electric arc furnace. These include installation of large furnaces (200-ton furnaces are already in operation), renewed consideration of six electrode elliptical shell design for even larger capacity furnaces in future, high power operation, intensive use of oxygen, preheating of scrap, continuous charging of sponge iron, and development of high density and high strength electrodes. The superior performance of high power operation is evident from the experience at Hojalata y Lamina, Monterrey, Mexico, where a 50 per cent increase in output and 12 per cent reduction in

production cost is reported. Preheating of scrap is being increasingly adopted and 15 to 20 per cent increase in production rate and about 15 per cent reduction in power consumption are generally achieved. These developments are important for developing countries where electric power cost is in many cases high and not available in abundance.

148. The paper highlights the considerable interest being shown on the use of pre-reduced material in electric arc furnace steelmaking. The relative availability and cost of scrap, iron ore and energy, particularly in developing countries that have plans for installing steelmaking facilities are important. Direct reduction also assumes significance in countries with large deposits of natural gas. Where adequate capital and raw materials resources are not available for installing integrated steel works with conventional iron and steelmaking facilities, electric arc furnace and continuous casting combination (using scrap and sponge iron) may well provide a starting basis for small plants in developing countries.

149. The trend towards using sponge iron to supplement scrap in developing countries is due to the fact that there is generally scrap shortage in developing countries. These countries cannot draw on a potential supply of capital scrap as the steel consumption in earlier periods was low. Also, the process scrap arising in a developing country is generally lower since a substantial proportion of the finished steel goes into construction, as compared to advanced countries where manufactured products such as automobiles, consumer durables and industrial machinery give rise to relatively more process scrap.

150. For the above reasons, direct reduction has been employed in South America and plants are being installed in South Korea, Brazil and New Zealand. Currently, pre-reduced materials equivalent to 640,000 tons of Fe per year are already being used in arc furnace steelmaking. This is expected to reach 1 million tons by the end of 1968. The recent development of continuous charging of sponge iron in electric arc furnaces indicates the possibility of increasing the production rate in high sponge heats compared to 100 per cent scrap charge heats by about 40 per cent.

151. The paper then presented a survey of electric arc furnaces in India. The total crude steel production in India is expected to rise from the present level of 6.6 million tons to about 18.5 million tons by 1975. During this period the

electric furnace steel is expected to increase from 230,000 tons to 1.4 million tons by 1975, accounting for 7.3 per cent of the total production. The paper described two of the latest arc furnace installations in India - the 50-ton arc furnace for alloy steel production in the Alloy Steels Plant at Durgapur of the Hindustan Steels Ltd. and the 25-ton arc furnace, with continuous casting facilities at the Kalwe plant of the Mukand Iron and Steel Co. near Bombay. In view of the difficulties in getting scrap in the required quality and quantity, the possibility of producing sponge iron to supplement the scrap requirements for arc furnace steelmaking is being contemplated.

152. High grade sponge iron with 92 to 95 per cent Fe can be produced from the rich iron ores of India, using the non-coking coals available in the country. The cost of sponge iron could be of the same order as the cost of good scrap, which currently sells at a price of $30 per ton. The cost of liquid steel produced in arc furnaces using 50 per cent scrap and 50 per cent sponge iron in the charge is roughly estimated to be of the same order as the cost of liquid steel produced by using 100 per cent scrap. In a country like India, the role of the arc furnace would be important in regions where adequate resources of raw materials are not available for installing large integrated steel plants.

153. The paper concluded that, for developing countries, arc furnace continuous casting plants could well be considered initially for small-scale steel production as the capital required will be low, operating costs can be competitive, technology is well established, and the necessary operating skill could be readily developed. The production of sponge iron to supplement the paucity of scrap in developing countries would enable, in particular, situations to use the limited resources or sub-standard raw materials available locally. Where large steel tonnages are envisaged because of favourable iron ore and coking coal reserves as well as market conditions, integrated steel plants with blast furnace and oxygen converters would be the answer.

"New theoretical developments in the field of steelmaking"
(document ID/WG.14/71)

154. This paper emphasized the importance of developing a sound theoretical basis and improving upon the concepts on the mechanism and nature of particular processes and reactions in steel melting, deoxidation and casting. Physical chemistry, hydro- and aerodynamics, and thermal physics, mainly of liquid steel but partly also of gaseous mediums, are the scientific foundations of the process theory of steelmaking.

155. The paper discussed how the steelmaking processes take place in the diffusion zone and showed the importance of mass transfer of reacting particles in determining the speed of the process. The diffusion between the oxidizing gas bubble and the layer of liquid metal zone around such a bubble has been considered. It is shown that the average relative contact-surface of oxidizing gases and metal during a heat is at least three times larger than the conventional bath surface of the converter. Experimentally it has been found that the effective diffusion co-efficient with the basic open-hearth process is in the range of 25 to 80 cm^2/sec, whereas with oxygen converter process it amounts to several thousand cm^2/sec.

156. From the above, it will be clear that the rate of oxidation processes is closely connected with the hydrodynamics of the molten bath. To find new ways of intensifying the process requires complex investigation of hydrodynamics and heat transfer in metal.

157. The paper then dealt with the theory of liquid metal structure, and the forms of impurity occurrence in the melt. The ionic theory of the structure of metallurgical slags is discussed. All these studies enabled the analysis of the transition of impurities from metal to slag and the role of the slag in transferring oxygen and hydrogen to the metal from the furnace atmosphere and thereby protecting from the penetration of nitrogen and sulphur. Slag can also act as a medium to assimilate non-metallic inclusions which come to the surface from the liquid metal.

158. The physical chemistry of surface phenomena in contact surfaces such as metal slag, metal gas, and even metal solid (refractories) is also discussed. This theory has wide application in refining metal from non-metallic inclusions, namely the products of deoxidation. In studying the equilibrium of various processes, and the activities of components dissolved in metal and slag, chemical thermodynamics has to take into account the extremely high temperature conditions of the reaction zone when oxygen is injected into the molten bath.

159. Finally, the paper referred to the physical chemistry of micro-metallurgical processes to understand the mechanism of the crystallization of metal and its effect on the properties of the cast metal. Today there are several methods available to make such structural analysis. These methods include electronography (electron diffraction study) neutronography (neutron diffraction study) and roentgenography. Instruments such as scanning electron microanalysers will be of special value in these studies. Microanalysis will help in locating the causes of defects in metal and help in developing methods for their prevention.

"SL/RN direct reduction process for the production of sponge iron and its melting to steel"
(document ID/WG.14/19)

160. This paper described the methods of reducing iron ore with gaseous or solid fuels. The use of low volatile coals of non-coking quality for direct reduction could make substantial savings in the cost of steel. It would also extend the steel industry, the production plans of which are hampered by lack of coking coal.

161. The SL/RN process, developed by three groups of companies, namely the Steel Company of Canada and Lurgi Gesellschaft für Chemie and Hüttenwesen mbH and the Republic Steel Corporation of the National Lead Company, shows promise for the future. The process is based on the use of a rotary kiln as reactor and solid carbon as a reducing agent.

162. The flow sheet of the process using pellets or lump ores and low volatile reduction coals is set out in the paper. The raw materials, ore, coal for reduction together with recycled coal and fluxes are charged into a rotary kiln and preheated to the reduction temperature at approximately 1100°C to avoid reoxidation of sponge iron. The grain size of the kiln feed is so adjusted that the major part of the sponge can be separated by normal screening. The fine sponge iron is removed by low intensity magnetic separators. The optimum reduction temperature of the kiln depends upon the fusion temperature of the raw materials.

163. A combined preheating unit and rotary kiln can be used for ores with a low gangue content, preferable for the production of sponge iron to be processed in the electric arc furnace. The necessary flow sheet based on a travelling grate is shown. The pellets are prehardened and preheated by the waste gases leaving the rotary kiln. The biggest units being designed are kilns with an annual production of 500,000 to 600,000 tons of sponge iron. The kilns required for this capacity will have a diameter of 6 metres and a length of 60 to 70 metres.

164. If sponge is used in the electric arc furnace, the gangue content of the ore should not exceed 5 per cent. However, when the reduced ore is treated in a blast furnace or in an electric ironmaking furnace, the gangue content is not confined within such limits. The burden size of the ore feed depends on its reducibility. The most important prerequisite is that the ash fusion temperature is about 100°C above the working temperature, i.e. 1200°C. The preferable burden size of coals is below 10 mm. The reactivity of the coal has a decisive

influence on the kiln through-put. Dolomite or limestone of 0.1 - 1 mm size is employed as a desulphurization agent.

165. Some typical sponge iron analyses are given in the paper. It is possible to attain reduction degrees exceeding 95 per cent with reference to iron oxide. The carbon content depends on the reactivity of the reduction coal.

166. The capital costs depend not only on the size of the plant, but also on the plant layout, which is necessitated by the type of raw materials to be used and by the method of processing the reduced ore. Local conditions and prices for machinery, electrical equipment and civil engineering also affect capital costs. Typical consumption figures for a plant with an annual production of approximately 300,000 tons of sponge iron are shown. These consumption figures are offered merely as a guide.

167. By the end of 1969 more than 1.8 million tons of iron ore will have been processed in four plants comprising altogether 7 kiln units.

168. The processing of sponge iron in the blast furnace is also described. The percentage decrease of the coke consumption in relationship to the degree of metallization of the total burden is shown. Despite the anticipated scattering, the values readily arranged themselves around a straight line representing a decrease in coke consumption of 0.5 per cent of the burden metallized. With a very high degree of pre-reduction it is doubtful whether the blast furnace is still the most economical aggregate or whether it would not be better to consider the use of low-shaft furnaces or hot blast cupola furnaces as an alternative for processing sponge iron.

169. In electric ironmaking furnaces the advantage of burden pre-reduction is still more evident than in the case of blast furnaces. According to the calculation of Astier, it is feasible by the use of 87 per cent pre-reduced burden - equivalent to 80 per cent degree of metallization - to achieve a coke consumption of less than 100 kg and an energy consumption of 800 kWh per ton of pig-iron.

170. In the cupola furnace the use of new methods, particularly the continuous charging of sponge iron into electric arc steelmaking furnaces, has enabled productivity increases of up to 45 per cent as compared with the standard scrap process to be obtained.

"Continuous steelmaking"
(document ID/WG.14/10) and
"The IRSID continuous steelmaking process"
(document ID/WG.14/25)

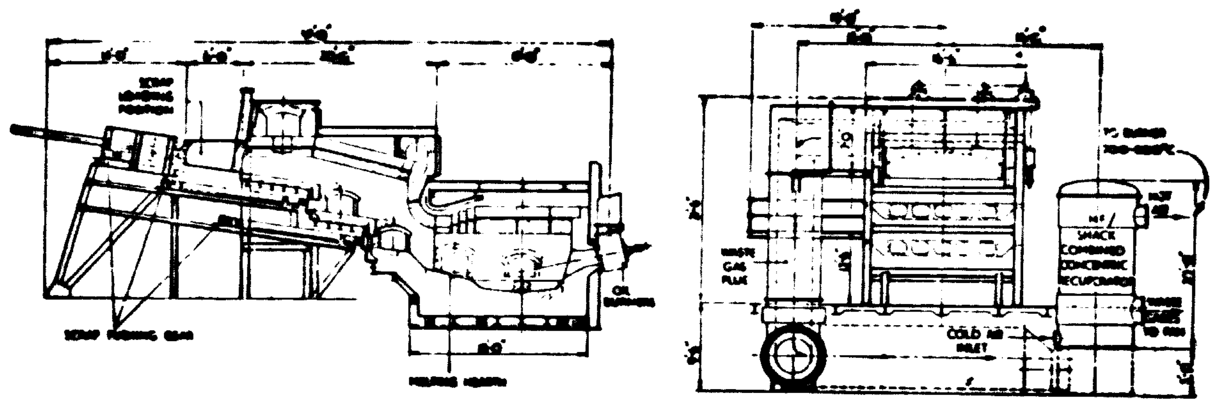
171. The two papers examined continuous steelmaking. The first paper described how in 1954 Thring proposed a continuous counterflow plant for steelmaking by scrap melting. Experiments were conducted at Sheffield University and the steel plants of Steel, Peach and Tozer and G.P. Wincotts and Ruhr Stahl A.G. Figure 1 shows a furnace which was built by Gebrüder Benteler at Paderborn in the Federal Republic of Germany. This furnace was to melt continuously but to be tapped every two hours, with 16 to 20 tons of molten steel which was taken to an arc furnace for finishing and continuous casting. The furnace melted satisfactorily at 8 tons per hour with an over-all thermal efficiency of 55 per cent. The yield of molten steel was about 90 per cent, which was considered to be satisfactory as the scrap was very dirty. The carbon could be controlled between 1.1 and 1.7 per cent by charging anthracite with the scrap.

172. Another development in this field, the BISRA spray refining process is shown diagrammatically in the paper "Continuous steelmaking". The molten iron falls in a stream from a tundish through two nozzles. Through the first of these lime and fluxes are injected as a continuous stream of powder, while supersonic jets of oxygen enter through the second, which is water-cooled. These jets pick up the lime and fluxes and impinge at a small angle on a falling stream of iron. The refined metal falls into a receiving ladle with a nozzle at the base for metal flow into the casting equipment and a side spout for slag overflow. Nearly all the carbon monoxide produced is burnt with the oxygen to CO_2; the waste gases contain 1 to 2 per cent carbon monoxide and 14 grains/ft^3 (32 g/m^3) of fume. The surplus heat can be absorbed by allowing the hot metal to melt up to 40 per cent of cold scrap.

173. IRSID have also been working for a number of years on a continuous steel refining process at the scale of 11 tons per hour and the progress is described in the paper "The IRSID continuous steelmaking process". The principle of the process is based on a considerable increase in the surface of the metal in the slag. To this end a continuous complex phase of slag, metal and gas is created. The process takes place in the first vessel, called a reactor. This reactor is fed with a regular known input of pig-iron. A blowing lance feeds in oxygen and lime for making the slag and, if so wished, the cooling agents necessary for obtaining the equilibrium in the heat balance. The cooling agents may be

Figure 1

10-ton/hr. one-way fired continuously charged scrap-melting furnace



added in lump form, using chutes. The reactor is equipped with an outlet connected to a device for cooling and cleaning the gases, which are treated without secondary combustion of CO with the ambiant air. An overflow aperture in the wall of the reactor, at a level higher than that of the pig-iron inlet, provides for continuous draw-off of the slag-metal phase, this metal being the desired raw steel.

174. A second recipient, called a decanting vessel, is installed alongside the reactor and receives the slag-metal phase. This decanting vessel, which is chemically inert, or nearly so, particularly when refining low phosphorus pig-iron, separates slag and metal and is equipped with an orifice for de-slagging and a siphon for extraction of the steel.

175. The reactor-decanting vessel assembly constitutes what is termed a processing unit and, to complete the installation, a number of indispensible peripheral apparatuses must, of course, be added.

176. The operating results obtained on the one-stage plant with an average flow of 12 tons per hour, the yield, heat balance and wear of refractory lining are considered promising.

177. Over the past year, a number of tests representing some 24 hours of continuous steelmaking have been carried out also on a two-stage plant with recirculation of the second stage slag (Figure 2). This type of continous steelmaking is perfectly adapted to pig-iron with a high phosphorus content for which processing in conventional furnaces also takes place in at least two phases.

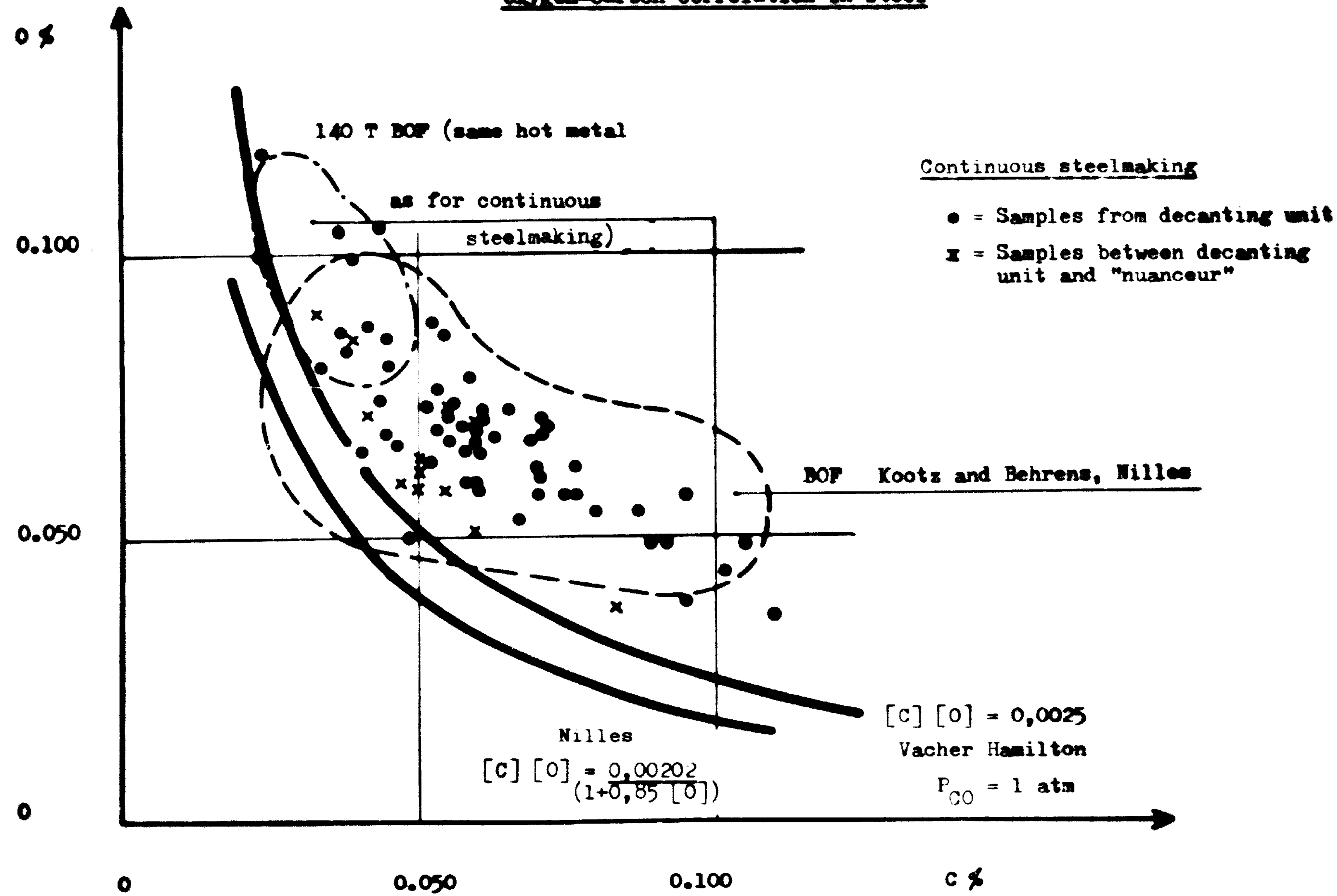
178. The results obtained are extremely promising for the processing of high phosphorus pig-iron. The operating figures obtained at the pilot scale concerned for yield, thermal balance and refractory consumption with high phosphorus are considered encouraging as well.

179. A semi-industrial unit has been designed for the processing of high phosphorus pig-iron at the rate of 700 tons per day and is expected to be operating in the middle of 1968. This will allow precise fabrication costs for both the one-stage and two-stage processes to be assessed.

180. It is known that the world resources of good quality low ash coking coals are slowly being depleted. As a consequence, the replacement of high ash coke for iron smelting in the blast furnace by the injection of auxiliary fuels is important from an economic and metallurgical standpoint.

Figure 2

Oxygen-carbon correlation in steel



"Injection of light petroleum naphtha into iron smelting furnace"
(document ID/WG.14/26)

181. Light naphtha is a by-product of the petroleum industry and being currently surplus in India, experiments were conducted at the National Metallurgical Laboratory on its utilization as an injectant for iron smelting and the results obtained were compared with those obtained with fuel oil injection.

182. A low-shaft furnace of circular cross-section having a hearth diameter of 1300 mm, back diameter of 1600 mm, diameter of the top of 1300 mm and an effective height of 3.5 m was used for these experiments. In view of the short stack height of the furnace, it was decided to employ an axial lance to ensure the complete combustion of the injected fuel. The investigations with either fuel oil or naphtha injection were subdivided into three stages in which the air blast was enriched with 1, 2 and 3 per cent oxygen respectively under practically the same operational conditions, until equilibrium conditions were obtained. The operational results with the fuel oil injection at different degrees of oxygen enrichment are summarized in Table 1.

183. The injection of naphtha with a simultaneous enrichment of the air blast with oxygen was noticed to increase the productivity with an appreciable decrease in coke rate. The replacement ratio obtained with naphtha injection was better than that for fuel oil.

184. The injection of auxiliary fuels normally reduces the coke rate, the replacement ratio 3/1 to 2/1 of coke by injected fuel should be obtained along with increased production rates. It may be observed from Table 2 that with the progressive increase in oxygen enrichment of the blast, the fuel rate was progressively lowered, associated with an increase in iron production. At a naphtha injection rate of 18 kg/tons of pig-iron and 8 per cent, oxygen enrichment, the fuel rate was lowered by 57 kg/ton and the productivity was increased by 20.5 per cent.

185. The economics of fuel injection will, however, largely depend on the local cost of the fuels, i.e. coke and the auxiliary fuels, the installation and operation of the injection system.

186. Assuming that the efficiency of the naphtha will at least be comparable to that of fuel oil for iron smelting, a weight replacement ratio of about 1 will strike the balance between the costs of coke saved and naphtha injected.

Table 1

Operational results of fuel oil injection and oxygen enrichment of the blast

Period	Base	First stage	Second stage	Third stage
1. Quantity of fuel oil/ton of pig-iron (kg)	Nil	31.0	30.7	30.6
2. Average oxygen enrichment (percentage)	Nil	1	2	3
3. Production rate (ton/day)	7.3	7.7	8.3	8.8
4. Productivity (ton/m^3/day)	1.0	1.06	1.14	1.2
5. Increase in daily production (percentage)	-	5.50	13.70	20.50
6. Corrected fuel rate fixed carbon/ton of pig-iron, (kg)	1,570	1,515	1,505	1,495
7. Slag volume (kg/ton of pig-iron)	1,045	1,029	1,010	990
8. Replacement ratio	-	1.80	2.10	2.42
9. Hot blast temperature (°C)	575	565	570	560
10. Top gas temperature (°C)	385	360	335	295
11. Hot blast volume, (Nm^3/hr)	2,400 - 2,600	2,400 - 2,500	2,400 - 2,600	2,500 - 2,600
12. Blast pressure (mmWG-average)	1,800	1,800	1,800 - 1,850	1,800 - 1,850
13. Metal analysis (percentage)				
C	2.50	2.80	2.60	2.70
Si	3.50	4.12	3.30	3.20
S	0.07	0.07	0.08	0.09
Mn	0.18	0.04	0.14	0.12
14. Slag analysis (percentage)				
CaO	34.30	31.60	32.27	34.70
SiO_2	35.60	38.48	35.08	37.10
Al_2O_3	22.80	22.50	20.40	21.20
MgO	3.80	4.30	4.01	4.82
FeO	1.20	1.60	1.80	1.40
15. Top gas analysis (percentage)				
CO	26.00	26.10	26.90	27.20
CO_2	4.30	4.50	4.80	5.30
CH_4	3.60	3.10	3.00	3.00
H_2	0.60	0.57	Nil	Nil
CO/CO_2 ratio	6.00	5.80	5.50	5.10

Table 2

Operational results with naphtha injection and oxygen enrichment of the blast

Data on	Base period	First stage	Second stage	Third stage
1. Quantity of naphtha/ton of pig-iron (kg)	Nil	18.4	17.8	17.8
2. Average oxygen enrichment (percentage)	Nil	0.74	1.4	2.6
3. Production rate (ton/day)	7.3	7.8	8.2	8.8
4. Increase in daily production (percentage)	-	6.8	12.3	20.5
5. Corrected fuel rate fixed carbon/ton of pig-iron (kg)	1,570	1,536	1,525	1,517
6. Slag volume kg/ton of pig-iron	1,045	1,026	1,014	995
7. Replacement ratio	-	2	2.5	2.95
8. Hot blast temperature (°C)	575	585	570	575
9. Top gas temperature (°C)	385	360	345	325
10. Hot blast volume (Nm^3/hr.)	2,400 - 2,600	2,400 - 2,650	2,500 - 2,700	2,600 - 2,750
11. Hot blast pressure, mmWG (average)	1,800	1,800	1,820	1,800
12. Metal analysis (percentage)				
C	2.5	2.7	2.51	2.60
Si	3.5	3.6	3.40	3.50
S	0.07	0.07	0.064	0.05
13. Slag analysis (percentage)				
CaO	34.80	33.90	36.20	36.50
SiO_2	35.60	35.70	35.80	35.60
FeO	1.20	1.30	1.20	1.00
14. Top gas analysis (percentage)				
CO	26.00	26.00	25.80	26.60
CO_2	4.30	4.50	4.67	5.30
CH_4	3.60	3.10	3.20	3.50
15. CO/CO_2 ratio	6.00	5.80	5.50	5.00

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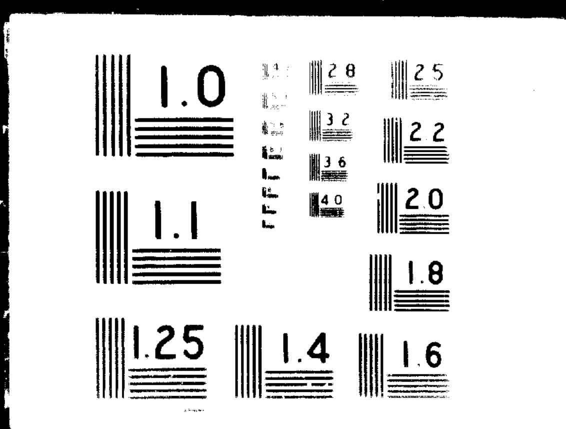

"Improvement of the steel quality by treatment with synthetic slags"
(document ID/WG.14/72)

187. Accelerated passage of impurities from metal to slag and their more complete removal can be achieved by enlarging the surface of contact between the metal and slag phase. The slag can be melted in a special slag melting furnace, drained off into a ladle and a heat of steel poured on to it. In the course of tapping owing to the work done by the jet of metal falling into the ladle, the slag emulsifies in the metal and as a result, the surface of their contact increases considerably, giving an additional opportunity for removing non-metallic inclusions from steel on account of assimilation by synthetic slag.

188. The method of refining steel with liquid synthetic slag in the ladle was first suggested by Mr. A. S. Techinsky. In the following year, it was repeatedly tested in a number of countries, including the Soviet Union, but primarily using acid and lime-ferruginous slag. Beginning with 1938, lime-aluminous slag for refining steel found a rather limited application in France and Italy.

189. Analyses of ball-bearing quality steel refined with synthetic slag in the ladle showed that it contained banded inclusions (sulphide, oxide silicate) at a lower level than that of the same steel melted in accordance with conventional technology. On the contrary, such a low level of pollution through globular inclusions is achieved only upon melting in an electric arc furnace according to a usual technology.

190. As a result of experiments it was found that the content of oxide inclusions proved to be at a minimum in heats with diffusive deoxidation of metal in the furnace and its consequent treatment with synthetic slag. The content of globular inclusions in structural steel was lower than in ball-bearing steel and diminished with decreasing carbon content in the steel. The content of banded oxide inclusions in structural steel, however, dropped with increasing carbon content in the metal. If aluminium was added to the metal in the course of its treatment with synthetic slag, the pollution of steel with banded inclusions of corundum and spinel sharply increased. The increase in the amount of aluminium added to the metal for final deoxidation led to a rise in the content of banded oxide inclusions and to a decrease in globular oxide inclusions.

191. Interaction between the metal and the droplets of synthetic slag floating from it to the surface resulted in a decrease in the content of non-metallic inclusions in the small ingots so produced. The degree of the decrease in their content differed, however, depending on the amount of the deoxidizers added to

the metal and, consequently, on the chemical composition of the inclusions. As the amount of the added silicon and manganese increased and correspondingly the content of silica in the composition of the inclusions rose, the degree of their removal from the metal diminished, the decrease in the amount of inclusions being proportional to the drop in the content of silica in them in relation to the metal.

192. Analysis of the results led to the conclusion that the inclusions enriched with silica and having a higher melting point and viscosity as well as solid corundum and spinel inclusions are more difficult to be absorbed by the slag than inclusions of non-viscous iron-manganese silicates.

193. As a result of these investigations, the following principal advantages of steel refined with synthetic slag have been established. When melted in electric arc furnaces, the sulphur content in the steel is 1.5 to 2 times lower and oxygen content is 30 to 35 per cent lower than in ordinary steel. Open-hearth steel refined with synthetic slag contains from four to five times less sulphur than ordinary open-hearth steel.

194. In the final analysis, the total content of non-metallic inclusion in steel refined with synthetic slag is five to ten times lower than in steel of the same grade melted according to standard technology. Owing to lower levels of pollution with various detrimental impurities, steel refined with synthetic slag possesses a higher level of ductility across the direction of rolling, greater uniformity, a smaller anisotropy of the properties and improved properties at very low temperatures. The index anistropy of the properties of steel likewise increases 1.5 to 2 times. There is also a substantial increase in its ductility at temperatures of hot deformation, as well.

195. The advantages of the process are above all, in reducing the rejection of steel at iron and steel works and machine-building plants with regard to non-metallic inclusions, the occurrence of fine cracks, exfoliation, the discrepancy between the mechanical properties and the requirements, the deficiencies of welding, cracks upon sagging of parts etc. The cost of treating a ton of steel with synthetic slag amounts at present to about 4 per cent of the cost of steel.

"Recent achievements in continuous casting technology"
(document ID/WG.14/73)

196. The Central Research Institute for Ferrous Metallurgy (TSNIICHERMET) has carried out a great deal of research work at the pilot and industrial plants in the field of continuous casting of carbon and alloy steels. The results of

these investigations made it possible to find out the principal conditions to provide for a reliable process of continuous steel casting.

197. They are as follows:

(a) A reasonable distribution of metal as it goes through the tundish into moulds;

(b) Casting of steel within the optimum temperature limits;

(c) Providing symmetrical crystallization during the formation of billets;

(d) Creating the conditions to reduce shrinkage strains in a solidifying billet;

(e) The withdrawal of billets at the assigned, and as constant as possible, speed;

(f) Protecting the molten metal from oxidation during the casting process;

(g) Maintaining the optimum rate of oxidation of the whole heat of rimming steel in the course of casting;

(h) A complete solidifying of billets in the secondary cooling zone under assigned conditions;

(i) Providing automation and mechanization of the plants.

198. The investigations of the tensile-stressed skin of the billet with smooth surfaces of the wide faces have shown that it is possible to decrease the stresses by shortening the linear dimensions of those areas of the skin of the wide faces that have separated from the walls of the mould. The stresses decrease with the increase of the height and with the decrease of the wave spacing The choice of the optimum shape and parameters of the corrugated surface with a certain ratio between the spacing and the depth of wave has made it possible, not only to reduce considerably the number of defects in wide slabs such as longitudinal surface cracks and transverse indentations, but also to eliminate almost completely scrapping slabs on account of surface defects.

199. Appearance of the inner cracks is stipulated by the occurrence of mechanical and thermal stresses as well as of the stresses caused by the phase transformations in the metal. The cracks appeared mainly when the critical value of tension or compression stresses at the boundary between liquid and solid phases has been surpassed. Almost all inner cracks appear in the temperature range of the so-called hot brittleness, i.e. immediately below the temperature of solidus.

200. Mathematical studies of the nature of defects such as the formation of hot surface cracks, indentation with internal cracks and central porosity, have shown that they depend on the analysis of the metal to be cast, on the casting

machine, on the geometrical dimensions and the design of the moulds and its surface condition as well as on the condition of casting and cooling of continous casting.

201. Developing the technique of continuous casting of alloy and high-alloy steels made it possible to change the temperature of casting without increasing the cast steel secondary oxidizing.

202. As a result, the refractory life has been improved, the consumption of alloys has been decreased, and one of the most difficult problems, and the most important one, i.e. to produce quality castings from steels of such type, has been solved.

203. In vacuum degassed steel, casting is started at a temperature 20 to 25°C lower than normal but the process of casting is run without forming skulls, the metal forming a good stream, and defects due to blisters are completely absent.

204. In continuous casting of rimming steel for the production of slabs for cold rolled sheet and automobile sheet it was established that the following factors were a decisive influence on the quality of continuous casting of rimming steel:

(a) The degree of oxidation of metal;

(b) The design of the mould;

(c) The properties of the lubricant as well as its uniform supply to the mould walls;

(d) The method of pouring metal into the mould;

(e) The location, quantity and distribution of blowholes along the height of slabs are determined to a great extent by the oxygen content of steel.

205. In the course of investigations it was also found that special measures should be taken to limit the amount of oxygen absorbed from the atmosphere.

206. The technique developed to cast continuously aluminium-stabilized steel (2.5 kg/ton) to produce non-aging sheet has enabled slabs of higher quality, cold rolled automobile sheet to be obtained. A surface quality of sheets rolled from continuously cast non-aging steel slabs was also found suitable for manufacturing facial parts of automobiles.

207. The pecularities of the continuous casting of square blooms was also examined. The initial stage of distortion of bloom shape is brought about by the emergence of an irregular gas gap that sharply decreases the heat removal

and leads to an uneven cooling along the perimeter of the bloom by different values of the friction forces between the solidifying skin and the walls of the mould along its perimeter. At the same time the non-uniform deformation of the bloom skin at the upper part of the mould occurs as a result of its insufficient strength. As a result, moulds of special design were developed which allowed identical conditions for cooling the corners of a continuously cast bloom. The use of moulds of such a type made it possible to produce cast blooms of correct geometrical shape as well as to eliminate the internal corner cracks.

208. The results of investigations showed also that a rolled metal structure can be produced at a suitable reduction if castings have an equiaxial structure with dispersed axial porosity. The basic technological parameters of casting (temperature of casting, withdrawal speed and intensity of secondary cooling) have been determined, which allows an equiaxial structure and a dispersed axial porosity to be provided for in case of casting different grades of steel into square section moulds.

209. A mould of round cross-section has been designed with a differential heat transfer along its height, which allows a regular heat transfer to be provided for at the places of variable contact of the billet and the mould to produce rounds of ideal geometrical shape.

210. To improve further the quality of continuously cast billets, theoretical investigations are carried out by TSNIICHERMET in the following directions:

(a) Development of thermo-, chemical- and erosion-resistant refractory materials for lining the steel pouring ladles and tundishes as well as making nozzles and non-swirl nozzles. The latter must ensure a long pouring time when submerged under the metal level in the mould.

(b) Further study of waved mould application (wave parameters, wall thickness), which makes it possible to cast wide slabs without longitudinal surface cracking.

(c) Extension of work on application of free-or-pressure pouring in combination with metal surface protection in the mould with exothermal mixtures, graphite or reducing gas.

(d) Study of the two-phase zone and its extension at certain chemical analysis in relation to the heat exchange conditions between the billet and the environment.

(e) Development of rapid methods for adjustment of the solidification process by influencing the solidifying metal with a magnetic field, vibration, ultra-sounds and by introduction of additional crystallization centres in solid, liquid and powder states.

"Water supply, re-use and disposal at an integrated iron and steel works in Great Britain"
(document ID/WG.14/11)

211. The paper examines the water requirements of iron and steel plants. In the production of iron and steel, hundreds of tons of water are required. Only a small percentage of this is actually used in the production of iron and steel, the major part being lost by evaporation. In cases where the water supply is limited the problems posed are considerable.

212. The paper describes the water supply and conservation in the Appleby-Frodingham works of the Midland Group of the British Steel Corporation. At this plant there is a limited water supply and also severe restrictions on the disposal of effluent from the works. The sources of supply are between two and a half and five miles from the works. This and the limited supply already mentioned and effluent disposal regulations have necessitated the use of recirculating cooling systems and the pursuance of a continued policy of water conservation.

213. There are three main sources of fresh water supply: a small river, the town sewage water and boreholes. Water drawn from the river and the sewage works is used for cooling furnaces, quenching hot materials and general works purposes while that from the boreholes supplies the steam-raising and amenity demands. Dual electric power supplies at the pumping stations, emergency reservoirs and ring main distribution systems on the works help to keep a continued water supply.

214. The water from all three sources is very hard and just over 60 per cent is softened before use. The alkaline hardness of the river supply and the sewage effluent is removed with lime in precipitation-type softeners before the water is used to replenish the losses from cooling recycling systems. The borehole water is chlorinated at the source to safeguard the drinking supplies. The portion used for steam-raising is lime-soda softened, followed by base exchange treatment to reduce the hardness to commercial zero. Solids arising from the softening process are collected as a sludge, which is used for liming the moulds at the pig-iron casting machine or discharged into a sludge-drying lagoon.

215. The sources of fresh water drawn upon by the works are capable of producing an assured supply at the rate of 3,550 gallons per minute and the average demand amounts to approximately 70 per cent of this. Nearly 90 per cent

of the water brought into the plant is lost as vapour to atmosphere, the remainder is discharged as effluent.

216. Twenty-nine separate systems recirculating and cooling are in use at the works. They may be divided into two groups:

(a) Indirect cooling systems in which the water is used only to remove heat from condensers, furnace elements, oil coolers etc;

(b) Direct cooling systems in which the water serves as both a cooling and cleansing medium, e.g. in gas-cleaning, rolling mills and continuous casting plants.

217. Indirect cooling systems take up about two thirds of the total water used. Their main purpose is to provide a continuous water supply of suitable quality to ensure efficient cooling of production equipment. The most common problem in these systems is the prevention of the formation of calcium carbonate scale as the already softened water is concentrated by evaporation in the cooling tower. This is achieved by the addition of acid and dispersants or inhibitors to the circulating water and a judicious control of bleed-off water.

218. In the direct cooling systems, water comes into contact with the substance being cooled, and in addition to absorbing heat invariably carries solids produced in many of the operations as in gas-cleaning plants, rolling mills, pig-iron casting machines and plants for continuous casting of steel. To ensure an efficient cooling system, these solids are generally removed by special equipment, which includes clarifiers, hydro-cyclones and filters. Two systems in which such equipment is used are described: blast furnace gas-cleaning, and section-mills water circulating systems. In addition, certain items of equipment like pumps, reservoirs, balance and emergency supply tanks and cooling towers which service both direct and indirect cooling systems are also described.

"Energetics of the iron and steel industry"
(document ID/WG.14/75)

219. This paper describes the development of energetics of the USSR iron and steel industry over a period of 50 years. The paper considers principal kinds of by-product energy resources used in the iron and steel industry and also the energy yielded by the by-products in production processes.

220. The development of energetics is shown in connexion with the rapid growth both of metal production and of operational unit capacities. Periods of forced delay in the development of iron and steel industry energetics in the time of the Civil War (1918-1921) and the Second World War (1941-1945) are discussed in the paper; its rise and progress in the following years are shown. It is noted

that even in the years of war, enormous work was carried out for transferring the metal production to the eastern region of the USSR and for increasing the energy capacities. This created a possibility for the production of more electrical power, which by 1945 exceeded that in the pre-war year 1940.

221. The section on the energy balances of the iron and steel industry gives the characteristics of fuel balances, their pattern and development for a number of years. The effect of natural gas use on the fuel balance pattern is considered as well as that of intensification of blast furnace production on decreasing the blast-furnace gas output.

222. Fuel utilization in metallurgical power supplies shows the provision of metallurgical units with modern electrical equipment incorporating improved control systems, automatic drives and telemechanized power supply systems.

223. Increasing power consumption in the iron and steel industry and rising production at the works power stations are shown. Due to the development of energy network and district power stations the share of power generated by works power stations in its total consumption in the iron and steel industry decreased from 63 per cent in 1950 to 25 per cent in 1967.

224. The heat supply section describes the development of heat supply of enterprises and neighbouring towns. The characteristic of heat balance of the iron and steel industry is given according to heat supply sources and their development by years.

225. The iron and steel industry is a large source of by-product energy. The by-product energy section of the paper considers the by-product heat and fuel sources, the parameters of waste heat installation operation and their productivity and efficiency.

226. The data of waste-heat boilers, evaporate cooling, invented and widely used in the USSR, and waste-gas hoods of oxygen converter shops are given. The methods of utilizing the surplus energy of gas pressure (1.5 to 2.0 atm) for exhaust-gas turbines used first in the USSR are described. Relative values of blast-furnace gas yield and of its use to reduce energy loss are given for a period of 25 years. Finally the largest coke dry quenching installations in the world utilizing hot coke heat are described.

227. The water supply section of the paper gives the schemes for water supply and the data of water consumption in the iron and steel industry. The large water requirements led to the necessity for building artificial water storage

reservoirs, channels, sewage disposal plants, plants for supplying boilers with water, power and waste-heat installations.

228. The section on the compressed air supply gives the technical characteristics of installations and equipment to provide compressed air for blast furnaces and air-separation apparatus at oxygen plants and for the technical needs of the production shops of enterprises.

229. The section on the power and air-blast stations shows the development of stations relative to capacities and steam parameters of boiler units, turbo-generators and turbo-compressors. An extensive use of high pressure steam is noted as well as combined heat and power production.

230. The importance of the establishment of metallurgical enterprises and the development of their energetics in poorly developed areas of the country in rapid industrial development, growth of population, planning and organization of public services and in cultural progress of this area is shown.

231. The section on oxygen in iron and steelmaking dealt with the effect of the iron and steelmaking intensification on the development of tonnage oxygen plants. The increased capacity of air-separating units and of the output of oxygen plants are outlined as well as the increased productivity and capacity of compressor installations. A survey of oxygen development is considered, taking into account the requirements for plant oxygen purity.

232. The automation section gives data on the development of production process automation in the iron and steel industry and of the effectiveness of the automation of separate units. The status of automation of the principal processes of the iron and steel industry and the technical principles of some automatic arrangements are given.

233. The section on air and water pollution control illustrates the measures for gas cleaning and sewage disposal carried out in the iron and steel industry The results obtained are pointed out.

234. The section on the organization of energy equipment maintenance and repair gives an account of the principal problems. The expediency of centralization of energy equipment, heavy repairs at specialized trusts and industrial enterprises is outlined.

235. The section on the outlook of the energy economy development sets forth the main trends in developing the energy economy of the iron and steel industry for the provision of all the various kinds of energy required as well as in assessing the problems of improving the techno-economic characteristics involved

236. The further development of the iron and steel energetics will be carried out with installation of the most efficient equipment, with modernization and replacement of obsolete equipment and with an extensive introduction of automation and telecontrol methods. Research institutes and specialized enterprises have been established in the USSR for solving these problems.

"Energetics of iron and steel works, evolution and application to developing countries"
(document ID/WG.14/27)

237. The paper reviews the energy balance of iron and steel plants in the world and shows:

(a) The steady decline of the energy consumption required to produce a ton of crude steel;

(b) A re-distribution in consumption among the various energy resources; namely

(i) An increase in the consumption of electrical power and of liquid and gaseous fuels and

(ii) A decrease in the consumption of solid fuels, especially coke or coking coal fines.

Finally, estimates have been made of the energy requirements of modern plants using the most recent techniques for the blast furnace, the electric pig-iron furnace and pre-reduction processes using oxygen-blast or electric furnaces.

238. The above concept has been applied to the energetics of an iron and steel plant based on the use of coal (coking or non-coking), charcoal, liquid or gaseous hydro-carbons and electrical power. This analysis shows that it is quite possible to contemplate, according to the available energy supplies, an iron and steel works with a capacity of a few thousand tons yearly, which would rely for its energy supply: either on coal, coking or not, or charcoal, for 100 per cent of its requirements; or on hydrocarbons (liquid or above all gaseous) for more than 95 per cent of its requirements; or on electric energy, hydro-electric or nuclear, for up to 20 per cent of the requirements. The importance of this in regard to the developing countries is well defined and discussed. It may be recalled that many of the countries that have good deposits of iron ore lack coking coal (the traditional ironmaking fuel) while they abound in non-coking coal, wood for charcoal, hydrocarbons (petroleum and petroleum gas) and/or sources of hydro-electricity.

239. Some remarks on the possible advantages of dividing an iron and steel plant into an ore production works and a smelting and rolling works are made. This may mean the production of pre-reduced iron ores, in cases of pig-iron or

even of semi-finished products, slabs or billets, in the developing countries where there are iron ore deposits. The possible advantages of such a line of action for developing countries as a result of transfer of investments and industrial activities from highly developed to developing areas are also pointed out.

"Processing of metallurgical slags at iron and steel plants"
(document ID/WG.14/7)

240. This paper examined the question of slag disposal, which is one of the problems of an iron and steel plant. However, the problem is reduced and economic advantage is taken when slags are processed and sold.

241. Processed slags have been standardized and there is therefore great confidence in their use. This paper considered the main processing methods and the use to which processed slags are put. Slags are produced mainly during ironmaking in the blast furnace and during steelmaking. The slag from the latter being characterized by a higher CaO/SiO_2 ratio and P_2O_5 content. Slags are therefore classified into blast-furnace slags and steelmaking slags.

242. The blast furnace slags produced per ton of pig-iron vary from one ton to less than one quarter ton, depending on the quality of the iron ore. Blast furnace slags can be processed in six different ways to produce air-cooled slag , foamed slags, granulated slags, slag wool, shaped slags and fused cement clinker.

243. The paper describes the various methods and the uses to which the processed slags are put, e.g. air-cooling, which is most common. The resulting mass is generally crushed and screened and used as aggregates for concrete, as roadstone, railway ballast and for other purposes. For most applications a certain level of mechanical strength of air-cooled slags is required. This means generally that the slags should be free from porosity, i.e. bulk density is at least 1,250 kg/m^3 (according to the British standard). Slags with poor mechanical strength, however, can still be used as soil conditioners, for instance, or in the manufacture of cement or glass. Owing to certain chemical features, the processed slag can lose its chemical strength in service, in which case the slags are said to be "unsound". There are three types of unsoundness, i.e. lime-, sulphur- and iron-unsoundness. A slag is considered free of lime unsoundness if its composition satisfies the following formula:

$$CO + 0.8\ MgO\quad 1.2\ SiO_2 + C.4\ Al_2O_3 + 1.75^{s}.$$

244. The slag is also considered free of sulphur unsoundness if the total sulphur does not exceed 2 per cent and the acid soluble sulphate 0.7 per cent; and it is free of iron unsoundness if FeO contents are under 1.5 per cent by weight.

245. The paper also indicates that the processing of steelmaking slag is more complicated. This is due to the fact that, while the processed blast furnace slags are noted for their physical properties and uses, the processed steelmaking slags are chemical in their action. For instance, with little or no processing after iron recovery, steelmaking slags can be used in agriculture as phosphate fertilizer or as soil conditioner. With metallic iron extracted, steelmaking slags still contain valuable constituents, which can be recovered and re-used in the ironmaking cycles.

246. The paper also deals with the handling and transporting of slags, since these affect the economy of slag processing to a large extent.

"Collection and processing of iron and steel scrap for iron and steel industry"
(document ID/WG.14/55)

247. The paper described the sources, achievements and problems of the processing of ferrous scrap, which is one of the vital raw materials of the iron and steel industry. Steel scrap is the second important constituent for steelmaking after iron or hot metal from blast furnaces. Quite apart from the favourable cost factor, scrap can constitute up to 100 per cent of the furnace charge in electric arc and open-hearth furnaces. In fact, scrap is sometimes described as instant steel. For every ton of scrap used in steelmaking, there are conserved approximately 3.5 to 4 tons of other raw materials like iron ore, coke and limestone. The effective processing and utilization of scrap is therefore of great economic importance to the steel industry.

248. There are a number of recognized specifications for iron and steel scrap that have been adopted by steel plants and the scrap processing industries. These specifications include grades for the basic open-hearth and blast furnaces, electric furnaces and foundries, cast iron and special grades, including alloy steels. The Institute of Scrap Iron and Steel of the United States has classified 43 different types of iron and steel scrap, as standard grades. In addition, there are a large number of specifications for alloy bearing scrap with limitations for certain alloying elements. In addition to the grading of the material according to the physical shape and size, the specifications have laid

great stress on the chemical composition. While the standard specifications define closely the physical and chemical requirements, there is always a saving clause included in the specification or contract, which would recognize certain tolerances with regard to the sizes and physical state of the scrap (such as the material being rusty and containing some amount of foreign matter). It is also a common practice that in addition to the standard scrap specifications, which are invariably followed for the purposes of processing, when buying and inspecting scrap, the consumers insist on following a practice of satisfying their individual needs.

249. Steel scrap is derived from various sources. In an integrated steel plant, about 30 per cent of the output will be available as home scrap, revert scrap or arising scrap as a by-product of various operations. All this scrap can be recycled, effecting direct economy in production costs.

250. In addition to home scrap, a fairly large tonnage of scrap is produced during the fabrication and manufacture of various products in the metal consuming industries. In blast furnace operations, iron scrap is recovered as runner scrap, ladle skulls, splashing, spilling etc. during casting and pouring into ladles and pig-iron casting machines. Steel scrap arises from pit scrap, short and rejected ingots, crop ends, discards of blooms and billets, cuttings and sheared pieces from rolled and finished products like plates, sheets, pipes etc.

251. Expensive alloying elements, such as nickel, molybdenum etc. are often economically extracted from steel plant slags, by suitable processing methods, such as crushing, screening and magnetic separations.

252. There is also a large variety of purchased scrap consisting of unusable materials from natural or forced obsolescent plant, machinery and other iron and steel objects. This scrap, generally known as "dormant" scrap consists of miscellaneous products from old ships, junked industrial machinery of various types, railroad materials like old rails, sleepers, chains, to loose and light materials such as tin cans and crown corks.

253. Because of its varied nature, dormant scrap and industrial scrap require careful sorting and classification. The steelmaker insists that density (weight/volume) should be the maximum attainable. The denser the material, the fewer the number of boxes to be charged into the furnace and the lower the handling charges. To meet these demands specialized equipment is employed. Shears and gas cutters are used for reducing the scrap to smaller sizes and hydraulic presses are used for balling and bundling loose and light scrap.

254. Processing of scrap material is thus a complex problem, which requires detailed engineering study to meet each individual steel plant requirement. Such a study can be carried out under the following headings:

(a) Availability and analysis of purchased scrap;

(b) Scrap source and the specific end-products;

(c) Design and selection of processing equipment including plant layout;

(d) Planning of yard organization, including the study of construction and operating costs.

255. Although world scrap consumption and trade have been very extensive in recent years, certain improved steelmaking methods have tended to lessen the importance of steel scrap as a raw material for steelmaking. The phenomenal progress made in the basic oxygen process, which depends mainly on hot metal, has reduced the need for scrap. Improved iron-ore reduction and conversion processes with suitable flux additions have also reduced the dependency on steel scrap. Furthermore, the growing continuous casting processes yield less scrap than the traditional route ingot casting followed by primary rolling.

256. Balancing these factors, however, has been the increased efficiency and flexibility of the electric arc furnace which, of course, can take almost the whole of its charge as cold scrap.

257. In the developing countries, the demand for steel scrap is rising not only for foundries and steel plants for remelting, but also in a number of re-rolling mills and small industrial units where steel scrap is used for conversion into re-rolled reinforced bars, structural sections, domestic and agricultural implements, plates and sheets.

"Automation in the iron and steel industry"
(document ID/WG.14/28)

258. This paper reviews over a hundred articles on the iron and steel industry, published between 1960 and 1964, and describes the researches, developments and applications of automation equipment carried out by many iron and steel countries in the various departments of iron and steel. It concludes that the greatest development in automation is achieved in rolling, particularly in the wide strip mills, which lend themselves readily to this form of control because of the continuity of the process.

259. In the iron and steelmaking departments the equipment that is available for many of the computing and control functions is found not to be robust and accurate to the degree required for the purpose. This is due to the arduous

conditions encountered. Measurement of the conditions inside a blast furnace, for instance, remains very difficult and the automatic weighing of raw materials and of semi-products accurate enough for purposes of automation still requires much study. There is a growing need for quality control equipment, for example, for continuous analysis of solids, liquids and gases. However, it is expected that rapid progress in development will be made by iron and steel works and by the manufacturers of automation equipment since there is a strong demand for increased production efficiency in all countries.

260. On the question of the economic advantages of automation it is found that although the benefit of individual installations can easily be evaluated, since many of the more complex systems of automation have been installed as an inherent part of the programme of complete plant reconstruction, it is more difficult to estimate separately the gain from automation. Moreover, many of the advantages realized through automation are attributable to improved product quality, production scheduling and production co-ordination, which is not always easy to express in money terms. Since a main feature of automation is its gradual introduction into the production process (through adding consecutively sensing devices and control equipment), the resulting economic effects will therefore be felt only in a gradual way. Very often automation projects are considered in the framework of an over-all research and development programme, which is not subject to the normal economic criteria for assessing their effectiveness, since long-range objectives have to be taken into consideration.

261. As regards the social effects of automation there is some anxiety that automation in some cases will lead to a reduced demand for labour. But while the number of unskilled and arduous jobs may diminish, automation gradually leads to an increased need for skilled workers and to the need for developing such higher skills. It is mechanization rather than automation that has lead to a greatly reduced demand for labour, for the biggest savings in manpower come from plant design modifications such as increasing the size of furnaces, mills and handling equipment and speeding up output. Nevertheless, in some countries, funds have been provided to meet cases of hardship and for research on the social consequences brought about by technical changes such as the introduction of automation. It should, however, be noted that if the development of automation is carried out with care and proper organization, no hardship should be caused in an expanding industry.

262. The paper covers all the main aspects of the application of automation, including the technical, economic and social aspects, and gives the bibliographical references on which it is largely based.

Discussion

263. There was a considerable amount of discussion on the new technological developments outlined in the papers. One of the points emerging and one on which a certain amount of differences of opinion became apparent was that of the suitability of newly developed processes to developing countries. It was agreed that continuous steelmaking processes should be examined closely by experts in developing countries, particularly in view of possible advantages of annual production and investment. It was suggested that developing countries may in fact be the ideal location for new processes because of the absence of vested interests in conventional processes. The general feeling, however, was that the onus of responsibility was on the developed countries to make more progress in the development of new processes. They would then be able to offer a proved system to the new emerging steel industries.

264. It was felt in the discussion on the paper on automation that at the moment installation of highly automated equipment in a developing country, which may not have the necessary supporting industries or supplies of skilled labour, could in some, but not in all cases, present difficulties.

265. In connexion with the new processes, the problem of variation in amount and quality of local resources was discussed. It was suggested that for the SL/RN process, for example, no ore of less than 65 per cent Fe should be used. Beneficiation presents its own difficulties as it may not be economically viable to upgrade certain local ores. In the case of Nigeria, it was suggested that combined activities of making use of the local gas and lignite and of Liberian ores would probably be more profitable than trying to upgrade the oolitic Enugu ore.

266. Another main topic was continuous casting. The questions discussed were problems involved in bending and in the use of on-line mechanical reduction methods. It was suggested that bending was difficult with high carbon and alloy steel qualities and that if bending was to be carried out after the secondary cooling zone, the metal should be internally solidified. Another matter was curved mould operation, which was stated to be very much the same operationally

as straight mould practice. The advantages of casting thin rather than thick slabs were also mentioned.

267. Considerable discussion took place on spray steelmaking. The representative from the Intergroup Research Laboratories of the British Steel Corporation stated that the corporation in planning new expansion stages, has decided that the process is insufficiently established as a mass production method. The works at Millom had been making progress with a 30-ton plant but that is now closed: Lancashire Steel Company (part of the corporation) is continuing work with an 80-ton per hour plant and acquiring valuable experience.

268. Low-shaft furnaces were briefly discussed and it was pointed out that many were operating very successfully. It was also suggested that the side-blown converter method for melting scrap may be worth examining under certain conditions.

269. It was agreed that it is the task of the developed countries to stimulate and possibly accelerate research on continuous steelmaking processes and into automation. It is important to make sure that these and any other new processes are flexible as raw materials and other resources are different in the various developing countries.

CHAPTER IV

PREREQUISITES FOR THE DEVELOPMENT OF THE IRON AND STEEL INDUSTRY ON A NATIONAL AND REGIONAL BASIS

270. Five papers on the technical and economic factors that affect the development of the iron and steel industry were discussed under this agenda item.5/ In general, it was noted that the development of the metallurgical industry in a given country is proportional to the level of industrialization. Before the Second World War there were only four steel producing countries among the developing countries: Argentina, Brazil, Mexico, India. In recent years, the emphasis on industrial development has greatly increased the demands for construction materials - the machine industry, the mining industry, the petroleum and gas industry, transportation etc.

271. In establishing an iron and steel industry it is necessary to give careful study to the following items:

(a) The present and future consumption of ferrous metals;

(b) The available raw materials and necessary fuels;

(c) Possibilities of personnel training for the operation and construction of plants;

(d) Finance, particularly the sources of capital investment; and

(e) The existence of the construction industry.

272. In estimating iron and steel consumption, it is necessary to assess the requirements for different types of machinery, for transport machinery, shipbuilding, agricultural machinery, heavy equipment, machine tools, electrical equipment, household equipment etc. Export possibilities must also be taken into account.

273. In studying raw materials account must be taken of the fact that iron ore can be used directly in the blast furnace if it contains not less than

5/ See Annex 4, nos.29, 30, 31, 32 and 33.

50 to 55 per cent Fe. At present, not only the low grade ores but also high grade ores are being beneficiated in order to lower the coke consumption. The sulphur and phosphorus content should not exceed 0.3 to 0.1 per cent in the ore to be used directly in the blast furnace. Alumina is required not to exceed 45 to 50 per cent of the silica in the ore. The arsenic, lead, zinc and copper should not exceed the acceptable limits in the ores. In modern plants, self-fluxing pellets and sinters are largely in use. Calcium oxide content in limestone should not generally be less than 50 per cent. Silica should not exceed 2 to 3 per cent in the limestone. The steel scrap required should also be assessed.

274. Fuel and power resources available should also be studied. Coke is the principal fuel for the iron and steel industry. The normal ash content of coking coal is between 8 and 10 per cent. Sulphur in the coal should not exceed 2 per cent, and the thickness of the plastic layer must be less than 15 mm. The volatiles are expected to be 28 to 29 per cent. The lump coke is used directly in the furnace, but 20- to 25-mm coke is being used as fuel for sintering or for other purposes. Mechanical hardness of the coke was as follows: 74 to 78 per cent fractions remain of the size exceeding 40 mm in a rotating drum. Natural gas and fuel oil is now injected into the furnaces. Many direct methods are also in application, only a few of them are commercially in operation.

275. Training of personnel is another important factor. It is necessary to train operators and engineers for the iron and steel industry. This training should be carried out before the completion of the construction of the plant.

276. Capital investment per ton of steel varies depending on the type and capacity of the plant. Generally, the figure is between $300 and $500 per ton of steel. In small plants this figure is much higher.

277. Usually special equipment is imported, but the rest of the construction work has to be done locally; therefore, the construction industry should be at an adequate level of development. In many developing countries, the demand is not high enough to establish an integrated plant. In that case, where a market requires 100,000 tons of steel, a semi-integrated viable plant can be very well established. If the demand is about 1 million tons of steel, an integrated plant should be erected. In the case where sufficient electric energy is available, an electric arc furnace may be the most logical plant. If sufficient scrap for such a plan+ cannot be obtained locally, then the plant should generally be located at the coast.

278. If high grade ores are available, an electric blast furnace could be installed. Although it is out of the question to compare semi-integrated with integrated plants, local conditions could make them profitable.

279. Steel production and apparent steel consumption in developing countries are shown in the following tables:

Table 3

Development of steel production in developing countries
(percentage)

Region	1913	1929	1938	1950	1960	1965
Latin America	-	5.9	11.5	34.8	56.5	67.6
Africa (excluding South Africa)	-	-	-	2.9	4.7	4.8
Far East (excluding China Mainland and Japan)	-	19.6	22.1	41.6	51.7	58.7
Middle East	-	-	-	-	9.6	16.4
Developing world	-	9.8	15.9	29.2	44.7	53.5

Source: "Long-term Trends and Problems of the European Steel Industry" ECE, Geneva, 1959; and "The European Steel Market", ECE, Geneva, several issues.

Table 4

Development of apparent steel consumption in developing countries by regions, 1913 to 1965
(1,000 tons crude steel equivalent)

Region	1913	1929	1938	1950	1957	1960	1965
Latin America	2,260	2,694	2,006	3,781	8,051	8,414	12,144
Africa (excluding South Africa)	425	504	459	1,171	1,648	2,135	2,512
Far East (excluding China Mainland and Japan)	2,643	3,280	4,110	3,541	6,026	8,187	13,852
Middle East	270	373	409	1,222	1,459	2,034	3,200
Developing world	5,598	6,851	6,984	9,715	17,184	20,770	31,708
Indices:							
1913 = 100	100	122	125	174	307	371	566
1957 = 100	33	40	41	57	100	121	185

Source: Same as for Table 3.

Table 5

Development of apparent steel consumption in developing countries by regions, 1913 to 1965 (kg per capita)

Region	1913	1929	1938	1950	1958	1960	1965
Latin America	25.0	23.9	13.2	23.3	41.0	39.0	50.0
Africa (excluding South Africa)	3.1	6.0	3.8	6.2	9.6	10.0	9.6
Far East (excluding China Mainland and Japan)	3.2	4.5	2.9	3.1	7.1	9.1	13.0
Middle East	6.3	12.7	9.7	19.3	20.3	25.5	36.0
Developing world	7.2	8.9	5.6	8.5	14.0	15.2	19.0
Indices:							
1913 = 100	100	124	78	118	195	211	264
1957 = 100	51	64	40	61	100	109	136

Source: Same as for Table 3.

280. It was stated that the existing tariff barriers in developing countries are retarding the growth of steel consumption. In developing countries, the demand for steel products differs widely. As soon as the manufacturing industry reaches a certain point the consumption of steel increases rapidly.

281. In almost all developing countries, the cost of steel is higher than in the developed countries. Latin American countries can be taken as an example. High investment is one of the main factors influencing the cost in many Latin American countries, when a large amount is required for infrastructure. In addition, oversize units have been installed in order to lower the cost for future expansion.

282. The price of the raw material used is also not comparable to that in the developed countries because of not having the advantage of being able to choose the cheapest raw materials. The other disadvantage is high cost of interest rates. The cost of social benefits is also high. Demand diversification forces the plants to produce a wide variety of small quantities, which affect the cost. All these factors in the developing countries considered, the first stage should be to establish a rolling mill and then a melting shop for billet production.

"Influence of various factors (market, deposits, energy, finance etc.) on the location of iron and steel plants"
(document ID/WG.14/77) and
"Steel plant location. A guide for the developing countries"
(document ID/WG.14/46)

283. The iron and steel industry is highly capital intensive and therefore the building of the industry may create a strain on capital, which is a scarce factor of production in developing countries. This makes project economics one of the essential stages in the planning process, which cannot be calculated without studying plant location. The process of the location of a plant has two stages: determining the area of location and selecting the site for construction of the plant. More detailed economic and technical information is required to make the choice of a site as compared with the matter of selecting the area of its location.

284. Factors influencing the location of an iron and steel plant can be studied broadly in two categories, namely, techno-economic and political factors. Techno-economic factors include market characteristics, raw material availabilities, availability of utilities, transportation facilities, manpower situation and the size and quality of infrastructure available. The political factors, on the other hand, include tariff and trade policy, subsidies and incentives and investment assistance. The effects of all these factors are changing with the advances made by society. Factors governing the location of a non-integrated steel plant are often quite different from those governing the location of an integrated plant.

285. The objective of an iron and steel plant location study is to determine the feasibility of establishing a viable or economic-size plant and to select the plant site compatible with project viability as such. Different factors played prime roles in iron and steel plant location in different stages of development. When the transforming of iron ore into metal was discovered, the prime locational factor was technological knowledge. As from the beginning of the nineteenth century, coal and coke became substitutes for charcoal, coal became a dominant locational factor; for, greater quantities of coal than iron ore were used to make iron.

286. The importance of coal as a locational factor began to decline in the early twentieth century because of increased efficiency in the utilization of coal and the introduction of electricity, petroleum and natural gas. The principal locational factors are discussed in more detail in the following paragraphs.

287. The market. In the early twentieth century the principal volume of steel production increased rapidly, technology changed and iron and steel scrap became an important substitute for virgin pig-iron. These changes made the market location the dominant locational factor since the Second World War.

288. The size of the market is the most important factor determining the size of the steel plant to be established in a given country. In most cases, the market is not large enough to justify the establishment of optimal size plants in developing countries. Because of the limitations of the export market, the decision on plant size should be based on the domestic market. However, since the domestic market is not large enough, regional co-operation can be a feasible proposition. Closeness of a steel plant to its market has certain advantages over its distant competitors. Those advantages are discussed in another context, namely that of regional co-operation among developing countries in the steel industry.

289. Market studies can be carried out on the basis of the following methods:

(a) Projection of steel consumption based on the country's past consumption trend;

(b) Correlation of steel requirements with planned economic growth;

(c) Analogies with experiences in countries having a more or less similar industrial structure and at an equivalent stage of overall development;

(d) Analysis of expected developments in the industries using steel.

In case a single method does not yield a satisfactory result, combinations of the four methods can be a better approach. In estimating the efficiency of a steel plant construction the economics of the import of metal have to be compared with its production at the works planned.

290. Raw materials. If domestic raw materials are to be used, there should be sufficient proved reserves to supply the plant for at least 25 years, including future expansions of the plant. Domestic raw materials of low quality can have a significant effect on process selection, production technique and costs. In this case imported raw materials may result in lower costs and in more competitive steel prices. Given the quality of the imported raw materials, their quantity would have a significant effect on the decision for or against a seaboard location.

291. Availability of utilities. Water and energy requirements of a steel plant are another area for careful investigation in order to delineate potential site areas. Although substitution of salt water is feasible, fresh water

is always required. Energy may be in different forms. These are steam, gas, coal, electric power and fuel oil. The potential sources of each need careful evaluation without disregarding the necessity for meeting emergency situations.

292. Transportation. Transportation is one of the most important parts of a plant location study because transport costs, both of raw materials and finished steel, may affect or outweigh the cost differentials of other factors at various locations under study. If the iron ore is transported by rail, the type of trains and trucks are of prime importance. The use of empty railroad cars returning from steel plant to the mine can make an economy of 30 to 40 per cent of the transportation cost. This factor may greatly influence the decision of locating an iron and steel plant.

293. Manpower. Availability of manpower of the right skill and discipline can become a critical or even the controlling factor in site location. There is a great difference in this respect between the developed and developing countries, these being considerably short of experienced steel workers and of skilled technicians and managers.

294. Infrastructure. A considerable amount of investment in infrastructure that affects the viability and location of a steel plant may be saved if such facilities as housing, hospitals, schools, shopping and recreational facilities, industrial services, transportation facilities etc. are already available. In the Soviet Union the criterion of an estimate, when comparing the alternatives of location, are the indices of the investment return. The conception of the efficiency index is also used. The formulation of these indices were explained in paper "Influence of various factors (market, deposits, energy, finance etc.) on the location of iron and steel plants" (document ID/WG.14/77). For a successful location study the following surveys should be made:

(1) Market survey

(a) Size and geographical distribution of market;
(b) Consumption pattern;
(c) Current and probable future product prices, tariff and import duties;
(d) Anticipated present and future product shortfalls;
(e) Indications of shortfalls by specific products;
(f) The present and future availability, quality and price structure of the scrap market;
(g) Export possibilities.

(2) Raw material survey

(a) The quantity, quality and availability of iron and/or agglomerates, coal and/or coke etc.;

(b) The mine-head or source cost of each;

(c) Applicable price, quality and quantity differentials;

(d) Applicable tariff and duties for importation;

(e) The prevailing transportation situation relative to each raw material and its source;

(f) Applicable transport tariff and related future policy;

(g) Estimated cost of development and timing for new raw material mines and transportation facilities.

(3) Utility survey

(a) The over-all availability in various areas with respect to location, capacity and characteristics of water, power and fuel;

(b) Development costs for transport links to markets and raw material sources;

(c) The availability of chartering and/or leasing services;

(d) The prevailing tariff structure;

(e) The limitations on handling of heavy loads and lifts for plant construction;

(f) Location of existing and future deep water ports;

(g) Harbour dues and taxes, customs procedures;

(h) Harbour equipment and development plans;

(i) Availability and cost of civil engineering;

(j) Prevailing vessels waiting times and flag restrictions;

(k) Prevailing market distribution patterns and future possibilities.

(4) Manpower survey

(a) Prevailing concentration of manpower;

(b) Prevalent and potential manpower skills and capabilities;

(c) Manpower aptitude and attitude towards training;

(d) Existing manpower costs and related policies by disciplines and skills;

(e) Estimated future costs and related labour policies.

(5) Infrastructure survey, accounting for both local and expatriate, should provide:

(a) Size of local population and number of resident expatriates;

(b) Housing, hospital facilities and schools;

(c) Existing utilities for construction and development costs to meet the needs of infrastructure expansion;

(d) Shopping, market and recreational facilities;

(e) Transportation and communication facilities;

(f) Availability and/or cost of service and maintenance industries;

(g) Prevailing policies on social and industrial planning;

(h) Method of financing infrastructure;

(i) Government agency responsibilities.

295. The establishment of a steel plant in a developing country may be desirable for a number of economic, social and political reasons. The iron and steel industry is a very capital intensive industry and therefore the economics of the project becomes extremely important from the point of view of capital as a scarce resource in developing countries. If adequate returns to capital resources are not assured and there is little or no potential net gain to the national economy above that of alternative investments in other sectors, then the capital should be channelled into more profitable sectors.

296. It is not possible to calculate the operating economics without studying plant location. On the other hand, plant location cannot be established without giving due regard to the economics of all the factors that affect the type, size and the location of the plant. All these factors are interdependent and must constantly be evaluated in terms of one another as data become available. It is always worth considering alternative areas of locating and siting, for such a comparison usually provides for making a better choice from the point of view of both capital and operation costs. Alternative locations may differ from each other also in terms of realization.

<u>"Economic advantages of the creation of iron and steel plants for small countries on a regional basis"</u>
(document ID/WG.14/16) and
<u>"Research for the iron and steel industry in developing countries, possibilities for regional co-operation"</u>
(document ID/WG.14/15)

297. The two papers examined the economic advantages of the creation of iron and steel plants and the possibilities of research centres on a regional basis.

298. The advantages of construction of iron and steel plants based on the resources and markets of several developing countries, arises first from economies of scale. These economies lie mainly in the savings in the investment cost, skilled labour, fuel and power required per unit of output. For the purpose of analysing economies of scale, the steelmaking processes may be divided into integrated iron and steel production (including casting), the rolling bar and sections and the rolling of flat products, hot and cold.

299. As for economies in investment, an increase in steel-producing capacity of 10 per cent requires an increase in investment of about 6 per cent up to about 200,000 tons per annum, and of 7 per cent up to 500,000 tons. For the production of hot rolled wide strip, the corresponding increases in investment are only about 3 per cent up to a capacity of about 400,000 tons per annum and then of 6 per cent afterwards. For cold reduced strip, up to about 300,000 tons capacity, an increase of 8 per cent in investment is required to obtain a 10 per cent increase in capacity, after which it rises to 10 per cent, i.e. there are no further economies of scale.

300. As regards the labour input, on the average labour per ton of product decreases sharply at lower levels of capacity, while it falls slowly at larger capacities. This is because in the iron and steel industry a high proportion of the manpower required is technical or skilled and this proportion will be higher still at low levels of capacity. The following table gives the estimated man-hours per annual ton, under African conditions, of product for the four processes:

Capacity in thousands of tons per annum	50	100	200	300	400
Iron and steel production and casting	20	14	10	9	8.5.
Rolling: bar and sections	16	8	6	5.5	5
hot rolled sheets	16	6	5	4	3.5
cold reduced sheet	12	8	6	6	5.5

301. With regard to the raw materials, including ferroalloys and the utilities such as fuel and power, those remain more or less constant per ton of product and these decline with increasing capacity, though not so rapidly as investment. Others, including some bought services, are proportional to output. Actual costs, however, especially of raw materials, depend on the distance to which they have to be transported. The larger market for iron and steel products can be obtained only at the expense of higher distribution costs and this must be allowed for in calculating the net advantage of economies of scale. Transport costs vary greatly according to the type of transport, i.e. sea, road and rail. Therefore, extra transport costs to be incurred by enlarging the market through regional co-operation depend largely on whether the location of a single works, which is to supply all the requirements of the region, is coastal or inland. It would appear that two inland works would have lower over-all costs of production and distribution than a single works, if the extra distance to be covered by transport from a single works were more than about 2,000 km

by rail. In more concentrated markets it would be economical to have two works of 500,000 tons per annum capacity instead of a million tons if the extra transport distance to the single works were more than about 4,000 km by rail.

302. The economics of specialization consists normally of retaining economies of scale at the rolling stage, while losing them at the steelmaking stage. The co-operation of small countries may also be facilitated by establishing a number of re-rolling works supplied with semi-finished steel from a suitably located integrated works. This is the converse of specialization in the sense that economies of scale are retained up to the steelmaking stage but lost at the rolling stage. Offsetting this loss is some advantage in transport cost, arising from the fact that handling and running charges on semi-finished products are usually slightly lower than on finished products.

303. In most developing countries some materials such as ferroalloys, refractories and spares have to be imported so that the decisive location resources are those of iron ore and coal and other forms of energy. Inferior local ores may have no advantage over the use of ores available on a subregional basis. In this connexion transport costs are vital. The location of a regional works can be established only after a careful calculation of the costs of assembling raw materials and of distributing the finished product.

304. Detailed location calculations of this kind have been made by the Economic Commission for Africa (ECA) for the West and East African subregion. In the West African subregion it was found that the lowest over-all cost site for a single integrated works supplying the whole subregion would be at Lower Buchanan in Liberia. Subsequently it was proposed to establish a number of re-rolling works based on Liberian works. In East Africa a number of possibilities were evaluated. Since, in contrast to West Africa, the main centres of consumption in East Africa are inland and transport costs are therefore higher, the argument in favour of a single integrated works is not so strong.

Regional co-operation for research

305. Many mechanisms exist for creation and transfer of know-how. All of them are fully used by developed countries, and none should be disregarded by the developing countries, particularly those now approaching the last stage of industrial development. Industrial development is accompanied by an increase of problems encountered in numbers and in difficulty. Many developing countries are increasingly aware of this fact. The solution is an increasing reliance on creative technology, especially research.

306. Research activity is usually associated with related activities. The success of a research effort depends on the judicious reunion and administration of a minimum "critical mass" of human and material resources, under intellectually stimulating conditions so as to maintain a chain reaction where ideas generate opportunities, which in turn lead to new ideas.

307. Iron and steelmaking technology, being full of opportunities for discovery and improvement, is an area in which developing countries can successfully participate. Developing countries face today increasing competition both among ore exporters and in the world market for steel products. In addition, there are increasing difficulties in obtaining outside help, which would commensurate with rapidly increasing needs for development. Developing countries will have to rely more and more on their own capability to solve problems of productivity and quality.

308. A survey of the situation of the iron and steel industry research in Latin America was made and possible measures to promote the creation and transfer of technology was identified. The findings of the survey, the possible measures identified for the development of research and the general activities of a regional research centre for Latin America, are explained in the paper "Research for the Iron and Steel Industry in Developing Countries, Possibilities for Regional Co-operation" (document ID/WG.14/15). The economic advantages of the creation of regional iron and steel plants and the possibilities of research activities were as follows:

(a) The capacity and location of a multinational iron and steel works must be decided only after a careful calculation of economies of scale and of all elements of the cost of production, the costs of raw materials, and the costs of distributing the finished products to the various market areas.

(b) Developing countries should carefully establish their national and regional technological policies and systems for the creation and transfer of technology. A regional centre for iron and steel research and technology should be created as part of a regional policy and a regional system.

(c) Developing countries should try to direct their main efforts towards short range applied research, for a faster yield on their limited investment in human and material resources.

309. The economic advantages of the creation of regional iron and steel plants are larger markets and a wider access to resources. Economies of scale in investment, labour and other operating costs are significant.

310. The advantages of specialization differ at various manufacturing stages depending upon certain conditions. In terms of cost of product the use of low

quality local ores may be less advantageous compared with using higher quality ores available on a regional basis.

311. Industrial development is accompanied by an increase of the problems encountered. The solution is an increasing reliance on research. Iron and steelmaking technology is an area in which developing countries can successfully participate, by establishing their national and regional technological policies and systems.

"The most essential metal production for developing countries"
(document ID/WG.14/78)
"Demand for steel and prospects for regional co-operation in South-east Asia"
(document ID/WG.14/30) and
"The supply of steel in developing countries"
(document ID/WG.14/31)

312. The three papers examined the supply and demand for steel in developing countries and the prospects for regional co-operation.

The present situation of steel supply in developing countries

313. The establishment of steel plants in developing countries has been gaining an increasing importance for various reasons such as foreign exchange savings through import replacement, and other objectives such as national or regional industrial development. For the preparation of programmes for establishing an iron and steel industry in these countries there are two basic prerequisites: firstly, an assessment of the present and prospective rise of the steel market in the country concerned and in adjacent countries has to be made, and secondly, the availability of supplies of raw materials and energy has to be ascertained. There are, of course, other factors that play an important role in this respect, such as the problem of financing and of management.

314. At present, nearly forty developing countries have iron and steel plants and/or rolling mills, mainly established after the Second World War. Due to the differences in the level of industrialization, the stage of development in these steel industries varies from one country to another. The developing countries where steel works are already in operation can be divided into two groups:

(a) In the first group, comprising nearly three quarters of the developing countries, are those in which steelmaking is at the initial stage of development or in which only the first steps have been taken to establish it. They are the countries with a small population and with a limited market for steel products. The common features of steelmaking in these countries are the existence of small firms operating small-scale rolling mills, using imported semis and producing a limited range of rolled products.

(b) The second group of countries are industrially developed, have rich natural resources and, in most cases, a developed mining industry. The countries in this group have about 23 integrated steel works of various sizes. The output of these integrated plants constitutes more than 80 per cent of total domestic steel production in these countries and covers roughly the same proportion of domestic consumption.

315. The volume of crude steel output in all the developing countries taken together stood at about 17 million tons or 3.8 per cent of the total world crude steel production in 1965. It was 12 million tons or 0.9 per cent of the total world production in 1937. Production of crude steel grew considerably faster in developing countries (12.7 per cent per annum) than in industrialized countries (5.6 per cent per annum) during the period of 1950 to 1965. The rate of growth was highest in Latin America (13 per cent per annum) and in the Far East (12.15 per cent per annum).

316. Steel imports into developing countries, although growing in absolute terms, have not managed to keep pace with over-all steel trade development during the last ten years, so that the importance of these countries as a destination of steel exports has fallen from over 34 per cent of total trade in 1950 to less than 20 per cent in 1965. Since the share of imports in total consumption is falling in almost all developing countries, it would appear that the expansion of domestic steel production has been used to decrease the degree of dependence on foreign steel supply. The share of total metal consumption met by imports was decreased by 25 per cent during the period 1957 - 1965 in countries of Latin America, by 44 per cent in India, by 20 per cent in the United Arab Republic. In 1965 all the developing countries imported 11 million tons of rolled products. The principal importers are Pakistan, the Philippines and Thailand.

Latin America

317. According to estimates, the capacity of the Latin American steelmaking industry in 1965 was more than 12 million tons of steel per year, of which 5.1 million tons were produced in Brazil, 2.7 million in Mexico and 1.9 million in Argentina. Crude steel production was about 8.2 million tons, which accounted for 68 per cent of the total consumption of steel in the region in 1965.

318. Generally speaking, the pattern of finished steel production in Latin America is very typical of that in all developing countries. The largest share

in output is held by sections that account for 35 per cent (1965). About half of the sections are accounted for by reinforcement bars and one third by light sections. Countries in which steelmaking has been established relatively recently produce almost exclusively these types of steel.

319. The proportion of flat products output is relatively high in three countries only: Brazil, Chile and Mexico. The rest of the countries with a limited metal production depend on their imports. Almost all the countries import also tubes for the oil industry. A considerable number of the countries of Latin America without an iron and steel industry (Bolivia, Costa Rica, Honduras, Nicaragua and others) import profiles, flats and tubes. The proportion of import relative to the apparent consumption ranges from 80-100 per cent (Bolivia, Peru) to 10-15 per cent (Brazil, Chile and Mexico).

Far East

320. The growth of the market in the countries of the Far East has in general been governed by similar factors as in the developing countries of the other regions. There are, however, a number of specific circumstances that reacted to a certain extent on the movements and pattern of the market. The size of population, the distance from advanced countries, their coastal location, the fact that some of the countries possessed supplies of the basic raw materials for steelmaking. The total output of crude steel of the region was 8.1 million tons in 1965. All developing countries of this region (except India) meet only a small part of their home consumption by their own production of iron and steel.

321. The general situation is that the existing plants, even if operated at full capacity, would not be able to produce sufficient supplies of ingots for the rolling mills. On the other hand, the output of rolled steel in the region covers only a small part of the domestic consumption in individual countries. Finally, the production of a narrow range of steel products, in small quantities, with high overhead costs can hardly compete with imported steel. Profiled bar sections account for a large part of the imports. The imports of flat products are negligible.

Middle East

322. The Middle East is one of the areas where steelmaking has only lately achieved considerable expansion. One of the reasons was that little was known of the area's natural resources, that the level of industrialization was low and the market restricted. With the exception of the United Arab Republic the

countries of the Middle East meet their metal requirements by import. The availability and exploitation in these countries of large reserves of crude oil and gas made it possible for some of them to obtain considerable revenue and to use this revenue to pay for imports of steel. Bars and steel tubes compose the bulk of imports. In recent years a trend towards the increase of import of sheet has been observed.

323. As in most of the other developing countries, steel is used in the Middle East mainly in construction and in the mining and extraction sectors. Steel sections account, therefore, for nearly half of all steel products.

Africa

324. Per capita consumption of steel in African countries is at present almost the lowest in the world. In recent years it reached only about 8 kg. The low level of industrial development led to the emergence of small consumers, principally building and repairing enterprises. The rolled steel products are generally consumed for building requirements (up to 40 per cent) and for packing needs. In recent years the import of steel tubes and pipes for agriculture as well as of tubes for the oil industry to produce and to transport oil and gas has also increased. There has been a tendency in these countries to set up and to expand their own plants further in order to satisfy, wholly or partly, domestic demand and to serve as a basis for the development of processing and other branches of industry. For the accomplishment of this aim there are a number of favourable circumstances. In certain areas of Africa there are abundant reserves of high-grade iron ore, some of the world's largest, richest and purest. The continent has also potential hydro-electric power resources.

325. The immediate problems that African countries have to solve in order to carry out schemes for building and steelmaking plants are the lack of capital and trained labour forces.

Demand for steel in developing countries

326. There is a close correlation between the demand for steel and economic growth. In the countries at initial stage of economic development the demand for crude steel increases faster than the economic growth, and in most cases it grows twice as fast as the economy grows.

327. Demand for steel products and its product pattern is discussed more systematically in another paper presented to the symposium "Factors Affecting Steel

Demand and its Product Pattern in Developing Countries" (document ID/WG.14/29). However, the product pattern of demand for steel has been discussed in another context, namely, "Demand for Steel and Prospects for Regional Co-operation in South-east Asia". The product pattern of the demand for steel in South-east Asia, analysed below, reflects more or less the pattern in all the developing countries.

328. Bars and sections. Bars and sections as basic building materials represent a high percentage of the share in total steel consumption in all the less developed countries as well as in South-east Asia. Since the bar mills can be operated on a small scale and do not require a high degree of technical knowledge, they can be set up in any developing country. Regional co-operation in bars and sections, therefore, has no merits.

329. Wire rods. Wire rods are the main inputs of wire and nail industries, which have been expanding rapidly. Wire rods, for this reason, have also become an important element in the total steel consumption in South-east Asia as well as in all developing countries.

330. Tin plates. The consumption of tin plates has been growing very rapidly in South-east Asia in recent years, due to the marked upswing in canned food exports. The production of this product, however, does not keep pace with the demand in the region, and therefore, the deficit has to be imported.

331. Heavy and medium plates. These products are used by heavy industries like shipbuilding. Heavy and medium plates are an industry that requires a high level of skill and technology with a desirable monthly capacity of 50,000 tons. Most of the developing countries, therefore, have to import considerable proportions of their domestic demand.

332. Cold rolled sheets. It is estimated that the ratio of demand for cold rolled sheets to the total steel demand will be about 21 per cent in 1975 in South-east Asia. The limited market conditions in the individual countries do not permit to set up large plants to expand production in order to meet increasing demand for the products in question.

333. Hot rolled sheets (including hot coils). This is another field for which individual markets are too small to erect optimal-size plants.

334. As the observations on the supply of, and the demand for, major steel products in developing countries show, most of them cannot be self-sufficient in the production of these products (like wire rods, tin plates, cold rolled

sheets and hot rolled sheets). This is because the demand for these products in individual countries is not large enough to justify optimal-size plants. There exist, however, the possibilities of setting up these plants on the basis of regional co-operation (discussed in other sections of this consolidated report) among the adjacent countries. But it has its own problems, which are discussed in the following paragraphs.

335. First, the production costs of steel are generally much higher in developing countries, due to the lack of efficient management, experience and know-how, inadequate infrastructure and distribution channels, the shortage of skilled manpower, high interest rates on capital etc.

336. Secondly, there is the possibility of unequal distribution of benefits from a project set up on a regional basis. The country in which the steel industry is to be established under regional co-operation is likely to be practically the sole beneficiary.

337. Thirdly, foreign trade of developing countries and especially of the countries of South-east Asia, is predominantly directed to the advanced countries. Intra-regional trade does not make a significant proportion of the total foreign trade of these countries because there is little or no complementarity in their production. The small volume of intra-regional trade gives rise to high ocean freight costs and inconvenient shipping schedules, which is itself an impediment to regional co-operation.

338. The establishment of iron and steel works in developing countries may entail a considerable change in the pattern of rolled products consumed and imported. At present, bars sections and rods for building requirements account for a large part of rolled products production and consumption in the developing countries. The consumption of flat products is not great. Some progressive trends however are outlined in this field, which can lead, in the next few years, to a market increase of flat rolled product consumption. It may serve as a basis for installing plate and sheet mills of a small capacity in these countries.

339. It is recommended that: first, intra-regional trade should be increased to the maximum possible level through practical ways and means; secondly, joint efforts should be made to establish transportation links between adjacent countries so that future co-operation could be facilitated; and thirdly, joint-

purpose enterprises in a number of industrial fields should be set up to distribute the benefits from regional co-operation equally and to initiate complementarity in production.

340. The documentation for this part of the discussion included papers dealing with preliminary and general problems related to setting up or developing of a steel industry. Two papers stressed the need for the planning of proper manning and resources well in advance and one dealt specifically with the problems as applied to small countries. The remaining papers considered methods of finance and the necessity for having a clear picture of standards and specifications and the interrelationship between the existing standards of developed countries.

341. One of the main problems to be solved in advance is that of providing and training the necessary number of workers and this is dealt with in the paper "Requirements of Manpower and Qualified Staff in the Creation of the Iron and Steel Industry and Training of Personnel" (document ID/WG.14/17). Complex and expensive equipment must be used fully and without interruption, which not only presupposes a high level of skill and training of the operating personnel, but also calls to an even greater extent for highly qualified technicians and supervisory staff. The numerical ratio of manual to non-manual workers is growing smaller and productivity is increasing.

342. The problems of training and preparing the necessary supply of workers for the iron and steel industry may vary but there are basically three main types of areas: (a) areas that have a low level of industrial development and few technical schools, and where there is no existing iron and steel industry; (b) areas that are partially industrially developed but where there is no balance between the existing industry and the level of technical schools; and (c) areas that are both industrially and technically developed.

343. In the case of the first type of area, the assistance of advisers capable of bearing responsibility for the development of the iron and steel industry from the beginning of the economic study to the entry into operation of the works, and for the training of skilled workers, is required. In the case of the second type of area, only technical assistance is required in the establishment of the works and the training of the technical staff.

344. Countries in the third category are capable of solving all the problems connected with the development of an iron and steel industry themselves and are also capable of helping the countries in the first two categories.

345. In the training of technical management personnel it is essential that such personnel should gain a thorough knowledge, in industrially developed countries, of the way to run an iron and steel industry, methods of long-term planning, and the organization of labour. The future technical management personnel should also be trained in industrially developed countries in technical institutions of various levels and in plants and planning offices, since at present there are still not enough training institutions of an adequate technical level in the developing countries where iron and steel plants are being constructed. Skilled production and maintenance workers should also be trained in industrially developed countries.

346. All the workers for a new plant could be trained on the spot, but this calls for the lengthy presence of a considerable number of qualified instructors and the method is not so effective, but unskilled and semi-skilled personnel are usually trained at the new works.

347. Experience has shown that it is best for the largest possible number of workers to be trained in iron and steel works in industrially developed countries on similar equipment as that which they are to use. Only some 18 per cent of the workers in iron and steel plants are engaged directly in the metal production process, the remainder being divided among the repair, transport, power and refractory sections and the so-called ancillary and auxiliary plants. This entails a large requirement for highly qualified management.

348. In addition to their long-term general training, management personnel should make a detailed study of the establishment of an actual iron and steel plant and their specific training should begin with the analysis of the data of studies and projects for the establishment of the plant in question and should cover the whole period of construction up to completion.

349. Future technical management staff members who possess the appropriate technical and theoretical knowledge could work as assistants to management personnel in the steel works of highly industrialized countries.

350. In deciding on the number of workers required, account must be taken, not only of the work load of the individual sections, repair shops, laboratories and so forth, but also of the detailed breakdown of the various operational sections and the requisite qualifications of the workers for them, the pay structures, and the required length of training. The essential criteria are:

(1) The absolute increase in the total number of workers relative to the construction plans and the volume of production;

(2) The variations in the number of workers as a function of the volume of production for the various trades;

(3) The sources of labour;

(4) The factors affecting the stabilization of the staff at the new plants (appartments, hostels, schools etc.).

351. Satisfaction of the former conditions must be ensured in the plans through preliminary discussion with the appropriate state or public organization.

352. Recent experience in establishing iron and steel works in less developed areas of Czechoslovakia has shown that the direct expenditure on the training of workers comes to approximately 0.5 per cent of the total investment in the construction of a new iron and steel plant. Good training of skilled workers makes it possible to cut down the time required for bringing iron and steel plants into full production and reduces stoppages in the operation of the main items of equipment.

"Pre-investment information for designing iron and steel plants in the developing countries"
(document ID/WG.14/18)

353. This divides developing areas into two types. Firstly, potentially weak countries that either do not possess raw materials of economic value and power resources or will not have a considerable market for iron and steel products in view of the inadequate size of their population. In this case, exportation does not arise. Secondly, potentially strong countries with large population and markets for iron and steel products, which might be expected to expand in the future, even with low specific consumption.

354. It is pointed out that the decision on the construction of non-integrated or an integrated iron and steel plant, depends on research into raw materials, fuel, power and water resources, demand and finance. On the basis of this short-term (5 to 10 years) and long-term (10 to 20 years) economic plans for the construction of both types of plant should be drawn up.

355. Non-integrated plants have about 10 per cent of the capacity of the integrated plants and both categories of countries mentioned previously, may begin construction of them without serious risk. Capacity might lie between 100,000 and 300,000 tons a year using imported billets. For this purpose the paper suggests the possible use of partially modernized European or American rolling mills that have been withdrawn from service.

356. After the construction of a small steel works, with Maerz-Bolenz open-hearth or electric furnaces of about 50-ton capacity or small 10- to 20-ton oxygen converters, with continuous casting, it is possible to manufacture rolled products from ingots produced in the works itself. The possible construction of a roughing mill and also of a two-high 850 mm or three-high 700 mm finishing mill is quite advantageous, since it may make possible both the expansion of the production programme and the simultaneous introduction of continuous casting. Where there is cheap and abundant labour, labour productivity is unimportant, which is why the proposed rolling mill solution would be advantageous.

357. It is a relatively simple matter to increase capacity in such a steel works particularly in the version with two oxygen converters, either by increasing the volume of the converters or by the construction of a third. By an increase in capacity it is possible to raise production to 600,000 tons of crude steel a year with relatively low capital investment expenditure. The latter might be $100 to $120 per ton of crude steel.

358. The increased output of steel would even make possible the production of thin sheet, and perhaps of plate by the construction of two-high or three-high mills for hot rolling; these could be obtained in the same way as the rolling mills for sections.

359. Integrated plants may be built later but only in the potentially strong countries. The potentially weak countries would have to associate for this purpose in order to create an adequate market. The decisive factor in construction is not resources of raw materials, except where their transportation would be economical (on the coast or the banks of navigable rivers). Before a decision is made to construct an integrated plant, it is necessary to carry out a complete market study of the demand for iron and steel products.

360. Geological research should be undertaken to ascertain the location of resources of raw materials, fuels and energy as well as to study transport from the economic point of view. It is necessary to ascertain the chemical and physical properties of the ore, the method of mining, beneficiation, preparation as well as reserves of ore. Losses in pelletization and agglomeration should not exceed 2 per cent. It is also necessary to discover the chemical composition and volatility of fuels, and, in the particular case of coal, the cokability, ash content and composition. A similar assessment should be made for oil and natural gas.

361. After deciding the location of the plant an economic study should be prepared on the transportation of the raw materials as well as the final product. This study should confirm whether, in the light of resources of raw materials or fuel, it is most economical to construct the plant on the seacoast or on the bank of a navigable river, or whether the raw materials should be prepared at the source or transported to the plant located on the coast or on a river bank. These remarks apply to both integrated and non-integrated plants.

362. It is necessary to determine the civil engineering required on the site, the hydrological situation and also to ascertain whether a complete town should be constructed for the staff. The structure, age and skills of the population should also be established.

363. It is advisable to study the advantages of foreign and domestic capital participation as well as participation by the state. The extent to which the state intends to grant the new plant economic advantages in the form of preferential prices and protective duties, particularly during the initial period should also be determined. It should be ascertained whether advantageous long-term credit is available.

364. The construction of an integrated plant always represents a considerable risk because of large capital investment. The greatest risk occurs when the marketing of the product is hampered by the impact of objective conditions.

365. To achieve maximum economy, large-scale production units should be chosen for integrated plants: batteries of high-capacity coke ovens with bulk loading (30 m^3), blast furnaces (2,000 m^3) with high concentration of Fe in the charge and minimum coke consumption, which can be reduced by injecting oil or natural gas through the tuyeres to the level of 450 kg of coke per ton of pig-iron. When the coke is imported, it may be better to locate the plant on the seacoast or on the bank of a river.

366. Oxygen converters are recommended in view of the shortage of scrap, and of capital investment costs, which are lower than for open-hearth steel furnaces (about 70 per cent) and the operating costs, which are also lower than any other steelmaking process.

367. Rolling mills in fact determine the total capacity of the plant. For example, a non-integrated plant, for an output of 2.3 million tons of rolled

products per year, could have the following structure in the first stage:

Blooming mill, diameter 1,150 mm	2,800,000 tons/year
Continuous billet rolling mill - billets	2,400,000 tons/year
Cross country rolling mill, diameter 65 to 150 mm	700,000 tons/year
Rolling mill for small and medium sections, diameter 18 to 65 mm	700,000 tons/year
Strip mill, diameter 400 mm	400,000 tons/year
Wide rod rolling mill, diameter 5 to 16 mm	500,000 tons/year
Two oxygen converters of 300 tons	2,800,000 tons/year
Two blast furnaces, 2,000 m^3	2,800,000 tons/year
Production of sponge iron	400,000 tons/year
Production of coke, 3 batteries	1,600,000 tons/year

368. Such an integrated plant could produce sections, sheet, girders, wire rod, U irons, angle irons, reinforcing bars, rails for mines, rounds etc. To this there can be added, vertically, the production of bright drawn steel, wire, tubes and pipes of up to 200 mm, screws and bolts, chains, nails, cables and wire netting as well as structural metalwork. The blast furnaces can manufacture hematite iron for foundries during part of the year.

369. The works should also include power plant, rail and other transport, a refractory brick plant and maintenance installations of all kinds, plants for oxygen and acetylene, compressor shops etc.

370. The rolling mills could be later equipped with a semi-continuous wide strip rolling mill for the production of sheet and plate of thickness up to 12 mm and a 3 m to 3.5 m four-high rolling mill for heavy plate. The construction of such an integrated plant would involve an expenditure of $150 to $160 per ton of crude steel.

"The financing of the iron and steel industry in a developing country: the case of Spain"
(document ID/WG.14/47)

371. The criteria for deciding whether it was advisable to encourage energetic development of the iron and steel industry and the advantages of such action were the following:

(a) To eliminate a growing deficit in steel imports;

(b) To modernize existing iron and steel plants, which would not be able to maintain productive capacity in the volume or in the technical level required;

(c) To create a necessary base for a whole series of productions which are large steel consumers.

372. The difficulties for developing the iron and steel industry were mainly to be found in:

(a) Obtaining and employing the necessary funds for carrying out sufficient investment;

(b) The low alternative private profitability of such investments.

373. The advantages mentioned swayed the balance in favour of undertaking a national iron and steel programme, which would bring the sector up to date in relation to steel needs of industrial development.

374. In the national iron and steel programme for the period 1964-1972, the necessary investment was calculated, which involved increasing almost fourfold the average annual investment compared with the period 1957-1961. Briefly, the features of the programme are as follows: first, the total practical capacity to be obtained is calculated on the basis of normal utilization percentage of the plant (90 per cent); secondly, paying special attention to distribution between integrated and non-integrated plants, bearing in mind the relationship between the size of the home market and the dimensions demanded by modern technology; thirdly, adequate distribution by products, giving particular importance to rolling mills, especially of flat products.

375. In the first stage (1964-1967), coinciding with the First Economic and Social Development Plan, investment was stepped up in finishing processes, which had a lower investment level, and imports were concentrated on ingots and semis of less added value.

376. In the second stage, investments will increase melting shop capacity and those in rolling mill output will be maintained at a high level. The most important feature in the present stage of the programming of Spanish iron and steel development is the financial one.

377. The principal difficulty in deciding an extensive development of the iron and steel industry, is the large amount of investment necessary. The level of self-financing in Spanish iron and steel companies is low. In the period 1960-1965, the companies managed to self-finance only 18.5 per cent of their investments. The capital market did not admit sufficient draining of funds on the part of the iron and steel companies, neither due to the volume of the market, nor to the profitability of the iron and steel business.

378. Consequently, if the National Iron and Steel Programme was to be put into practice, it required some special financing instrument. This instrument was created in 1965, with the establishing of a special system, known under the name "Combined Action",

379. The companies taking part in the National Iron and Steel Programme, and whose projects were approved, could obtain the following assistance and benefits under the Combined Action system:

(a) Official credit for up to 70 per cent of the investment approved;

(b) Freedom of depreciation allowances over a period of five years, extendible for further five years;

(c) Relief from certain taxes and customs duties;

(d) Obligatory expropriation of land necessary for the investment.

380. This policy has made it possible:

(a) To reduce the import deficit;

(b) To modernize production techniques;

(c) To improve the productive pattern.

381. From the above it can be concluded that a developing country that has no iron and steel production should possess at least one of the three following requisites before deciding to begin production:

(a) Rich iron ore resources;

(b) A sufficiently large market to warrant applying modern techniques and the dimensions required;

(c) A structurally deficient balance of trade, without economic sectors with comparative exporting advantages.

382. Apart from the principles mentioned for developing plant by installing in the first place the rolling facilities, there are formulae for saving investment, by means of co-operation between neighbouring developing countries:

(a) By means of customs agreements;

(b) By setting up a common iron and steel plant;

(c) By iron and steel development on a regional basis between developing countries, with the adequate distribution of investments and of trade between the regions.

383. Despite the saving in investments that can be achieved, the problem of financing investments will remain to a greater or lesser extent more severe in developing countries, owing to their weaker firancial potentiality. For this reason, it is essential that the state gives assistance to the development of the iron and steel industry, which may vary from total intervention (with the nationalization of the sector) to supporting action (by means of granting financial assistance at low rates of interest and, at times, not repayable).

"Standardization of steel and steel products to facilitate co-ordination of national, interregional and international specifications and to promote trade among different countries"
(document ID/WG.14/33)

384. The paper pointed out that instead of following the specifications of a few industrially advanced countries, developing nations have set about the task of laying down their own standards at national as well as regional levels. The coming into being of a multiplicity of specifications has thus given rise to new problems in the interchange of steel and steel products between nations.

385. Taking India as an example, since independence in 1947, rapid industrialization of the country led to the import of technical know-how, materials and equipment from a number of foreign countries for the establishment of various industries. In almost all cases, equipment, manufacturing schedules and specifications for raw materials were based on practices followed in the donor country, thus leading to a host of differences in specifications for engineering materials. As a consequence, most of the manufacturers were compelled to depend heavily on imported materials for their manufacturing programmes.

386. A programme of rationalization and formulation of specifications for all types of steel including alloy and special steels, was undertaken by the Indian Standards Institution in 1956. The programme resulted in the formulation of the following Indian Standards: IS: 1570-1961 Schedules for Wrought Steels for General Engineering Purposes. The Standard lists 156 varieties of steel compared to more than 1,500 varieties then being used in the country. To achieve further economy, the number of steels has since been reduced to only 86 varieties, thus facilitating the creation of indigenous production capability at reduced cost. In addition, an increased availability of product is obtained.

387. As a further aid to the industry, IS: 1871-1962 "Commentary on Indian Standard Wrought Steels for General Engineering Purposes" was published with a view to assisting the user in selecting the proper steels for specific purposes. This commentary deals with steels in groups according to their metallurgical behaviour and heat treatment.

388. Conservation of steel through the efficient use of available resources has been achieved through rationalization in the number of steel sections and improvements in their production. Four years of intensive study at the Indian Standards Institutions as well as by expert committees has resulted in the

formulation of Indian Standards on improved and rationalized series of beams, channels, angles, T-bars and bulb angles. All these standards have been based on the metric system of measurement.

389. Member countries of the European Coal and Steel Community (CECA) carried out similar work by developing a new series of beam sections, which are more economical than those rolled earlier in these countries as they achieve economy and also compete with other building construction materials. Similar developments have taken place in the United Kingdom and the USSR.

390. Attempts have also been made to establish regional standards, taking into consideration the raw materials and techniques available in each region. Standards now being evolved among the Latin American countries and the efforts that have already been put in by the CECA countries and many of the eastern European countries are typical examples of regional standardization.

391. All these developments underline the need for unifying national and regional specifications so as to facilitate interchange and mutual exchange of products and materials between different countries. Taking note of this need, the International Organization of Standardization, through its Technical Committee ISO/TC 17 - Steel, has been making efforts to formulate recommendations on specifications and methods of tests for steels used in industry. The Committee has so far published 47 recommendations and more are under preparation. India is trying to adopt these recommendations as far as possible in preparing her national standards. A similar approach by other countries would go a long way in reducing varieties of steel used in industry, leading to greater collaboration between nations and the promotion of international trends.

"Ways of development of iron and steel industry in developing countries"
(document ID/WG.14/79)

392. Half of the world's population lives in developing countries. Almost half of the world deposits of iron ore and natural gas and 85 per cent of oil are found in these countries. More than 20 per cent of the world's total of iron ore is mined in these countries, but the production of steel is only about 4 per cent of the world output.

393. Considering the importance of the iron and steel industry in technical progress and industrial development, it is expedient to speed up the establishment of the iron and steel industry in many of the developing countries as a

basis for making economies of these countries really independent. The creation of development of such industries must be an integral part of the general plan for industrialization, and its success depends to a large extent on the effectiveness of individual firms and the interest taken by the government. The national iron and steel industry should be given priority.

394. It is most expedient to build integrated iron and steel works based on classical technology beginning with coke and ironmaking. As in most developing countries the scrap resources are inadequate, non-integrated steel works would be hardly economical except in rare cases. While the classical coke and blast furnace should be preferred, other technologies, such as electric ironmaking, are not excluded. In the case of some developing countries that do not have the resources needed for installing steel works, a group of such countries may jointly create the iron and steel industry on a regional basis.

395. The industrially developed countries must play their positive role in this task. The USSR renders financial and technical assistance to several developing countries such as Algeria, Ceylon, India, Iran, the United Arab Republic etc. for establishing iron and steel plants. Long-term or commercial credits, repayment of credit with traditional exports and repayment, not necessarily in hard currency, are some of the attractive terms offered by the USSR.

"Possibilities of developing an iron and steel industry with other than fully integrated plants"
(document ID/WG.14/1.)

396. This paper discussed primarily the semi-integrated plants (only steelmaking and rolling without ironmaking), and the non-integrated plants (only rolling and finishing). Commercial success of a new fully integrated steel plant with blast furnaces is doubtful if the potential market for the plant cannot support 2 million net tons per year of raw steel production. An integrated plant with direct reduction must have a source of high grade (65 per cent Fe or more) iron ore or concentrate, a readily available reductant and a location close to the market for its products - but its capacity can be much less, as small as 100,000 tons of raw steel per year.

397. The product mix for semi-integrated plants should preferably exclude sheets, plates and tabular products as the investment for these facilities would be difficult to justify in developing countries installing small plants. Therefore, the production of light sections only, bars and wire rods has been considered, and the plant capacity is based on 72,000 tons per year of these

products. This figure is derived by taking a minimum import of 200,000 tons per year, of which an average of 36 per cent is accounted for by light sections, bars and wire rods in selected developing countries.

398. As regards major production units, electric arc furnaces, continuous casting machines and rolling mills, they have been considered with provision for doubling and trebling the initial capacity later. In view of the unstable and higher price of imported scrap compared to imported reduced ore, metallized ore, the metallic charge to the arc furnace for steelmaking could consist of 70 per cent reduced material and 30 per cent scrap. (An arc furnace with a continuous charge of reduced material would be more economical to use than an open-hearth furnace or cupola - LD converter combination.) Also, the arc furnace heat cycle is more compatible with the continuous casting cycle. Capital cost and production costs were estimated and given.

399. The production cost of similar products rolled from imported billets in a non-integrated plant having only a rolling mill is shown to be higher than the production cost obtained in a semi-integrated plant. The paper concludes that a semi-integrated plant using a reduced or metallized iron ore as the basic raw material provides the best solution for the development of an iron and steel industry with other than fully integrated plants.

"Possibilities in the development of the iron and steel industry, other than fully integrated plants"
(document ID/WG.14/61)6/

400. In their efforts to create steel industries, the developing countries in some cases have got into problems of heavy capital investment and over-sized plant and manpower requirements by attempting to install fully integrated steel plants. In other cases, equally difficult problems have resulted by trying to adopt unorthodox and untried methods to minimize capital outlays.

401. As the economics of the outlaying provinces of Canada have expanded, non-integrated steel plants have been constructed in eight of the ten provinces. There are twelve non-integrated bar mills and four non-integrated flat product mills in Canada. All of the steel required (other than purchased slabs and billets) is made in electric arc furnaces. All the bar mills with two exceptions operate, or are installing, continuous casting machines.

6/ **Summary only issued.**

402. Case histories of Canadian non-integrated steel plants were presented to provide some guidelines for planning such plants for the developing countries. Four cases dealing with hypothetical situations are given, along with plant layouts for annual capacities ranging from 50,000 to 300,000 tons of finished products covering wire rods, bars, light sections, plate, skelp and strip. Typical capital and operating costs were given.

403. In view of the shortage of scrap generally encountered in developing countries, the use of reduced material by two of the direct reduction processes has been considered for arc furnace charge.

"Assistance of the advanced countries to develop the iron and steel industries in the developing countries"
(document ID/WG.14/32)

404. Investments in new iron and steel plants impose a heavy burden on developing countries and they have come to rely, therefore, on foreign assistance for both finance and technology. Owing to the large investments involved, steel projects are often jointly financed by the government of the receiving country and loans and grants from international agencies and foreign governments. The total investment required by developing countries during the period 1965-1970 for their steel programmes announced so far, would be approximately $7,200 million, with a foreign exchange component of about $4,500 million.

405. The adverse terms of aid and the increasing balance of payment difficulties experienced by most developing countries emphasize the need for drastic improvements in the pattern and terms of aid. The terms vary according to the lending agency and often range from loans with interest of 0.8 per cent to those with interest of 6.5 per cent for 3 to 50 year terms with grace periods of 2 to 10 years (DAC, IBRD, IDA etc.). The loans granted by socialist countries usually bear an interest of 2.5 per cent for a term of 12 years with 4 year grace period. The over-all aid picture is not satisfactory. Debt service charges are mounting and accounted for 45 per cent of gross official bilateral lending in 1966. There is a strong case for softening the terms of aid and for wider use of interest free loans.

406. A wide variety of arrangements is possible, and upon the choice of arrangement will depend the effectiveness of aid from the point of view of the developing country. No one questions the usefulness of foreign aid and collaboration, when judiciously employed. What is objectionable is the restrictive aspects of collaboration agreements that hamper technological progress and interfere in the

domestic policies of recipient countries. The tendency of developing countries to accept eagerly any offer of collaboration has also led to the over-importing of capital in some sectors, while starving others.

407. Some of the unsatisfactory features of foreign aid were revealed in recent case studies of foreign collaboration in India, such as the high cost of imported raw materials, plant and equipment, obsolete know-how and outmoded plant and equipment, the insistence on foreign control and management even where local expertise is available. The study also brought to light instances of over-importing of capital and know-how, restrictive provisions, and extra-territoriality. By and large, the experience of Latin America and that of some other developing countries in Asia and Africa appear to have been similar.

408. Foreign collaboration agreements should therefore be entered into where absolutely necessary, based on well defined principles, namely: (a) purchase of technology on a highly selective basis, utilizing indigenous skills to the maximum; (b) procurement of know-how from the best and most economic source, instead of being saddled with an obsolete or "mixed bag" of technology; (c) management and control of project; and (d) channeling of "purchased" technology through a competent local technical agency and making it available to other entrepreneurs.

409. Technology and equipment purchased on a competitive international basis will ensure that the most suitable schemes have been obtained on the most reasonable terms, resulting in considerable savings in project costs. In turnkey and "tied aid" projects the supply is narrowed down to one source, resulting in an increased cost to the recipient country. According to a UNCTAD study, the tying of aid incurs the recipient with substantial direct and indirect excess costs, which reduce the value and usefulness of the aid. Case studies have indicated that direct excess costs range from 10 to 20 per cent (Iran 10 per cent, Chile 12.4 per cent and Tunisia 20 per cent). Other independent studies have confirmed the excess costs of tying aid to be much higher - as high as 30 to 50 per cent. In addition, there are substantial indirect costs in the form of higher prices for spares, higher cost of foreign personnel, increased development costs etc.

410. The paper states that valuable conclusions can be drawn from the Indian experience of foreign assistance to the steel industry. As aid negotiations and collaboration agreements were conducted by bureaucrats without any technical experience - local expertise, though available, was excluded from them -

avoidable difficulties and mistakes have arisen in the subsequent design and engineering of the projects, resulting in high plant costs. The aid-giving country's pressure and insistence on providing its own experts for the project report and engineering are stated as also having been responsible for this.

411. A number of countries have specific experiences, particularly of the pitfalls and mistakes, of aid from both the western and socialist countries. Experts from these countries are not in a position to share their experience with other developing countries. It is suggested that such experts from the developing countries, perhaps under UNIDO auspices, may serve as the watch dog agency to scrutinize aid offers and to ensure that the recipient country benefits by them.

"Technical assistance of the USSR in establishment and progress of ferrous metallurgy in developing countries: its main principles and arrangements, long-term credits and their repayment"
(document ID/WG.14/80)

412. The new independent countries of Africa, Asia and Latin America have raw material and power resources sufficient for operation of large modern enterprises of ferrous metallurgy without difficulties for long periods.

413. The scope and location of these resources in many developing countries gives an opportunity even now to start the practical implementation of development plans in this branch of industry as an important step in the course of overcoming the economic backwardness of these countries.

414. The Soviet Union has since 1955 been rendering technical assistance to the developing countries in designing and building of ferrous metallurgy projects, and at present has an appropriate agreement with eight countries, namely, Afghanistan, Algeria, Ceylon, India, Indonesia, Iran, Turkey and the United Arab Republic.

415. In the above countries there have been designed, already constructed or are at present under construction, fifteen units (total capacity of ore mining 13.4 million tons per year, production of sinter 11.9 million tons per year, coke 7.2 million tons per year, iron 9.1 million tons per year, steel 9.5 million tons per year and commercial rolled products 8.3 million tons per year).

416. It was estimated that by 1 January 1968 six units would have been commissioned with a total rated capacity of: 4 million tons of iron ore per year, production of sinter 2,120,000 tons per year, coke 2,570,000 tons per year, iron 2.4 million tons per year, steel 2.5 million tons per year, commercial

rolled products 2.1 million tons per year and other products.

417. Taking into consideration the concern of the new developing countries to strengthen the government sector, the Soviet Union has been rendering technical assistance mainly in this field. For the purpose of payment for Soviet services in the construction of metallurgical enterprises, the USSR extends credits on favourable terms to interested countries.

418. Technical assistance to foreign countries in the creation of ferrous metallurgy is rendered through "Tjashpromexport" taking into account the maximum utilization of the available resources and the technical abilities of the countries receiving this assistance. The division of labour and expenses between the supplier and the customer facilitates the most efficient utilization of local resources and the mobilization of national wealth and an increase of employed population.

419. The credits extended by the USSR to the developing countries for the progress of metallurgical industry, are on long term and of a favourable character. The credit of the Soviet Union, as is well known to the developing countries, has a low rate of annual interest, a long period of its utilization and payment, and the absence of special conditions attached to the agreements on credit. (The amount of the credit granted is guaranteed because it has the gold clause.)

Discussion

420. The papers in Chapter IV dealt with the prerequisites for the creation of steel capacity in developing countries such as size of plant, location, regional co-operation etc. Although economies of scale may indicate large integrated steel plants as the economic unit, small-scale steel plants in most developing countries make a good case. On the question of the developing countries and exports it was suggested that though it would be a mistake for a developing country to start a new steel industry on the hopes of export there is no reason why exporting should not represent a temporary stage. Some speakers suggested that certain countries could built 1.5- to 2 million-ton plants, from which excess production could be channelled into exports until the home demand reached the required level.

421. On the other hand, objections were raised to the implications contained in one paper that 50,000-ton plants were impractical. Though many countries will probably need large integrated steel plants, there are many countries

that need only constructional steel from a plant of annual capacity of less than 150,000 tons. Although the developed countries tended to think in terms of very large plants, it was agreed that this did not mean that only big units were viable. It was implied that blast furnaces should either be large or another ironmaking process should be used, but this viewpoint was not generally accepted since the criteria for optimum capacity could be determined only by local and specific conditions and could not be fixed at a pre-determined level.

422. There was general agreement that investment must be based on specific maximum efficiency and it was expressed that there had been insufficient studies on the question of the relationship between investment and production. Under- and over-capacity are equally to be avoided, but the position can be complicated by raw materials problems. Recommendations were made that new steel industries should look into other metallic sources such as sponge iron and electric pig-iron as the scrap market was often very unstable.

423. Specific experience in certain countries was described. For example, one country had found that the creation of a steel plant in the prevailing conditions placed a very heavy financial burden on the country in spite of the favourable raw materials situation. The representative from that country suggested that it would be wrong to try to produce products with no certainty of selling them. It would be better to sell the raw materials. In this particular case, special attention was recommended to the papers that outlined possibilities other than fully integrated plants. In another country, in 1962, a 100,000-ton per annum plant began to operate. It was suggested that it might have been better to build a plant two or three times the size as the infrastructure, which had to be created and financed, was out of proportion to the size of the plant.

424. The importance of training labour was also stressed, particularly when the situation tended to be complicated further by the insistence of aid-giving countries on regaining too much technical and managerial control. More assistance in training indigenous people to fill managerial and technical posts would be welcomed. It was pointed out that the training of labour was not in general necessarily a slow process and if, as suggested, continuous casting plants should be installed in developing countries, then this presupposed a fairly high level of skill, in which case it might be possible to install other sophisticated processes without difficulty. It was thought that personnel to

fill what were termed "craftsmen positions" would be better supplied by sending groups to learn in the industrial environment of a developed country so that they could return to train others.

425. Doubt was expressed about the practicability of the frequently discussed desirability of combined resources through regional co-operation. The two main sources of doubt were that political-economic co-operation must be assured before tangible projects are handled and that inequalities in the share of the economic burden and benefits would be bound to arise. It became clear during the discussions that regional co-operation was a good stimulus to industry in general and that its benefits might be more widespread than was thought, but probably co-operation in the metallurgical field does not have the high priority it has in such fields as communications and health.

426. The representatives of a number of countries were particularly interested in research co-operation. A shortage of trained personnel made it difficult for countries to deprive industry of experts and have them concentrate on research. If a research facility was shared by a number of countries, however, they could all contribute in manning it. It was strongly urged that the research and development effort in new steel industries should be directed towards raw materials. National resource surveys are therefore needed and a real contribution could be made in this direction. Countries with deposits of high grade ore should give close consideration to the establishment of ore processing industries. Research results should be applicable and a country should be able to absorb its research output. At the same time it should be understood that research sometimes fails, and if it does not, the programme is probably insufficiently imaginative. Positive progress towards the establishment of research facilities is being made in one country in Latin America where a comprehensive survey of the market for research and the existing organizations is being evaluated. Research must be accompanied by pilot plant work and here is further ground for co-operation.

427. The question of aid to developing countries was discussed. In particular, the question of local design and engineering services was given attention, together with the use of indigenous equipment manufacturing capacity. Developing countries should be able to handle their own design and engineering work since the necessary skill was, in some cases, already in existence. Aid giving countries sometimes insisted on providing the complete design engineering services and equipment supply even when some of this may be available in recipient countries.

428. Standards must receive close study. Developing countries need co-operation and advice on the adoption of standards and on the setting up of standards organizations.

CHAPTER V

OPTIMUM CAPACITY AND STAGES OF CONSTRUCTION OF THE IRON AND STEEL PLANTS AND THEIR PARTS

429. Under this heading two groups of papers were presented. The first group dealt with new and modern equipment for oxygen steelmaking plants and the second group with equipment for the continuous casting of steel for small- and medium-size works in developing countries.

"New equipment for oxygen steelmaking plant"
(document ID/WG.14/35)

430. This paper outlined major factors governing the design and layout of oxygen steelmaking plant. Among these factors are: the required total production tonnage, availability of raw materials, grades of steel to be produced and air and water pollution control requirements. The paper then described the major plant units required for the process. Particular attention was devoted to the design of the steelmaking vessels with oxygen lance equipments, waste gas cooling and dust collecting plant and to provisions for the automation of the process. Among the other steel plant facilities, mention was made of hot metal mixers, scrap charging machines, ladle transfer cars and relining stands.

"Modern equipment for oxygen steelmaking"
(document ID/WG.14/60)

431. The paper outlines the trends that led to the present day shapes and design of LD vessels. Special attention was paid to the fixation of the vessels in the trunnion rings and to the latest development in this field.

432. One of the chapters was devoted to the planning of the LD vessel plants in existing steel work bays. It is shown that by installing movable vessel plants of the same production capacity, the investment costs can be reduced. For the successful performance of the LD process, the lance equipment necessary for introducing the oxygen into the reaction vessel is of great importance.

The paper, therefore, describes in detail the development of the lance equipment from the single-hole to the multiple-hole lance and other special designs. These especially refer to the ring-nozzle lance and other developments for blowing in simultaneously solid materials such as lime powder.

433. In the last part of the paper, a description is given of steel plant installations equipped with instrumentation for the automation of the steel producing process, e.g. continuous bath temperature measuring and handling equipment for the fully automatic performance of various functions.

"Waste gas cleaning systems for large capacity basic oxygen furnace plant" (document ID/WG.14/53)

434. The paper compares the main alternative waste gas cleaning systems available for large capacity basic oxygen furnace plants. In the past, the choice facing the steelmaker at the plant design stage was limited to one of two well tried systems, whereby the furnace waste gases are burnt in a plentiful supply of combustion air and cleaned in either electrostatic precipitators or wet scrubbing plants. This choice has now been widened by the introduction of reliable, unburnt gas collection systems, which appear to have the attractive feature of requiring less plant and lower capital outlay. A comparison is therefore made of the comprehensive capital and operating costs for three selected gas cleaning systems suitable for 300-tons capacity basic oxygen furnaces.

435. The three waste gas cleaning systems selected for comparison are:

(a) A dry plate electrostatic precipitator equipped with a pressurized hood system;

(b) A variable throat wet scrubber plant equipped with a pressurized hood system;

(c) The Yawata OG unburnt gas collection system.

436. It is recognized that waste gas cleaning systems other than those selected in this comparison have been put into successful operation.

437. Two schemes are considered for each of the above systems:

(a) Scheme A - two B.O.F.'s installed, one operating;

(b) Scheme B - three B.O.F.'s installed, two operating.

438. The paper first establishes the basic design data and discusses the determination of gas cleaning plant capacity in terms of the waste gas flow rate and the rate of carbon removal. Relationships are given for the mean and peak rates of carbon removal and for the peak gas flow rates for the full combustion systems.

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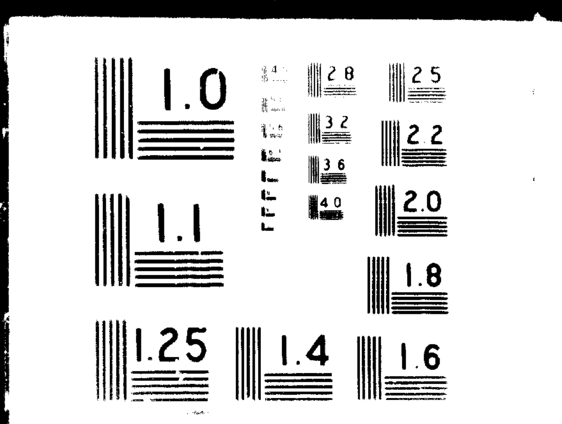


439. Utilization of heat by waste heat boilers using auxiliary firing and steam accumulators is discussed. The pressurized hood system is selected as the best technical and engineering solution to the problem of collecting the waste gases from the converter mouth.

440. The paper discusses further the excess air requirement for waste gas combustion. Excess air quantities of 150 per cent and 75 per cent have been selected for the precipitator and wet scrubber schemes respectively. In comparing hoods required for excess air quantities of 150 per cent and 75 per cent it is found that the latter results in a larger hood for the same gas exit temperature.

441. Two types of electrostatic precipitators are considered, namely, wet plate and dry plate. Due mainly to the disposal problems of the iron oxide slurry with the wet plate precipitator, the dry plate precipitator is selected on the basis of resulting lower capital cost. The precipitator plant proposed is briefly described.

442. The wet scrubbing plant comprising a venturi quencher and variable throat venturi scrubber is described.

443. The Yawata OG Recovery system is discussed with particular emphasis on the use of nitrogen for purging the system. It is pointed out that a full OG system is required for each furnace installed and also that the use of a secondary ventilation system is considered normal with the OG system. A complete list of existing and new OG plants is given.

444. Reference is made to dust pelletizing, and the distinctive characteristics of the process dusts arising from both the burnt and unburnt systems are tabularized.

445. Comparative displays are given for the capital and operating costs for the three gas cleaning systems.

446. A comparison of the systems using combined capital and operating costs is not given since assessments are dependent upon conditions relating to taxation, investment grants etc.

447. Finally the paper considers the question of process yield, which is claimed to be an advantage for the OG system. The actual tapping yields for the No.1 and No.2 LD plants at Tobata operating with open and closed hoods respectively are compared graphically. The results indicate an increased yield for the closed hood system of 1 per cent and the significance of this result is discussed.

448. Two papers devoted to the application of continuous casting processes for production of semi-finished products were presented.

"Continuously cast and rolled semi-finished material for light section and wire mills in developing countries"
(document ID/WG.14/50)

449. This paper described recent developments of new processes especially suited for the application in developing countries. The choice of the processes and the required equipment is known to be influenced by the intended type of operation, which in turn depends on the scale of operation.

450. For large-scale production of ferrous metals, the following plants and equipments are available: coke ovens, coked fire blast furnaces, basic oxygen converters, blooming and slabbing mills, continuous casting machines, plate mills, cold and hot strip mills, profile and bar and rod mills. For medium and small steel mills, the blooming mills have been replaced by continuous casting machines, which are also gaining in importance in large steel mills. In medium and small steel mills, the continuous casting machine has attained a dominating position for the production of semi-finished sections. This applies especially to small-scale operations, which rely on scrap and the cheap freight rates of both the scrap and the finished products.

451. Continuous casting machines have found widespread application in the field of ferrous metallurgy. They have attained a high degree of perfection as regards their operational safety and low costs of production. Continuous casting machines can be classified as in the following paragraphs.

452. Slab casting machines of all sizes. They supply excellent starting materials in the form of 1-metre-wide slabs for further rolling in strip mills. The rate of production meets the demand of large-scale operations. The development aims at full continuous casting, whereby up to six heats have so far been cast in one continuous operation. During continuous operation, the casting costs are reduced by the disposal of non-productive set-up times and the smaller consumption of high quality refractories per ton of steel.

453. Billet casting machines are mainly designed as multi-strand machines in order to attain the necessary production rate. On account of the smaller cross sections and reasons pertaining to the quality of the cast sections, the rate of production is considerably lower than for the casting of slabs. Billet

casting machines, employed for the casting of sections, which can be used immediately in light section and rod mills are very sensitive to improper casting and set-up operations. By the development of integral billet casting and rolling machines, considerable progress has been made in this respect.

454. Integral billet casting and rolling machines permit the rolling of the cast section immediately after casting in one heat. In this manner, a medium-sized cast section can be selected, which inreases operational safety, although the finished billet possesses a sufficiently small cross-section to make it suitable for use in finishing mills. The billet obtained in this way has the additional advantage that prior to its rolling in the rolling mills it has been subjected to a hot forming operation whereby its as-cast structure is converted into an as-rolled structure. In this manner, certain limitations regarding further processing are abolished.

455. Integral continuous casting and rolling machines give greater operational safety at higher rates casting, improved quality, and often lower casts for the casting small sections, as compared to the conventional continuous casting machines. The greater operational safety is derived from the fact that the casting of larger sections poses fewer difficulties. The greater rates of casting are possible on account of the larger cross sections, which can be cast by this method whereas the improved quality is derived from the direct conversion of the as-cast into an as-rolled structure. The reduction in costs is derived from the reduced number of strands as compared to conventional continuous casting machines, which results in a decreased consumption of refractories, nozzles, stoppers and tundish linings.

456. The yield can be considered equal to that attained in conventional continuous casting machines and lies between 96 and 98 per cent of the liquid metal in the ladle.

"Equipment for the continuous casting of steel for the needs of small steel works"
(document ID/WG.14/64)

457. This paper set out the present state and development prospects of the steel industry of Poland and described the continuous steel casting installations operating at three iron and steel plants.

458. The favourable technical and economic results obtained in the operation of continuous steel casting installations give grounds for foreseeing the wider use of this method in the Polish steel industry, which is being expanded and modernized.

459. The introduction of such installations is envisaged, both in steel works that are to be modernized and in newly built plants.

460. The main reasons for envisaging the introduction of this process are:

(a) To increase the yield of useful products with respect to the output of molten steel;

(b) To link the steelmaking sections directly with the rolling mills, without the need for blooming mills;

(c) To increase the through-put capacity of the casting bays of steel works;

(d) To improve the working conditions of casting bay workers.

461. As far as the choice between vertical and curved-mould installations is concerned, the main factors to be taken into account are the section of the continuously cast billet, the site conditions, and the space available, particularly in the case of already existing steel works.

462. Where the continuous billet to be cast is of large section (over 220 mm), and site conditions are favourable, a vertical system is indicated.

463. Where the continuous billet is of relatively small sections, the geological conditions are unfavourable, and there is sufficient space available on the casting floor of the steel works, a layout with a curved mould can be selected.

464. The concluding part of the paper shows the possibilities for technical co-operation in this field between iron and steel industry of Poland and those of developing countries.

"Determination of the optimum capacity of the fully integrated iron and steel plant and its parts"
(document ID/WG.14/48)

465. The paper stated that the capacity of a steel works is mainly influenced by the rate of production and diversity of the products. The criteria that have to be considered are: the economics of scale, the relationship of capital to operating costs, the yield of processes, questions of unsatisfied demand, and variation in demand, as well as of product mix, shortage of resources, sociological benefits, or of political strategy and profitability. Before attempting to define these, it is essential for the planner to find some common ground for comparison by studying the effects of each criterion on the costs of the enterprise and by converting them into their cost equivalent. In taking account of both capital and operating costs, capital can be regarded as a commodity hired for an annual charge.

466. This paper considers the four principal criteria affecting optimum capacity: (a) those that affect parts of the plant; (b) those that affect the whole plant; (c) those that have national implications; and (d) those that are related to the life span of the project.

467. The capital cost of plant per unit of capacity falls as the size increases, but the limit tends to be determined by the maximum plant size that can currently be built. A somewhat smaller plant, the cost of which is not greatly above this asymptotic value may be justified on the economic grounds of saving the transport costs of imported steel, but a much smaller plant will carry such high capital charges per ton that its installation would have to be justified on other than economic grounds.

468. The relationship between capital and operating costs varies from one country to another. A process of a certain capacity that is viable in an industrial country may be uneconomical in a developing country where capital costs are higher, even though labour is cheaper.

469. The yield of a process affects the economics of earlier processes in the chain. Thus a rolling process with a low yield will result in a greater demand for steel to feed it.

470. A country's demand for steel does not in itself determine the opportunity for sales from a new works. The important factor is that of an unsatisfied demand, taking into account the capacity of other existing works. Consequently, the growth of the total demand does not necessarily mean a growth in unsatisfied demand if new plant has already been planned to meet the needs.

471. Shortage of resources may impose a temporary or permanent limit on the capacity of a steel works. The limit is essentially economic since all shortages, whether of material supplies, labour or finance, can be overcome at a price.

472. Sociological benefits may justify the establishment of a steel industry that is unacceptable on purely economic grounds, but the cost of such a decision must be calculated in order to check whether the increased prosperity of the people can in the long term repay the investment.

473. The principal effect of political strategy is the saving of foreign exchange, but the viability of a plan may also depend on existing trade agreements or economic alliances.

474. Profitability is an assessment of the dynamic efficiency of a plan. As a yardstick of the effective use of money, its measurement is just as necessary for a publicly owned enterprise as for a private business. A discounted rate of return on the cash flow is the generally accepted means of measurement, which takes account of performance through time.

475. In an iron and steel works, the processes are conveniently divided into primary, from ore to liquid steel, and secondary, from liquid steel to the finished products. The capacity of primary processes may be governed by the supply of raw materials, but possible unit plant sizes are so large that economies of scale play an important part in the decision, and it may be worth supplementing local supplies by imported raw materials to achieve these economies. One process may be cheaper than another at low capacities, but the second cheaper at high capacities. Moreover, the change-over point in a developing country may be at an entirely different capacity from that in an industrialized country.

476. The capacity of secondary processes is governed by market factors (unsatisfied demand and product mix) and design characteristics of plant (such as yield and economies of scale).

477. Product mix greatly influences the capacity of secondary processes, a higher average size of product giving a higher capacity to the rolling mill producing it. Iron and steelmaking plant can be designed for a wide range of capacities, but it is difficult to design mills for specific capacities. There are a limited number of mill capacities suitable for a given product, each covering a range of capacity, but not necessarily the complete range. Consequently, for some outputs, the plant must run below capacity.

478. Some plants, such as primary mills, have an inherently large capacity and are uneconomical to install for low outputs. In such cases the production of billets or slabs directly from liquid steel by continuous casting may be more economical.

479. In a given set of conditions, curves can be drawn for the comprehensive cost of alternative process chains over a range of capacity and the envelope of these curves gives the most economical solution for any required capacity.

480. When primary and secondary process costs are combined, not only differences of yield but also energy and scrap balances are introduced. A different, and at first sight less economical steelmaking process, may have to be adopted

if there is an excess of scrap that cannot be sold and must therefore be considered as a free supply.

481. Shortage of resources may lead the planner to restrict the works capacity to a lower level than the market justifies. Shortages of capital may lead to the adoption of a minimum capital cost strategy, which is over-all less economical. An alternative is to build only part of the works initially, for example rolling mills to use imported billets.

482. Restricted fuel and power resources can be overcome by importing fuel, and water shortages to some extent by an increase in recirculation.

483. Industrialization may be regarded as such a desirable goal that the installation of an uneconomical iron and steel plant as the first step is justified.

484. Steel works to serve the whole region depend for their viability on political and economic co-operation between countries to secure the necessary large markets, and existing agreements may hamper such co-operation.

485. The planner must test each criterion in turn to understand the part it plays in determining optimum capacity and arrive finally at a short list of possible strategies for detailed study.

486. The final test is that of profitability through the life of the project, which is evaluated by listing expenditure and revenue, year by year, and comparing the discounted rates of the cash flows for each of the strategies under study. The capacity of the whole works is seldom in balance until it has reached its fully developed state, and the optimum capacity at any stage is that which forms part of the most profitable over-all strategy.

487. This strategy forms the long-term plan for the development of the works. The plan must be kept under review and reappraised every three to five years, or whenever a new phase of the development is imminent, to take account of technical innovations, shifts in market demand and shortages of resources. Any ohanges in plan must take into account the heritage of plant already installed.

"Modern designs of blast furnaces"
(document ID/WG.14/81)

488. This paper covers the latest designs of blast furnaces in the USSR. In 1967, 75 million tons of pig-iron were produced in the USSR. The average ooke rate per ton of pig-iron amounted to 561 kg. The production of sinter in 1967 was 126 million tons.

489. The world's highest outputs of blast furnaces have been obtained in the USSR. In 1967 a blast furnace N3 of 2,000 m^3 volume at the Cherepovez plant achieved an output of 1.6 million tons per annum. The maximum useful volume of the operating furnace is 2,700 m^3. A blast furnace of 3,000 m^3 volume is under construction.

490. Blast furnace operation at an elevated top gas pressure is used extensively in the USSR. More than half of all the blast furnaces operate at top gas pressure being higher than 1 atm gauge including 15 furnaces with the pressure ranging from 1.5 to 2 atm gauge.

491. A blast furnace operation blowing natural gas into the hearth has been developed and perfected in the USSR. The consumption of natural gas in 1967 averaged 87.7 cm^3/ton of pig-iron.

492. Oxygen is also widely used in the Soviet blast furnace practice.

493. In 1967 the actual average blast temperature was 963°C and at a number of blast furnaces it reached 1,150-1,180°C.

494. The increasing of the volume of operating blast furnaces during the scheduled overhauls is a wide practice in the USSR.

495. Standard blast furnaces in the USSR have the following main-dimensions:

	Volume of blast furnaces (m^3)				
Dimension	1,033	1,386	1,719	2,000	2,700
Useful height (m)	26.0	27.3	28.5	29.4	31.20
Diameter (m):					
hearth	7.2	8.2	9.1	9.75	11.0
bosh	8.2	9.3	10.2	10.9	12.3
furnace top	5.8	6.5	6.9	7.3	8.1

496. Blast furnaces are designed to operate at a completely prepared burden, with the injection of natural gas, to use a blast with constant humidity, heated up to 1,200°C and oxygen-enriched up to 30 per cent. Top gas pressure amounts to 1.5-2.5 atm gauge. Blast furnaces are provided with a blast by turbo-compressors with a steam drive.

Characteristics of main designs of lately commissioned blast furnaces

497. The all-welded shell of a blast furnace is made of low-alloy steel plate. The lining of the hearth bottom is a combination of carbon and alumina-silicate refractory bricks. The walls of the hearth up to the level of the slag notches

are lined with carbon blocks and above the slag notches with fireclay bricks. The bosh, body and the stack are lined with alumina-silicate refractory bricks.

498. The furnace refractory lining is cooled by vertical cooling plates. For the bottom and the hearth, smooth cooling plates are used, in the tuyere zone and bosh, ribbed ones with cast-in bricks, in the stack, plates with projections are used. The furnace cooling is either water or evaporative. The underneath of the bottom is cooled by air.

499. Blast furnaces of a large volume are designed to have two casting houses both equipped with magnetic cranes. Molten iron and slag are run into the ladles with the help of movable chutes.

500. The hot-blast stove shells are welded and made of low-alloy plate steel. The wall linings of the hot-blast stove, the dome and checker in the high-temperature zone, the internal lining of the fire chamber over the whole height and the external lining in the high-temperature zone are made of high-alumina bricks. For medium-temperature and low-temperature zones fireclay bricks are used. The hot-blast stoves can operate in sequential and couple-parallel order.

501. Primary gas cleaning is carried out in the dust catcher. The steel shell of the dust catcher, is lined inside with refractory brick. Release and moistening of dust is done by two screw conveyors.

502. Blast furnaces are skip charged. Lifting of skips and manoeuvring the bells are done with the help of winches. Raw materials are carried to the skips by apron conveyors through weighing hoppers. Coke is charged into skips directly from the bunker through weighing hoppers. Skip charging with materials is done automatically according to a pre-set programme. The system of conveyor supply of materials to the skips together with the main hoisting system makes blast furnace charging fully automatic.

503. Automatic checking and control is effected by the following parameters: heating of hot-blast stoves, the temperature of the hot blast, top gas pressure, moisture content of the blast, supply of natural gas into the furnace.

504. The blast furnace is equipped with a system of centralized checking and control of the blast furnace process, including the use of computers. The main technical directions of development of the blast furnace practice in the USSR are the following field's construction of larger, more mechanized blast furnaces, improvement of burden preparation, utilization of the latest achievements in advancement of the technology of blast furnace process, reconstruction

of blast furnaces with the purpose of increasing their volume and advancing their technical level. The second area of interest is to ensure intensive operation of blast furnaces and their auxiliary facilities with the highest possible temperature of the blast and maximum top gas pressure. Thirdly, a wide introduction of mechanization and automation of production and technological processes alongside with sanitary engineering arrangements is pursued to improve the working conditions.

"Modern design of blast furnace"
(document ID/WG.14/34)

505. This paper described the latest design of blast furnace in Japan. In this country the development of iron producing equipment and techniques has been attained through pioneering experiments and by efficiently employing the newest techniques developed in the United States, Federal Republic of Germany and other countries. Especially recently, it has been possible to mass-produce pig-iron at low cost since the enlargement of the blast furnace equipment and the employment of the new techniques for pre-treatment of the charge, humidity control blasting, oxygen enrichment, injection of auxiliary fuel, high temperature blasting and high top pressure operation resulted in increased production efficiency and lower coke rates. By employing these new techniques, the design of blast furnaces has also developed considerably.

506. The achievement in blast furnace design and further improvements continuously developed in Japan during the last ten to fifteen years were enumerated.

Blast furnace design

Furnace construction

507. The blast furnaces operated in Japan today are classified as follows:

(a) American type, to support the furnace top by the mantel column through the shaft shell;

(b) German type, to support the furnace top by the furnace scaffold (Gerüst) but not by the mantle column; the furnace itself is free standing;

(c) Combination of American and German type;

(d) Type holding the mantle by brackets from the furnace scaffold.

508. To design a modern blast furnace it is necessary to consider the resistance to the pressure caused by employing a high top pressure operation, the resistance to wear the bricks of the lower shaft and bosh caused by blowing with heavy oil and the case in changing tuyeres and blow pipes.

Furnace proper

509. The enlargement of blast furnaces has increased with the development of blast furnace operations techniques. In Japan before the Second World War, the maximum blast furnaces were of 1,000 m^3 inner volume, and today the nine largest installed blast furnaces have 2,000 m^3 inner volume. Three of these are of over 2,500 m^3.

510. The furnace lines are fixed at certain levels, though there is no change in the furnace height. Since carbon brick has been used for the hearth, the life of the furnace has been extended and the molten iron has rarely flown out from the hearth wall. The furnace walls have become thinner since the quality of fireclay brick has improved. For this purpose it is necessary, however, to employ the effective cooling method in the main parts of the furnace.

511. The following four systems are employed for cooling the furnace in Japan:

(a) External water spray system. The hearth jackets of most blast furnaces are cooled by this system, and the bosh jackets of blast furnaces with carbon bosh are also cooled in this way.

(b) Cooling plate system. The shafts of most blast furnaces are cooled by this method. Cooling plates are also inserted into the brick of the bosh area and the iron notch area. It is necessary to employ a sealing device in the high top pressure blast furnace to prevent the gas from leaking.

(c) Blister cooling system. This system is seldom employed except, for example, for bosh jackets.

(d) Stave cooling system. This system is employed for the hearth jackets in many countries. Research has been made for employing this system for the bosh and stack, but there are still some problems to be solved. As this system has an excellent cooling effect and allows thinner brick walls and as there is no gas leakage from furnace shell and evaporative cooling is possible, the use of this system is expected to increase.

512. Recently large furnaces employed under-hearth cooling system combined with the use of the all-carbon hearth, to protect the foundation concrete.

Furnace top equipment

513. McKee-type distributors had mostly been used before the high top pressure operation came into practice. By employing the high top pressure operation, however, the life of the equipment has been remarkably shortened. Therefore, new furnace top equipment is being developed. The development is divided roughly into two directions. One is to strengthen the McKee-type distributor and at the same time to improve the speed of changing of worn out parts, and the other is to develop new equipment, which is fundamentally different from McKee-type distributors. In Japan the latter development has been emphasized,

and the valve seal system has been succeeded by applying the conception of a three-bell system. The development of wear-resisting materials has advanced, high chromium cast-iron has been successfully used for the small bell and hard-faced cast steel for the large bell. The life of the large bell under high top pressure has been extended to the level of a normal top pressure blast furnaoe by using valve seal system.

Burden preparation

514. Sizing of ore. At present all the plants employ the circulated crushing and screening system to limit the range of the size to 30 - 8 mm, as it has been proved that the removal of fine ores enhances the operation results of the blast furnaces.

515. Sintering. Sintering was developed for the purpose of fine ore recovery. The equipment of sintering has been expanded in the last ten years: self-fluxing sinter has proved to be very efficient for lowering the coke rate and increasing furnace productivity since it has better reductivity in comparison with lump iron ores. The sintering machines have become larger with the increasing size of blast furnaces. At present, nine sintering machines, under construction or planned, with an effective area of more than 150 m^2 are operating.

516. Pelletizing. In Japan, pelletizing plants are not so widely employed as sintering plants, and mainly imported pellets are charged into the blast furnace. The plant, which was constructed in 1966, employing the grate-kiln system, produces 3,600 - 4,000 tons per day of self-fluxing pellets.

Furnace charging equipment

517. It is advantageous for large blast furnaoes of more than 2,000 m^3 capacity to employ the belt conveyor systems, because it has a much larger charging capacity and lower construction cost than the skip system, and it is possible to plan the cast house without considering the charging equipment.

Hot stoves

518. At present the hot blast temperature is generally 1,000-1,100°C, by employing burden preparation, humidity controlled blast and fuel injeotion. Moreover, even 1,250-1,300°C temperature stoves have been constructed. These high temperature stoves depend mainly on the improvement of refractories for hot stoves and the improvement of stove burners and valves. Stabilization of operation has been possible by introducing stoves with external combustion chambers. An external combustion chamber design stove was constructed for the first time

in 1965, and this type of stove has since accounted for half the hot stoves installed. Automatic stove reversal equipment is widely employed all over Japan.

Blowing equipment

519. At present the axial-flow blower is widely employed. With the enlargement of blast furnaces and the employment of the high top pressure operation, a blower of large volume and high pressure has been required. A blower of 38,000 KW 7,400 Nm^e/min and 5 kg/cm^2 gauge is under construction. Various operating conditions have also been imposed. Therefore, the blower should be of a wide range of efficiency and safety since it is frequently used beyond optimum design conditions. For instance, the angle of static blade of the blower is varied in many cases to control blast volumes.

Gas cleaning equipment

520. As much cleaner blast furnace gas is required as a fuel for coke ovens or hot stoves, gas cleaning equipment is generally designed under the condition of less than 5 mg/Nm^3 dust content. Gas, from which large size particles are removed by the conventional dust catcher is generally cleaned by the cleaning equipment in two stages, primary and secondary. The combination of these stages used to be mainly the combination of a gas washer and electrostatic precipitators, but since the high top pressure operation has been employed, the venturi scrubber, which requires a large pressure drop, has been employed as a primary stage. Some plants employ the venturi scrubber as a secondary stage, making efficient use of its advantages: low installation cost, easy operation and maintenance and small installation space.

Cast house layout and mechanization

521. Casting time has increased with the increase of blast furnace capacity, which has resulted in insufficient time for the maintenance of runners. In Japan the blast furnace with two tapholes has been employed since 1962, which was the beginning of rationalization in cast house practice. All blast furnaces of more than 2,000 tons per day constructed or remodelled since then have two tapholes.

522. Molten iron is transported to the BOF plant by a torpedo-type mixer car. The method of disposing of slag into dry slag pits adjacent to the blast furnace has recently been widely employed as a method of treatment of large amounts of slag at low cost.

523. The clay gun, taphole drill and slag notch bott are all remote controlled, and are equipped to all blast furnaces. Several plants employ the tuyere changing machine effectively and the runner maintenance machine and replaceable trough so as to mechanize cast house practice.

Plant and equipment, optimization of production and economics of scale

524. Six papers in this part of the discussion[7] presented, as a group, information and suggestions concerning the following topics: first, plant and equipment suggested as being most suitable for the needs of developing countries, secondly, optimization of production and thirdly, economics of scale.

525. These topics are interrelated. First, the main determining factors that influence the choice of process and type of production units in the iron and steel industry were examined both from the technological and economic point of view. The papers then discussed considerations related to the cost of production relative to capital outlay and the relation with the factors below.

526. The effect of each of these and their interrelationship was examined with a view to indicating the means of reaching workable solutions and compromises to suit different situations, with special reference to the needs of developing countries.

Required volume of production

527. It is to be assumed that the required volume of production has already been determined, using established market and economic indicators. If a large-scale plant is required, the choice of processes and equipment becomes comparatively simple. Iron would be produced in large capacity blast furnaces, basic oxygen converters would be installed in the steelmaking plant and continuous rolling mills would be used to produce the finished products.

528. The difficulty arises when a small-scale plant is required, in which case a very close examination should be conducted to determine the most suitable processes, based on local conditions especially regarding raw materials, fuel and power.

529. A small blast furnace is no longer recommended unless cheap high grade ore and low cost metallurgical coke are available. It is assumed that a blast

7/ See Annex 4, nos. 58-63.

furnace producing: less than 800 tons per day is considered small, from 800 to 1,500 tons per day medium and over 1,500 tons per day large.

530. Even when local conditions allow the production of low-cost iron from a small blast furnace, difficulties will be encountered in the conversion of hot metal into steel with regard to the economy of scale at the steelmaking plant.

531. Electric shaft reduction furnaces lend themselves quite favourably to small and medium-scale ironmaking plants, on condition that low-cost electric power is available. Another advantage of the electric shaft furnace is that medium-grade ores are suitable and low-grade coke can be utilized.

532. If high-grade ore and low-cost natural gas are available, one of the gaseous-solid reduction processes could be the answer, where small-scale production is required. The product is sponge iron, which does not present a steelmaking problem with regard to economy of scale, since the electric arc furnace can melt the sponge iron and convert it into steel successfully. In which case the electric steelmaking plant would have an economically feasible capacity.

533. The open-hearth furnace can no longer compete with other processes for steelmaking except in very special circumstances. The predominant process nowadays is the basic oxygen converter, but here again the process is not economically feasible for small-scale production, i.e. below about 350,000 tons *per annum*. It is most suitable for production of about 700,000 tons *per annum* and above.

534. The electric arc furnace, on the other hand, is most suitable for small-scale production, provided that low-cost electric power is available.

535. The rolling process does not present problems of economy of scale unless flat products are involved. Rolling mills producing shapes possess a degree of flexibility and present such a wide variety of equipment that, in most cases, an economically feasible unit can be designed to meet the volume requirements while retaining the possibility of future expansion.

536. A well designed rolling mill producing reinforced concrete bars, having an annual capacity of 30,000 tons, could compete with a mill producing 300,000 tons of reinforced concrete bars *per annum* in both cost of production and capital outlay per unit of production.

537. Although the situation is more complicated with regard to the production of flat products, the introduction of the planetary mill for hot strip rolling

and cluster mills, together with the long established four-high reversing mill for cold strip rolling will help in finding a solution of the problem of scale in this field.

538. Tube-making presents ideal flexibility where problems of scale are concerned. It is possible to construct economic units for the production of welded tubes, longitudinal welding for tubes of 4 in. and below and helical welding for tubes of 6 in. and above.

539. A longitudinal welding tube mill producing the full range of 4 in. and below can have its capacity increased considerably by running 4 in. tubes only and adding a stretch reducing mill to produce the smaller diameters from the 4 in. shells.

540. In the field of seamless tubes it is also possible to construct an economically feasible small- or medium-scale plant utilizing the push-bench process or the hot extrusion process for the production of shells for subsequent rolling on a stretch reducing mill.

541. In conclusion, the rule of thumb is that the larger the volume the lower the capital outlay per unit of production and the cost of production and vice versa. This is a general statement that does not apply in all specific cases. Owing to the diversity of iron and steel producing processes and rolling mill combinations, it is possible in many cases to find an economical size of unit for widely varying production volume through the choice of the most appropriate processes to suit local conditions.

542. In this respect it is very important not to concentrate solely on fully integrated iron and steel plants, for semi-integrated plants present interesting possibilities for developing countries during initial stages of industrialization.

Type of products and/or product mix

543. The choice of the ironmaking process is not influenced by this factor unless it is desired to produce foundry irons, in which case a small blast furnace is usually utilized. The only bearing this factor has on the choice of steelmaking processes is when medium and high alloy steels are to be produced.

544. The electric arc process is the recognized process for the production of alloy steels. Often the furnace is fitted with a magnetic stirrer to ensure homogeneity and rapid slag-metal reaction. High frequency induction furnaces are used when the melt weight is limited and for some special types of high-grade alloy steels.

545. Low alloy steels can be successfully produced in the open-hearth furnace and the basic oxygen converter.

546. The production of high alloy steels is usually carried out on a small scale. The question of economy of size does not arise here since these steels are high priced and, because of their large variety, are produced in small batches.

547. It is the rolling mills that are influenced most by this factor. It is possible to design rolling mills that are capable of producing a very wide variety of products both in shape and in dimension.

548. The wider the variety, the higher the capital outlay per unit of production and, consequently, the cost of production. It is, therefore, advisable to limit the designed production programme of any particular rolling mill to the so-called "natural" design characteristics. These "natural" limits, with good design and layout, provide for quite a satisfactory latitude in production variety.

549. There is no doubt that specialized mills are the most economical, for the installed equipment could be fully loaded all the time, whereas a "jack-of-all-trades" mill will have idle equipment at any particular time. It should always be possible to reach an acceptable compromise between the two extremes giving satisfactory results. A special type of rolling mill is designed to roll special and alloy steels. These mills are more expensive than those designed for rolling carbon steels, but they produce a high cost product and cater for special markets.

Quality of product

550. The emphasis on quality becomes increasingly important as consumers' requirements become more demanding and commercial competition increases.

551. An iron and steel production unit is designed normally with a view of ensuring standard quality requirements. There are several technological developments and devices, however, which, while not necessary for normal operating conditions, yield higher than normal quality standards.

552. Such developments and devices are expensive and are bound to increase the capital outlay per unit of production. On the other hand, when well studied and reasonable decisions are taken in this direction, it is found that such devices pay off within a short period of time and in fact reduce the cost of

production. It is always necessary to find a oompromise between this factor and that of availability of capital.

553. Good quality is achieved through knowledge and understanding of the processes, with the availability of the right type of equipment and through an effective feed-back and control of the many variables that affect the whole metallurgical process.

554. Assuming that knowledge and understanding are available to the operating personnel, the choice of equipment to ensure the appropriate quality standards will depend in some cases on the type of product and in all cases on the availability of capital.

555. It is not possible to obtain a high quality level in the finished product unless the same level is observed in all the preceding processes. The most decisive factors in attaining high quality standards in ironmaking are burden preparation and close and rapid control of the metallurgical processes within the iron reduction unit.

556. Burden preparation is carried out through a series of operations, i.e. crushing, screening, bedding and agglomeration for iron ore, while for coke and limestone proper sizing is sufficient.

557. These processes require the installation of expensive plants, and while it is possible to operate a blast furnace using an unprepared burden, in all cases it can be proved that, apart from quality considerations, these processes will, from the economic point of view, more than justify their existence. If capital availability presents a difficulty, a burden preparation plant can be tailored to suit the available means, and its completion can be carried out in stages.

558. Close and rapid control of the metallurgical processes with the blast furnace, for instance, is done through a large number of censors measuring temperature, pressure, flow rates, burden level and gas analysis at various points.

559. The installation of these censors and their accompanying recorders does not increase the cost. Recently there have been several attempts with very encouraging results to automate blast furnace operation through the use of a computer linked to these censors. However, blast furnace automation represents a degree of sophistioation, which is not available for a country in the initial stages of industrialization.

560. Quality control in steelmaking does not involve high capital expenditure, with the exception of computer control of the basic oxygen converter, and for which the same considerations stated above for the blast furnace apply.

561. In rolling mills, higher quality is achieved through the following:

(a) Inspection and surface conditioning of ingots, slabs, blooms and billets;

(b) Close control of heating prior to rolling;

(c) Accurate and rapid control of the rolling process to insure close dimensional tolerances in the finished product;

(d) Thorough non-destructive testing of the products in all stages of rolling;

(e) Close control of all the finishing processes, particularly for flat products, such as pickling, tinning and galvanizing.

562. These processes and controls can be obtained in various degrees of complexity. That they should exist in some degree is necessary in order to ensure an acceptable level of quality. The extent of their application and degree of sophistication should depend on the type of product and availability of capital.

563. Computer control has been applied with success to many rolling and finishing processes such as ingot heating, blooming mills, plate mills, hot strip rolling, tinning and galvanizing lines.

564. The higher the volume and the faster the rate of production the more important the problem of quality becomes, since any rejection in this case represents considerable loss. The same applies to small-scale plants producing high priced products, such as alloy steels.

565. In conclusions, measures leading to high quality standards should not be applied indiscriminately, the whole matter should be examined and decisions taken based upon purely commercial and economic considerations. Furthermore, it would be a mistake to take the view that high standards of quality are a luxury on which developing countries should not embark.

<u>Considerations related to cost of production in relation to capital outlay</u>

566. Owing to the highly competitive state of the world market for rolled steel products, which has been prevalent in recent years, every effort has been made to introduce new techniques aimed at cost reduction. These factors will be discussed and examples given to illustrate measures taken to produce cost reduction.

Produotivity

567. Any increase in the productivity of a given production unit results in proportionate reduction in the fixed costs of production. This is achieved mainly through the optimization of the metallurgical processes within the production unit.

568. The most spectacular results in this field were obtained in ironmaking in the blast furnace, when productivity was increased considerably through the application of the following techniques:

(a) Burden preparation;

(b) Blowing under high top pressure;

(c) Control of humidity in the blast, and, oxygen enrichment of the blast.

569. Other measures were introduced to reduce the rate of coke consumption, which in turn results in increasing the productivity of the blast furnace.

570. The productivity of the basic oxygen converter has been increased through improvement of the refractory lining, which results in a longer life. Oxygen lancing in the open hearth is another example where a given production unit has attained productivity figures far in excess of the original design capacity.

571. Fuel consumption. The blast furnace also gives an outstanding example of cost reduction through the application of modern techniques, in this oase through the lowering of the rate of coke consumption. This has been achieved by the application of the following techniques: (a) the use of self-fluxing sinter and pellets; (b) the injection of fuels cheaper than metallurgical coke and (c) high blast temperatures.

572. Yield. This factor plays a major role in the cost of production of ingot steel and rolled structurals. The introduction of continuous casting for the production of slabs, blooms and billets directly from liquid steel has resulted in improvements of about 10 per cent in the yield as compared with rolling cast ingots into semi-finished products.

573. Similarly, the introduction of computer control into the hot sawing lines of structurals has resulted in a yield increase of about 5 per cent.

574. Down-times. Two outstanding examples for this factor are the introduction of sequential casting in continuous casting plants, which saves the down-time required for setting up the machine after a cast is finished, and the rapid roll change systems introduced in rolling mills, where a programme change is carried out in minutes instead of hours.

575. Power consumption. The two production units where electrical power consumption constitutes a major cost element are the electric shaft reduction furnace and the electric arc furnace. For the former, the charging of a preheated and pre-reduced charge has resulted in considerable saving in power consumption; in the electric arc furnace preheating of the scrap charge and oxygen lancing have given similar results.

576. It can be seen from the above that some cost reducing measures require appreciable capital expenditure. However, any decision to introduce such measures based on sound technological and economic investigations would be a good investment.

577. It is also clear that there is a very strong interrelationship between the factors that influence the choice of the process and the type of production units, the resultant cost of production and the required capital outlay.

578. However, all these considerations and factors should be viewed through the following criteria:

(a) Local conditions as regards raw materials, fuel and power;

(b) The market;

(c) The macro-economics of the country in question.

Discussion

579. The discussion on the group of papers outlining modern designs and optimum capacity of steelmaking plants centred on technical topics and contributors asked for elaboration on points of interest in the papers.

580. Information on the type of blast furnace equipment was requested and the practice that might be offered to developing countries and there was some discussion on the charcoal blast furnace. It was agreed that these furnaces should be equipped with the same modern ancillary plant and injection facilities as large conventional blast furnaces, though they may only have a capacity of 300-400 tons per day. It was pointed out that, although electric reduction furnaces produced impressive results, a well operated blast furnace will as a rule be a better proposition. On the subject of blast furnaces, there was some discussion on the nature of linings. The authors of the papers from developed countries indicated that various combinations of alumina and carbon bricks were being tried since the problems centred around the hardening of alumina in service and the limitations of carbon in certain parts of a furnace due to its wear characteristics.

581. Details were provided on the design of oxygen converters, and the question of cooling trunnion rings was dealt with briefly. Tube-making was also discussed. It was stated that it is quite possible to produce welded tube of a quality comparable to that of seamless tube. Seamless production involves greater initial costs than welded tube production. A comparison of push-bench and extrusion techniques showed that extrusion was cheaper but capacity was lower. The difficulties and expense involved in lubrication and dies was stressed.

582. The papers on continuous casting were found to be of great interest. The continuous casting process was agreed as being, at present, suitable for casting many grades of steel though it was stated that certain high-alloy steels still present some difficulties. The economies of curved-mould versus vertical-mould machines were discussed. Steel quality was stated to be equal with both types but the operating costs of curved mould machines may be slightly higher.

583. The strand reduction technique was an important step towards the development of making one continuous process from refining, through casting, to rolling. Strand reduction reduced central porosity in the billet and made higher production rates possible. It was stated that one on-line direct strand reduction plant is in commercial operation and four more are under construction. Reduction is carried out while the metal core is still liquid. Comments on steel surface quality obtained by this technique were made, indicating that it was probably slightly better than by other methods. Surface conditioning losses from austenitic stainless steel and other grades were reduced.

584. Interest was shown in the hot strip planetary mill process. It was stated that there were no great differences in the quality of material rolled on such a mill, but the important criteria to be noted were first, that the scale formed on the strip was fine and could be removed by pickling faster than the thicker scale formed during conventional hot rolling processes and secondly, that the gauge tolerances were superior to hot-rolled strips normally produced. A wide range of steel qualities could be rolled on these mills.

CHAPTER VI

ECONOMIC ANALYSIS, RECONSTRUCTION AND MODERNIZATION OF THE IRON AND STEEL INDUSTRY

"Economic analyses as an instrument of the management system in metallurgical production" (document ID/WG.14/37)

585. This paper emphasized the necessity of economic analyses for up-to-date managerial control in the iron and steel industry. A thorough survey of the present market situation and its possible development is also essential.

586. This survey must be related to the perspective analyses for a correct research programme aimed at the development of new technologies and products. The planning of new production equipment and the modernization of existing equipment must be in line with the corresponding programmes of rationalization and organization of production.

587. The analyses conducted in separate sections of management control take into account the volume, structure, quality and balance of production capacities. The adequacy of preventive analysis aimed at obtaining the maximum utilization of the production units is mainly determined by the adequate assessment of reserves and by the fact that the construction of new facilities is frequently accompanied with charges in the structure of the products, raw materials, fuels etc.

588. In order to establish objectively the factors that influence the efficiency of the plant as a whole, various methods of economic analysis can be adopted.

589. The analytical method, which is typical, is used and is practically inseparable from the comparative method.

590. To accelerate and simplify the analyses for assisting production, empirically and mathematically established tables with economic consequences are

used such as the volume and structure of production, changes in the composition of charges etc. The graphic methods, monograms etc. can also be used.

591. The adoption of economic analysis in metallurgical production is becoming a fundamental instrument of permanent innovation and systematic improvement of the quality of products as well as of the efficiency of production. The initial function of economic analysis is to serve as an instrument for evaluating the relative advantages and disadvantages of technical changes and market conditions A second function is to serve as a tool for the economic control of a project when it is being implemented.

592. Economic analysis serves also as a means for increasing the participation of working people in managerial activity and permits the staff to understand their work in the whole economic picture of the enterprise.

593. Management has to use the economic analysis to improve its own activity and determine the respective responsibility in order to improve its over-all control of the production processes.

594. There exists a direct relation between the quality of economic analysis and the efficiency of production and management of an enterprise. High quality is generally a result of the common effort of economists and technicians.

"Modern techno-economic indices and ways of their attainment in blast furnaces, steelmaking and rolling mills"
(document ID/WG.14/38)

565. The paper defined a combination of technical parameters with economic results.

596. The techno-economic indices in the blast furnace area relate the effect of plant layout to the performance of sinter and blast furnace equipment, the effect of different processes on specific raw material consumption for a given final product and the effect of the size of equipment and size of plant on capital and labour costs etc.

597. The techno-economic indices in the steelmaking shop comprise the effect of type and size of production units on economic performances, mainly through the specific consumption of raw materials.

598. The techno-economic indices in rolling mills relate mainly to rolling mill techniques, the production rate, product quality, the amount of mechanization and automation, the degree of integration with steel plant, specific raw material and energy consumption etc.

599. The techno-economic indices in the energy production area comprise parameters of control of energy consumption, trends in the consumption of oxygen and oompressed air and trends in water distribution and other utilities.

600. The techno-economic indices of an entire steel works depend on the optimum size of steel mills, the layout of a steel mill and its product pattern and the degree of integration.

"Efficiency of mechanization and automation in the iron and steel industry. Economic aspects of computer control of the oxygen steelmaking process"
(document ID/WG.14/39)

601. In this paper attempts were made to furnish an economic evaluation of computer control of the oxygen steelmaking process and to discuss its various economic advantages. In introductory chapters reviews are made of some general aspects of computer control in the iron and steel industry and statistics are given of the numbers and kinds of computers installed.

602. In general terms the cost composition of the oxygen steelmaking process is as follows: raw material cost is 80 per cent, operating cost is 15 per cent and capital costs are 5 per cent. The cost of installing a computer is only a small part of the total capital cost of the plant. About two thirds of that amount is spent on standard instrumentation equipment. Expressed as a fraction of the total steelmaking costs, total computer costs become less than 1 per cent of the steelmaking costs. Consequently, an improvement of the process or a cost reduction of 1 per cent or more will make the installation of computer control economic.

603. Improvements that can be expected from computer control of the steelmaking process relate principally to the metallic yield, the production rate and the steel quality. While capital and operating costs or manpower requirements for a given installation are not likely to change significantly, due to the introduction of computer control, the relatively large savings obtained through an increase in production rate and iron yield will generally reduce the over-all steelmaking production cost per ton. Moreover, the possibility of improving over-all production planning and co-ordination will have to be added to the specific advantages of the process. Such advantages, however, are not always obtained. They are difficult to assess precisely and can usually be achieved only in the long run.

604. An evaluation of the economic advantages of an improved technical performance of the oxygen steelmaking process, showed that computer control practice has made the oxygen steelmaking production process more economical. The main items of production efficiency have been analysed by taking into account the iron yield of the process, its production rate, the lining life of the converters and the final steel analysis.

605. The general conclusion regarding the economic aspects of computer control of the oxygen steelmaking process is that raw materials are better utilized, the final product has a more consistent quality and the process itself, in addition to some savings, becomes more regular and runs closer to time schedules. Some of these improvements are essential for the proper co-ordination of the oxygen steelmaking process with the associated departments, especially if continuous casting is involved. Moreover, the use of data-logging and data-analysis equipment, which are the basic part of most computer installations at the present time will help to arrive at a better understanding of this new steelmaking process. Another important aspect of computer control equipment is its role of safeguarding the steelmaking installation from inadequate operational procedures, through safety interlocks and alarm systems. Computer control of the oxygen steelmaking process, therefore, can be expected to expand the application of the process since it brings these installations rapidly but safely to their optimum degree of utilization. It makes the process more independent from the human factors and it is of great help for maintaining a high standard of production.

"Experience and economic profit of continuous casting in steel plant" (document ID/WG.14/40)

606. The paper showed that developments in continuous casting since its introduction over ten years ago have been remarkable. In recent years, the number of continuous casting machines in the world, including machines under construction has increased by more than 200.

607. In Japan, pilot installations have operated since 1955. In 1965 continuous casting machines have increased and total 25, including those under construction.

608. At the beginning, continuous casting machines of steel were of the vertical type and total machine heights were very tall. Since the development of the curved mould type the total machine height has been reduced by half, as

compared with vertical type machines and the total erection costs are estimated as being 15 per cent cheaper. Moreover, this machine can be installed easily in the existing casting shops.

609. A recent development is the multistrand continuous casting machine of the six strand curved mould type. In 1966 a six-strand machine began its operation in Japan. The monthly production of over 10,000 tons was achieved in only three months after the starting date. It is intended to produce 20,000 tons every month from 1968 on.

610. Continuous casting billets have the advantage of excellent billet surface and less chemical segregations are obtained when compared to conventional billets. Various types of steel billets were produced by continuous casting and have yielded good quality production.

611. Cost advantages of continuous casting of steel are obtained from the simplification of the operation, improvement of yield, improvement of working conditions during casting and decrease of labour cost. Usually a production cost decrease of 4 per cent is obtained, relative to conventional processing.

612. It is concluded that continuous casting of billets will gain increasing acceptance throughout the world since it was confirmed that continuous casting can yield good quality productions compared to conventional casting, and with lower production costs.

"Conversion of open-hearth shops into basic oxygen furnace shops at Fuji Iron and Steel Co. Ltd."
(document ID/WG.14/41)

613. This paper reported that the basic oxygen top blowing process has made remarkable progress and LD steel is now assuming an increasingly large proportion in the total crude steel production of the world. In Japan, 65 per cent of the national crude steel production in 1967 was by the LD process, and the percentage is expected to grow even greater in the future. In 1965 an open-hearth furnace at Fuji's Muroran Works was replaced by an LD plant after confirmation of the advantages of this process. Similarly, open-hearth furnaces at Kamishi and Hirohata were also replaced by BOF vessels in 1965 and 1967, respectively. As a result, at present about 98.6 per cent of the Fuji Iron and Steel Company's total crude steel is produced by the BOF process. The advantages of the BOF process in terms of both productivity and quality have been confirmed.

614. For the installation of the BOF plant the existing site and facilities of the open hearth were used, thus reducing construction cost and construction time by about 30 per cent.

615. In the case of the Muroran Works, the open-hearth shop consisted of a 700-ton mixer and six 200-ton open-hearth furnaces. Of these six furnaces, the first was removed and a 50-ton test converter was installed in its place. Later, the second open-hearth furnace was replaced by a second 50-ton converter. Their combined production equals that of the six open-hearth furnaces.

616. In the case of Kamishi, there were two mixers of 1,000 tons and 400 tons respectively and five 150-ton open-hearth furnaces in the open-hearth shop. Of these existing units, the 400-ton mixer and the first and the second open-hearth furnaces were removed and two 90-ton converters were built, giving the same production capacity as the five open-hearth furnaces.

617. At Hirohata, there were seven 200-ton open-hearth furnaces in the open-hearth furnace plant. Then the fifth and the sixth open-hearth furnaces were replaced by two 100-ton converters. The shell inner volume is 85 m^3 at Muroran, 133 m^3 at Kamaishi and 178 m^3 at Hirohata. The height of the converters at Muroran is 6.5 m, Kamaishi 7.9 m and Hirohata 8.5 m.

618. The simplest water cooled hood system was adopted for gas-cleaning in the case of Muroran. At Kamaishi, steam recovery was also unnecessary and a low pressure type heat exchanger system with a forced circulation was employed.

619. At Hirohata, a heat exchanger system using a low-pressure boiler is employed for the saving of water. Dust collection is achieved by a wet type multi-venturi device. The piping system and Dorr thickener of the previously existing open-hearth furnaces are used without any alteration.

620. In so far as the operation is concerned, the production of high carbon steels by the catch carbon method is now in a satisfactory state, through the adoption of the "double catch carbon" method combined with slag control. This permits a satisfactory dephosphorization within the high carbon range. Although production of other alloy steels is still in the experimental stage, such varieties as C 1.1 per cent, Si 1.8 per cent, Mn 1.7 per cent, Cr 1.2 per cent steels have been made.

621. At Kamaishi works the production of medium and high-carbon steels amount to 70 per cent of the works' total steel production. The medium-carbon steels are for the production of structural steel, sheet, piling and shipbuilding materials and the high-carbon steels are for machine components, wire rods, rails.

622. The proposed remodelling of open-hearth furnaces is far more advantageous than a newly erected converter plant, if the production capacity is in the range of 80,000 tons to 120,000 tons a month, if the plant size available is small and if it is difficult to obtain an additional site for a new plant.

Discussion

623. The role of economic analysis in the operation of iron and steel plants under different conditions was discussed. One major problem was the prediction of the most appropriate technologies that could apply in the future. Economic analysis is generally made on the basis of existing technology. The point was raised as to what effect a new technique, such as LD steelmaking and continuous casting would have on such an analysis.

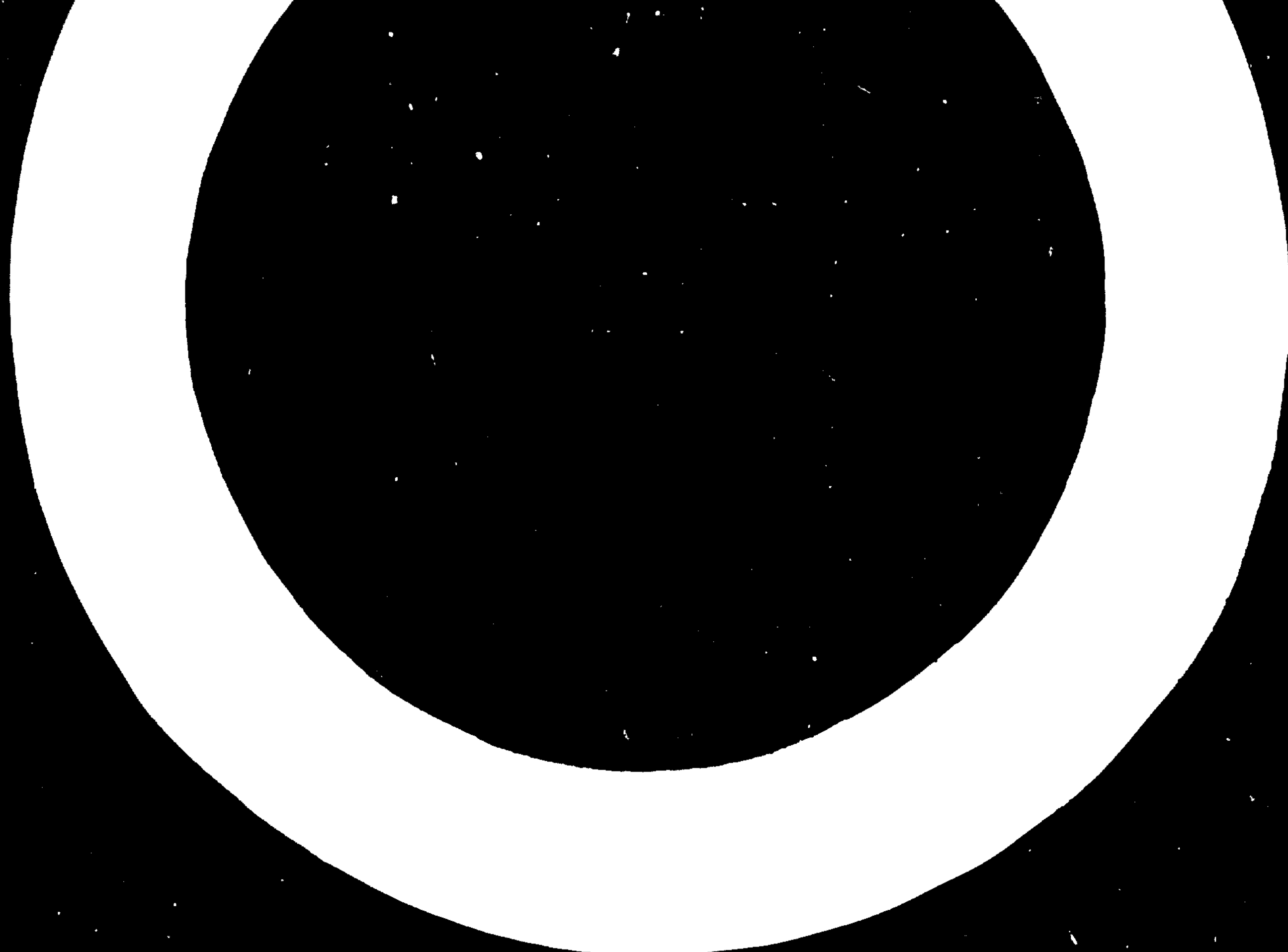
624. Cost curves, investment of conversion cost related to capacity of the plant should be looked at with regard to the period during which they might apply. The changing level of technology in the industry will affect the shape of the cost curves.

625. It was also suggested that most management techniques have to be specially formulated to meet the requirements of small-scale producers and that a selection be made of the management methods, techniques etc. that can be adopted more widely in small-scale plants in developing countries.

626. Economies of scale were thought not to have any absolute meaning and that the minimum capital cost for a steel works (at about 4 million tons) does not necessarily lead to minimum production cost. An example was given where by low-cost modification the capacity of the blast furnace was almost doubled.

627. A discussion took place on the comparison between the conversion of an existing open-hearth shop into an LD shop and building a new LD shop on a green field site. It was suggested that transformation costs might be about half of the investment needed for a completely new plant. Heavy cost centres in new LD shops are the building itself 25 per cent, the cranes 25 per cent, the electrical equipment 25 per cent and the waste heat boiler system 25 per cent. When it is possible to convert an existing melting shop, the last two mentioned cost centres are dispensed. Caution was expressed against cost comparisons in general since local conditions may often be very different.

628. On the subject of making cost savings, attention was drawn to by-products, inter-industry co-operation, raw materials preparation, optimization of yield (one of the papers presented showed that 80 per cent of production costs in BOF steelmaking was accounted for by raw materials) and the application of modern techniques.



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ANNEX 3 LIST OF WORKING PAPERS PRESENTED TO THE SYMPOSIUM (BY SERIAL NUMBER)

ANNEX 4 LIST OF WORKING PAPERS PRESENTED TO THE SYMPOSIUM (BY MAJOR SUBJECTS OF DISCUSSION)

ANNEX 1

LIST OF PARTICIPANTS

AUSTRIA

B. TARMANN
Chief of Industrial Development
Gebrüder Böhler and Co. AG
Kapfenberg

F. WEGSCHEIDER
Director of Co-ordinating and Planning Department
Vereinigte Österreichische Eisen- und Stahlwerke AG
Linz

BELGIUM

A. POOS
Chief, Blast Furnace Department
Centre National de Recherches Metallurgiques
Liège

BOLIVIA

L. GUZMAN VELASCO
General Director of the Iron and Steel Division
of the Ministry of Mines and Petroleum
La Paz

G. MURGUIA SANCHEZ
General Director of Mines of the Ministry of
Mines and Petroleum
La Paz

BRAZIL

B. Martins de ANDRADE
Assessor
Assuntos Siderurgicos
Ministerio Industria e Comercio
Rio de Janeiro, G.B.

C. dos Santos BRUN
Executive Secretary
Metallurgical Group
Ministerio Industria e Comercio
Rio de Janeiro, G.B.

M. A. CONTRUCCI
Technical Director of Tecnometal S.A.
Associate Professor of Steel Technology at
Engineering School
Catholic University
Rio de Janeiro

L. C. CORREA DA SILVA
Head, Metallurgy Division
Instituto de Pesquisas Tecnológicas
Sao Paulo

F. J. H. PEGURIER
Secretary-General of Instituto Brasileiro
de Siderurgia
Rio de Janeiro, G.B.

BRAZIL (cont'd)	S. de Sant'Anna e SILVA Delegate Brazilian Treasury Delegation New York
BURMA	H. TIN Shift Engineer Steel Mill Rangoon
CANADA	G. R. HEFFERNAN President LASCO - Lake Ontario Steel Company Ltd. Hopkins St. South Whitby, Ontario
CEYLON	B. E. I. PERERA Developing Engineer Ceylon Steel Corporation Aturugiriya
CHILE	A. GOMEZ Secretary-General Instituto Latinoamericano del Fierro y el Acero Santiago
	D. S. VUCETICH Sales Executive Vice-president Compañía de Acero del Pacífico Santiago
COLOMBIA	G. ALMANZAR Vice-president, Acerías Paz del Río, S.A. and Vice-president National Railways Bogotá
CUBA	A. ORLANDO NACER Metallurgical Engineer Antillian Enterprise of Steel
	R. I. GONZALEZ PLANAS Technical Chief Antillian Enterprise of Steel
CZECHOSLOVAKIA	O. FIALA Director Institut Poradenství Prague
	J. HLAVACEK Chief Engineer of Metallurgy Department of Planning Institute 'Hutni Project' Ostrava

CZECHOSLOVAKIA (cont'd)

O. MALUKHA
Technical Director of Planning Institute
'Hutni Project'
Ostrava

Z. VOLF
Head of Department for Metallurgical Planning and Development
Ministry of Heavy Industry
Prague

V. ZDRAZIL
Engineer
ZDAS - Sdarske Strojirny a slevarny N.P.

FRANCE

L. ALLO
Chief Engineer
SOFRESID
Paris 1e

J. ASTIER
Director
Institut de Recherches de la Siderurgie (IRSID)

A. G. BUREAU
Vice-president
Chambre Syndicale de la Siderurgie Francaise
Rue de Madrid
Paris

P. L. DANCOISNE
Chef du Service Etude et Procedes Metallurgiques
Institut de Recherches de la Siderurgie (IRSID)

A. J. MITKO
Manager, European Sales
Procedés Sendzimir
11 Quai du Président Paul Doumer
92 Courbevoie

FEDERAL REPUBLIC OF GERMANY

G. HEITMANN
Diploma Engineer
FERROPLAN GmbH
Essen

W. H. MIETH
Director
HOESCH AG
Dortmund

J. MIETZNER
Head of Development Department for Rolling Mills
DEMAG AG
Duisburg

H. REIHLEN.
Dr. Eng.
DEMAG AG
Duisburg

JAPAN	M. IIMORI Assistant to General Manager of Chemical Plants Division of Ishikawajima Harima Heavy Ind. Ltd. 4, 2-Chome Otemachi, Chiyoda-ku
	Y. KAWAMOTO Senior Metallurgical Engineer of Research and Development Department Sumitomo Metal Industry
	T. NAGAI Assistant Manager Ironmaking Department Chiba Works Kawasaki Steel Corporation
	K. NAKAJIMA Deputy General Manager Construction Department Fuji Iron and Steel Company
	N. OZAWA Assistant General Manager of Marketing Division Nippon Kokan Kabushiki Kaisha (Japan Steel and Tube Corporation) Otemachi, Chiyoda-ku Tokyo
JORDAN	F. M. A. DAHER Director of Industrial Department Ministry of National Economy Amman
LIBERIA	J. BRIGHT Senior Industrial Research Officer Department of National Planning and Economic Affairs Monrovia
MALAYSIA	K. S. POH Acting Assistant Superintendent Malayawata Steel Berhad Butterworth
	K. Y. TAN Managing Director Malayawata Steel Berhad
MALI	S. F. SAMOURA Engineer Economic and Industrial Problems
MAURITANIA	K. SAMBA Mauritanian Embassy Moscow
	K. CHEIKHOUNA Mauritanian Embassy Moscow

FEDERAL REPUBLIC OF GERMANY (cont'd)	H. SCHIRMER Fried. Krupp GmbH Industriebau Essen
	R. W. TSCHOEPKE Consulting Engineer Grundstoffberatung Essen
GUINEA	A. BAH Counterpart in Scientific Organization of Work and Planning of Production
	S. B. B. CONDE Engineer at the Direction of Industries Conakry
INDIA	A. B. CHATTERJEA Deputy Director and Head of the Low Shaft Furnace Project, National Metallurgical Laboratory Jamshedpur
	M. N. DASTUR Chairman and Managing Director of M. N. Dastur and Co. Private Ltd. Calcutta 13
	B. S. KRISHNAMACHAR Deputy Director-General India Standards Institution New Delhi
	S. R. PRAMANIK Chief Metallurgist Durgapur Steel Plant
	T. V. S. RATNAM Director M. N. Dastur and Co. Private Ltd. Calcutta
INDONESIA	T. ARIWIBOWO Senior Officer of the Department of Industry Djakarta
	J. RAHMAN Senior Official of the Department of Industry Djakarta
IRAN	A. A. DABIRIAN Member of the Director's Board Mining and Metallurgical Corporation Ministry of Economy
ITALY	P. MUZZIOLI Manager COMERINT - Commissionaria Mercantile Internazionale S.p.A. Rome

MOROCCO	M. DOUIEB Mining Engineer Chief of Mineral Treatment Service Direction of Mines and Geology
NIGERIA	A. ADEGBOYE Head, Iron and Steel Unit Federal Ministry of Industries Lagos
	J. A. OLUBODE Lecturer University of Lagos
NETHERLANDS	E. P. WESTERDIJK Head of Steel Section of Technical Economical Department of Engineering Division Koninklijke Nederlandsche Hoogovens en Staalfabrieken N.V. Ijmuiden
PAKISTAN	M. I. CHOWDRI Deputy Chief Metallurgist WPIDC
PHILIPPINES	P. P. MILLAN, Jr. Sen. Ind. Programmes Office Presidential Economic Staff Manila
	J. F. SINGSON Special Assistant on Steel Projects Ind. Programmes Office Presidential Economic Staff
POLAND	A. MULAS Design Engineer Rolling Mill Department Design Office for Metallurgical Equipment 'BIPROHUT' Gliwice Warsaw
	I. MYDLARZ Head of Designer Group of Steel Plant Department Design Office for Metallurgical Equipment 'BIPROHUT' Gliwice Warsaw
ROMANIA	O. E. S. TAKACS Counsellor Engineer in the Ministry of Metallurgical Industries Bukarest
SPAIN	L. GUERECA Head of Economic Research Department Ministry of Industry Madrid

SUDAN	M. S. EL SHEIK Maintenance Engineer Plant lay-out specialist
SYRIA	M. R. HATAHET Member of the Iron and Steel Committee Ministry of Petroleum Electricity and Execution of Industrial Projects
THAILAND	B. WATANASUPT Chief of Metallurgy Division Department of Mineral Resources Ministry of National Development
TURKEY	F. KIRIMLIOGLU Head, Industrial Planning Section State Planning Organization
	E. YARATAN Metallurgical Expert State Planning Organization
UNITED ARAB REPUBLIC	M. A. BEKTASH Member of the Industrialization Bureau of the United Arab Republic in Moscow
	A. H. M. EL SAFTY Vice-chairman Iron and Steel Organization Cairo
	A. S. SALEM General Director Industrialization Bureau of the United Arab Republic in Moscow
	S. M. TAHER Chairman and Managing Director Delta Steel Mill Co. Cairo
UNITED KINGDOM	B. A. BASSETT Project Engineer Ashmore, Benson, Pease and Comp. Ltd. Stockton-on-Tees
	G. W. COOK Steam and Water Services Officer Appleby-Frodingham Steel Company Scunthorpe Lincs.
	I. M. D. HALLIDAY Consultant United Steel Companies Ltd. Barrow-in-Furness

UNITED KINGDOM (cont'd)

S. KLEMANTASKI
Head, Chemistry Department
BISRA - The Inter-group Laboratories of the
British Steel Corporation
London

K. T. LAWSON
Chief Development Engineer
Head, Wrightson Machine Company Ltd.
Middlesborough, Yorks.

J. H. LINGARD
Deputy Technical Manager
Steel Plant Division
Ashmore, Benson, Pease and Comp. Ltd.
Stockton-on-Tees

B. S. SOAN
Head, Process Planning Department
W. S. Atkins and Partners
Planning, Engineering and Management Consultants
Woodcote Grove, Ashley Road
Epsom, Surrey

M. W. THRING
Professor and Head
Mechanical Engineering Department
London University

R. B. WOOD
Assistant Secretary, Administration
The Iron and Steel Institute
4 Grosvenor Gardens
London

UNITED STATES OF AMERICA

J. B. AUSTIN
Retired Administrative Vice-president
Research and Technology
United States Steel Corporation
Pittsburgh, Pa.

E. T. CULVER
Manager, Project Sales
KOPPERS Company Inc.
Pittsburgh, Pa.

R. L. DEILY
Technical Editor
"33 Magazine"
Green Brook, New Jersey

J. PEARCE
Co-ordinator
Project Development and Facilities Planning
KOPPERS Company Inc.
Pittsburgh, Pa.

UNITED STATES OF AMERICA (cont'd)

R. TIETIG, Jr.
Assistant to Vice-president, in charge of steel plant projects
KAISER Engineers
300 Lakeside
Oakland, California

UNION OF SOVIET SOCIALIST REPUBLICS

G. K. BOBYLIEV
Deputy Head of Department
Ministry of the Iron and Steel Industry of the USSR
Moscow

I. M. DENISENKO
Senior Scientific Officer
Economic Research Institute of the State Planning Commission of the USSR
Moscow

I. N. GOLIKOV
Director of the Central Institute for Ferrous Metallurgy
Moscow

N. V. IGOSHIN
Chief of Section
State Institute for the Planning of Iron and Steel Works
Moscow

V. I. JAVOYSKI
Chief of Department of Steel Production
Moscow Institute of Steel and Alloys

M. M. KULESHOV
Director
Central Research Institute of Information and Techno-economic Investigations for Ferrous Metallurgy

V. V. LEMPITSKI
Chief of Department
Ministry of Ferrous Metallurgy of the USSR

B. N. MALININ
Ministry Chief of the Foreign Relations
Export and Import Department
Iron and Steel Ministry of the USSR

A. I. MANOKHIN
Head of Laboratory
Central Scientific Research Institute for the Iron and Steel Industry
Moscow

A. F. MYRTSYMOV
All Union Scientific Research Institute for Metallurgical Engineering

UNION OF SOVIET SOCIALIST REPUBLICS (cont'd)

S. M. PETROV
Deputy Director
Central Institute for Ferrous Metallurgy
Moscow

P. V. SAMOKHVALOV
Director of Institute
Institute for Mechanical Processing in the Iron and Steel Industry
Krivoi Rog

A. G. SHALIMOV
Director
Institute of New Metallurgical Technology
Central Scientific Research Institute for the Iron and Steel Industry
Moscow
Deputy Chief Engineer, GIPROMEZE

P. A. SHIRJAEV
Professor
Institute of Steel and Alloys
Moscow

A. E. SUKHOURKOV
Chief
Furnace Department
GIPROMEZE

M. I. SYRJAKOV
State Committee for Science and Technology
Moscow

N. N. TIMOSHENKO
Chief
Department of Metallurgy
Central Scientific Institute for Ferrous Metallurgy
Moscow

V. M. TSITVER
Chief of Economic Department
GIPROMEZE
Leningrad

A. P. ZAITSEV
Power Board
Ministry of the Iron and Steel Industry of the USSR
Moscow

URUGUAY

O. LOPEZ ESTREMADOURO
Director of Instituto de Mecánica y Electrotécnica de la Universidad del Trabajo

VENEZUELA

A. CERVINI
President
Venezuelan Steel Corporation
Siderurgica Venezolana "Sivensa" S.A.
Caracas

M. FERNANDEZ LOPEZ
General Manager, Venezuelan Steel Corporation

VENEZUELA (cont'd)

M. M. SHEROVER
Director
Venezuelan Steel Corporation

YUGOSLAVIA

K. S. DULAR
Consultant Engineer
Manager of Technical Department
Yugoslav Iron and Steel Federation
Belgrade

I. M. STEFANOVICH
Consultant Engineer
Federal Institute for Economic Planning
Belgrade

Representatives of UNIDO secretariat

B. CROWSTON
Associate Industrial Development Officer
Industrial Technology Division

S. N. GLEBOV
Industrial Development Officer
Industrial Technology Division

M. A. MAURAKH
Industrial Development Officer
Industrial Technology Division

B. R. NIJHAWAN
Senior Interregional Adviser
Industrial Technology Division

E. E. WARD
Assistant Director
Technical Co-operation Division

Representatives of other United Nations organizations

ECA

R. ROBSON
Regional Adviser, ECA
Africa Hall
Addis Ababa
Ethiopia

ECAFE

V. M. SUBRAMANIAN, Chief
Metals and Engineering Section
Division of Industry and Natural Resources, ECAFE
Sala Santitham, Rajadamnern Ave.
Bangkok

ECE

D. F. ANDERSON
Economic Affairs Officer
Industry Division, ECE
Palais des Nations
Geneva

ECE (cont'd)	R. KARASSEV Economic Affairs Officer Industry Division, ECE Palais des Nations Geneva
	F. A. MULLER Economic Affairs Officer Industry Division, ECE Palais des Nations Geneva
ECLA	R. SUAREZ Industrial Development Division, ECLA Santiago Chile
ILO	S. I. RUMIANTSEV ILO Branch Officer Petrovka 15 Moscow K-9 USSR

Other organizations

EMAB	V. KHLEBNIKOV EMAB Ul. Petrovka 14 Moscow K-31 USSR
	L. MAKH EMAB Ul. Petrovka 14 Moscow K-31 USSR
	A. PENKOVSKY EMAB Ul. Petrovka 14 Moscow K-31 USSR
	K. PLISHTIL EMAB Ul. Petrovka 14 Moscow K-31 USSR
	I. SHIBAEV EMAB Ul. Petrovka 14 Moscow K-31 USSR
ECSC (CECA)	A. F. DU CASTEL Direction Générale Crédit et Investissements, ECSC Commission des Communautés Européennes Luxembourg

OECD	H. D. HILL Secretary of the Special Committee on Iron and Steel, OECD Paris XVI^e France

Observers from the USSR

SOKOLOV, P. E.	Deputy Minister Ministry of the Iron and Steel Industry of the USSR Moscow
ARKHIPOV, I. V.	Deputy Chairman State Committee for External Economic Relations Moscow
ISAEV, I. G.	Deputy Mayor of Moscow
SHUMAEV, M.	Head of Section Department of Technical Assistance through the United Nations USSR State Committee for External Economic Relations
SAMARIN, A. M.	Director Institute of Metallurgy of the USSR Academy of Sciences
PERTSEV, M. A.	Chief Metals Department USSR State Planning Commission
SALAMARIN	Scientific and Technical Council of the Ministry of the Iron and Steel Industry
GOLOVANENKO, S. A.	Director of the Institute of High Grade Steels of the Central Research Institute for the Iron and Steel Industry
EVTEEV, D. P.	Head of the Department of Continuous Steel Casting Central Scientific Research Institute for the Iron and Steel Industry
PISKAREV, V. M.	State Institute for the Planning of Iron and Steel Works
KORNEENKO, A. N.	USSR State Planning Commission
TAINES, S. D.	Correspondent, "Novosti" Press Agency
RUTES, V. S.	Head of Laboratory, Central Scientific Research Institute for the Iron and Steel Industry
EFIMOV, A. N.	Head of Laboratory Central Scientific Research Institute for the Iron and Steel Industry

Observers from the USSR (cont'd)

PERLOV, N. I.	Iron and Steel Industry Information Service
PIVOVAROV, E. F.	Director, Scientific Experimental Institute USSR State Planning Commission
TOLKACHEV, A. S.	Scientific Research and Experimental Institute USSR State Planning Commission
GURSKII, G. V.	USSR State Planning Commission
GLINKOV	Professor Institute of Steel and Alloys
ZOTIEVA, A. S.	Experimental Institute for Machine Tools
KAMALOV, G. B.	Iron and Steel Industry Information Service
IVCHENKO, E. V.	Iron and Steel Industry Information Service
KUNIN, V. I.	Non-ferrous Metals Information Service
SAVELIEV, I. P.	State Public Works Commission
GRIGORIEV, O. M.	Chief Project Engineer State Institute for the Planning of Iron and Steel Works
EFIMOV, V. P.	State Institute for the Planning of Iron and Steel Works
FILATOV, V. P.	State Institute for the Planning of Iron and Steel Works
POROSHINA, M. I.	State Institute for the Planning of Iron and Steel Works
SEMIKOZOVA, A. P.	Chief Economist Economic Section State Institute for the Planning of Iron and Steel Works
KULAGINA, Z. A.	Chief Designer Division of Raw Materials and Mining, State Institute for the Planning of Iron and Steel Works
YARKHO, E. N.	Head of Division of Raw Materials and Mining State Institute for the Planning of Iron and Steel Works
TRUBITSIN, K. S.	Head of General Planning and Transport Division State Institute for the Planning of Iron and Steel Works
DYNAKONOVA, I. S.	Chief Designer Special Design Bureau Continuous Steel Casting Directorate State Institute for the Planning of Iron and Steel Works

Observers from the USSR (cont'd)

PASHKOV, V. D.	Head of Heat and Power Division State Institute for the Planning of Iron and Steel Works
TATARINTSEV, N. A.	State Committee for Science and Technology
CHERNYAEV, K. P.	State Committee for Science and Technology
PANIN, V. G.	All-Union Scientific Research Institute for Metallurgical Engineering
PARTSEVSKII, A. B.	Iron and Steel Industry Information Institute
GREKOVA, A. I.	Iron and Steel Industry Information Institute
KAMELOV, R. G.	Iron and Steel Industry Information Institute
FEDOROV, Yu. K.	Scientific and Technical Division Ministry of the Iron and Steel Industry
KOSTYUKOV, I. I.	Central Committee of Trade Unions
RUPASOV, G. V.	Head of Section External Relations Directorate Ministry of the Iron and Steel Industry
DELLO, A. A.	External Relations Directorate Ministry of the Iron and Steel Industry
MYSOVSKII, S. P.	External Relations Directorate Ministry of the Iron and Steel Industry
KRIVONOSOV, Yu. I.	Head of Section Technical Directorate Ministry of the Iron and Steel Industry
GOLDIN, Ya. A.	Deputy Director Iron and Steel Industry Information Service
SHIRIN, V. N.	Head of Scientific Section Iron and Steel Industry Information Service

ANNEX 2

STATEMENTS TO THE SYMPOSIUM

Statement of Mr. I. H. Abdel-Rahman, Executive Director of the United Nations Industrial Development Organization

Opening address of Mr. V. V. Lempitski, Chief of Department, Ministry of Ferrous Metallurgy of the USSR, Chairman of the Symposium

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Statement of Mr. I. P. Kazanez, Minister, Ministry of the Iron and Steel Industry of the USSR, Moscow

Statement of Mr. I. V. Arkhipov, Deputy Chairman, State Committee for External Economic Relations, Moscow

Statement of Mr. I. G. Isaev, Deputy Mayor of Moscow

Closing statement of the Director of the Symposium, Mr. E. E. Ward

Closing statement of the Chairman of the Symposium, Mr. V. V. Lempitski

Closing statement of the Director of the Symposium, Mr. I. N. Golikov

STATEMENT OF MR. I. H. ABDEL-RAHMAN, EXECUTIVE DIRECTOR OF THE UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

It gives me great pleasure to address you on the opening day of the Second United Nations Interregional Iron and Steel Symposium, the first to be held since the establishment of UNIDO.

UNIDO - the United Nations Industrial Development Organization - came into being in January 1967 in order to intensify United Nations efforts to promote the industrial development of developing countries. To fulfil this mandate, UNIDO carries out two types of activity, which we call "operational" and "supporting".

Under operational activities, experts and consultants work in the developing countries themselves, helping them to establish new industries or improve the operation of existing ones. In addition, UNIDO carries out supporting activities, which include studies, seminars and symposia designed to increase the transfer of technical knowledge to developing countries.

The iron and steel industry is not only important in itself but also for the stimulus it gives to other industries such as engineering. UNIDO and other United Nations bodies have therefore paid particular attention to this industry. Since the inception of UNIDO only a little over a year ago, the Organization's activities in iron and steel have covered a wide field ranging from a feasibility study on the development of ore bodies to the setting up of a quality control system for the rolling of steel plates. Though there is no adequate means of measuring the real impact of all these activities on the economies of developing countries, we feel that they have already provided useful guidance to these countries in setting up and operating their iron and steel plants.

In the field of supporting activities, you will no doubt remember that the United Nations held the First Interregional Symposium on the Iron and Steel Industry in Prague and Geneva in 1963. In addition, considerable attention was paid to this sector at the International Symposium on Industrial Development in held in Athens last December. UNIDO also plans to convene meetings and working groups on such specific aspects of the industry as pelletizing, direct reduction of iron ore, continuous casting and manufacture of tin plate, with particular emphasis on the experience of developing countries in these fields.

The Second Interregional Symposium which opens today is concerned with a number of specific technical and economic problems facing the developing countries in the establishment of their iron and steel industry. It is indeed gratifying to know that so many distinguished scientists, technologists and economists from both developed and developing countries are participating in this symposium, and that so many papers of such high calibre have been prepared and presented for your consideration.

The period which has elapsed since the first United Nations Interregional Symposium in 1963 has been one of steady, if not spectacular, progress for your industry. The papers presented in the first part of the programme review the status and potential of the iron and steel industry during this period. The over-capacity of steelmaking facilities in developed countries during the last five years has not been favourable to the growth of steel industries in developing countries. Nevertheless, the iron and steel output of developing countries has continued to increase. Much further progress is still required, as you will see from a comparison between steel consumption in industrially developed countries - about 500 kg per capita per year - and that in some of the less industrialized countries - about 0.005 kg.

In the same way, although the technological developments described in the papers presented in the second part of the discussion have not been dramatic, there has been continued progress in some fields, such as burden preparation and subsequent blast furnace performance, LD and electric arc steelmaking, and primary rolling and finishing operations. I hope that you will consider here the particular importance of pelletizing and direct reduction, continuous casting and finishing processes for developing countries. I am also interested to note the inclusion in the agenda of this symposium of papers on the use of natural gas and water.

The remaining three parts of the discussion are undoubtedly the most important of all. Under these items, you will, I am sure, wish to discuss at length the prerequisites for the development of iron and steel plants on both the regional and interregional levels, optimum capacity and stages of construction, as well as economic analysis, expansion and modernization.

This symposium brings together some 200 specialists in iron and steel from every region in the world. Your industry has a reputation for its open door approach. Steelmakers from all countries are welcome visitors to steel works throughout the world. With this spirit of co-operation, I have no doubt that the symposium will be successful, and that your recommendations will provide useful guidelines for future action by UNIDO and other members of the United Nations family working in this field.

That the USSR should so graciously have invited the United Nations to hold this interregional symposium on its soil can be regarded as an expression of this country's concern with rapid industrial development, as shown by its own achievements in the field of iron and steel. The record of the USSR in developing its iron and steel and other metallurgical industries is without parallel. I wish to express my gratitude to the USSR authorities for having, in so many respects, facilitated the organization of this symposium.

Our gratitude also goes to the governments, steel corporations and federations of Czechoslovakia, France, India, Poland and the United Kingdom, which have so kindly made arrangements for study tours to a number of steel plants in their countries, within the framework of the symposium.

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

OPENING ADDRESS OF MR. V. V. LEMPITSKI, CHAIRMAN OF THE SYMPOSIUM

I express my gratefulness for honouring me by electing me Chairman of this Symposium. The Second Interregional Iron and Steel Symposium held by the United Nations Organization was prepared by UNIDO, together with the Regional Economic Commissions of Europe, Africa, Asia and the Far East and Latin America, with the participation of the Soviet Organizational Committee.

The iron and steel industry, just as several other branches of industry, is going through a period of rapid technical progress. Direct reduction of iron ore, the implementation of oxygen, natural gas, high temperature blowing, agglomeration and pelletization, the rapid development of the LD converters in steelmaking and the intensification of existing processes by the use of oxygen, the use of pre-reduced pellets, the continuous process of steelmaking, the use of automation in pipe making and rolling, electrical pickling and galvanizing for tin plate and many other innovations - are only part of what has been done in the iron and steel industry. Many of these during the period of the first symposium were not widely used in the industry, they were actually being tested. We can now say that during these five years they have already gained a great deal of industrial experience and economic evaluation and are now widely used.

In 1962 the total capacity of continuous casting was 3 million tons and by 1967 this had increased to 26 million tons and at present approximately

5 per cent of all the steel in the world is being cast by this continuous casting method. During the past six years, the capacity of continuous casting has increased by more than ten times. In 1967, 150 continuous casting installations were installed with 450 streams.

There are many other examples of the rapid technical progress in the iron and steel industry. This symposium is to solve problems which have greatest significance for the developing countries, but many other matters of interest to all participants of the symposium will also be discussed. The rapid progress in metallurgy I have just mentioned, has led to the fact that many of the reports which were heard at the first symposium will be heard by us, five years later for the second time, because during these last five years, a great deal has changed economically and technically. Rolling was not, however, included in the first symposium, but it will be covered in this symposium.

The developing countries will most certainly establish their own iron and steel industry on the basis of the most modern technical achievements of the highly developed countries, taking into account local conditions and the scale of production and possible advantages for groups of developing countries, that is, the building of iron and steel plants on a regional basis. The symposium will serve to strengthen and to create new personal contacts between iron and steel workers of five continents, between economists working in the iron and steel industry. This is particularly important as the iron and steel industry is one of the bases for the industrialization of any country. The participants of the symposium will be able to see the achievements and many innovations of plants in the Soviet Union and then also of plants in many other countries. Allow me once more to wish you interesting and fruitful work.

OPENING ADDRESS BY MR. E. E. WARD, DIRECTOR OF THE SYMPOSIUM

(Assistant Director, Technical Co-operation Division, UNIDO)

I hereby convene the Second Interregional Symposium on the Iron and Steel Industry and on behalf of the United Nations Industrial Development Organization I have the pleasure of welcoming you all to this opening meeting. This symposium has been organized by the United Nations Industrial Development Organization in conjunction with the Government of the Union of Soviet Socialist Republics, which is our host and is providing the facilities for our work. The symposium is part of the programme of UNIDO to promote the industrial development of developing countries. By bringing together specialists from countries at various stages of development, it is a means of transferring knowledge and experience for the benefit of those countries that are establishing or developing their iron and steel industries. The first symposium, which took place from 11 to 26 November 1963 in Prague and Geneva, was on the subject "The application of modern technical practices in the iron and steel industries to developing countries" and covered two main topics: firstly, the preparation of raw materials for iron and steelmaking and the conversion of these materials into steel ingots and secondly, the problems arising from the establishment and development of iron and steel applications in developing countries.

The Second Interregional Symposium will concentrate on the technical and economic factors affecting the development of the iron and steel industries in developing countries. It will, I feel, be most useful to outline to you what the programme of the symposium includes, how we will carry out our work and what we aim to achieve. As you will see, the programme is divided into five parts,1/ for which a total of 68 papers will be presented. The first part will examine the present status, potential possibilities and long-term plans of the world steel industry, with particular emphasis on the situation in developing countries. The second part will examine recent technological developments in the iron and steel industry. Although we have not seen any startling new development during this period to compare with that of the LD in the early 1950s and continuous casting a few years later, nevertheless, steady progress has been made and I am certain that this part of the programme will be most enlightening. The remaining three parts cover more complex issues. Papers presented at these parts will cover aspects of particular interest to developing countries, including prerequisites for the development of iron and steel industries on regional and interregional basis, optimum capacity and stages of construction of iron and steel plants, technical and economic indices and expansion and modernization of the industry. It is in these three parts that the symposium will have its most difficult task. We have therefore allowed more time for the discussion of them and we hope that some definite answers to the problems posed will emerge.

This brings me to my second point: how we will carry out our work. After the election of the Chairman we will proceed to present and discuss the papers in five parts. The discussion leaders and rapporteurs for five parts of the programme have already been appointed. The discussion leader will conduct each meeting so that a balance is obtained between the time alloted for each

1/ Chapters II-VI of this publication.

speaker to present his paper and for discussion. The discussion, of course, is open to all participants.

A draft report on each part will be prepared by five teams under the responsible discussion leader and rapporteur. These draft reports will be considered by the whole symposium immediately following the presentation and discussion on all the papers in that part.

So that we do not become too academic amongst our piles of papers, we will visit the Moscow Institute of Steel and Alloys and then divide into four groups to visit the Zaporozhye plant, the Krivoi Rog plant, the Cherepovets plant and the Novo Lipetsk iron and steel works. Following these visits to steel plants, visits will be made to the State Design and Projecting Institute and the Central Research Institute for the iron and steel industry of the USSR. Meanwhile, the Report Committee will combine the draft reports of each part and prepare a report on the symposium. This draft report will then be considered by the symposium.

Further field visits to steel plants in Czechoslovakia, France, India, Poland and United Kingdom will take place on the way home.

Apart from the general exchange of information, which will take place both inside and outside the symposium meetings, the final report will, we hope, contain a number of conclusions about the problems discussed, which will act as a guide for future action by UNIDO, other United Nations bodies and the countries establishing and developing their iron and steel industries.

The task before us is not an easy one, but by digesting the papers and contributing to the discussion, I hope that we can make our way through this formidable programme to the mutual benefit of all countries. Above all, the word symposium means free exchange of views and discussion and if we can quickly achieve an informal atmosphere, we will be well on the way to the accomplishment of our task.

STATEMENT OF MR. I. P. KAZANEZ

(Minister, Ministry of the Iron and Steel Industry of the USSR, Moscow)

I am very happy to welcome the participants of this symposium. The United Nations Industrial Development Organisation has asked the Soviet Government to

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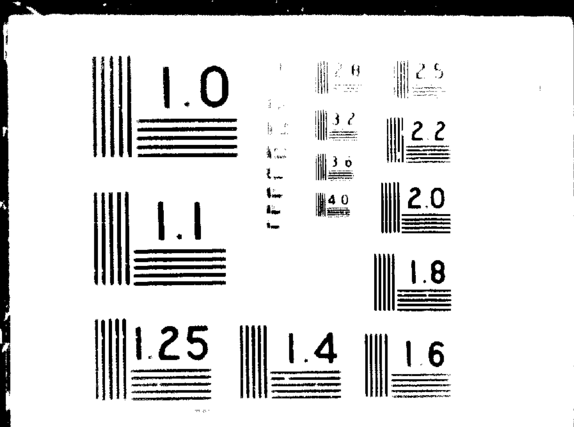

allow the Second Interregional Symposium on the Iron and Steel Industry to be held in the Soviet Union. We think this is correct, to hold the symposium in a country that has such a powerful metallurgical industry and we shall do our best to make your visit here most fruitful. Allow me to convey greetings on behalf of the multi-thousand army of Soviet iron and steel workers. The iron and steel industry of the Soviet Union occupies the second place in the world. But in various branches of the iron and steel industry we occupy the first place: in the production of iron ore, ferrous alloys and steel pipes. The achievements we have attained in the iron and steel industry are the result of the tremendous amount of active work of our metallurgical workers, of scientists and engineers. The Soviet Union at present produces over 100 million tons of steel a year. In the very near future, the iron and steel industry in the USSR will increase greatly. The scientific and technological research work usually belongs to the more developed industrial countries. They have a great deal of experience in organizing production, in building new plants and training highly qualified personnel. The Soviet iron and steel industry has a large network of scientific research institutes and among these, some of the leading ones are the Central Scientific Research Institute of the Iron and Steel Industry, which you will visit. The Soviet Union has also a number of institutes for the designing of metallurgical plants. One of the leading ones is the "GIPROMEZE", which you will also visit.

The developing countries are of course interested in industrial development and therefore it is necessary to make use of the experience of the more developed countries in building up their ferrous metals industry. This should not be confined to building metallurgical plants in developing countries: the experience should be used for the development of iron and steel industry on the regional basis, as well. However, the achievements of metallurgy of developed industrial countries cannot always be easily applied to developing countries for various reasons (e.g. large-scale versus small-scale production, specific circumstances concerning raw materials). That is why the reports of economic nature take up a great deal of time of the symposium.

Our country helps in building of the new iron and steel industries of the socialist countries in oil, natural gas and other materials. Our experience in the iron and steel industry, I am sure, will be of help to many of the developing countries.

Here, at this symposium we have iron and steel workers from several countries that received from the Soviet Union technical and economic aid in building up their own iron and steel industries. The technical level of our new plants not only corresponds to the technical level of the best plants in the world, but in some cases it even overtakes them. I could mention such plants as the Novo Lipetsk metallurgical plant. It uses the most modern equipment of the iron and steel industry and the plant continues developing and improving its equipment.

Our country is the home land of the continuous casting method and we continue to improve this method. Some of our furnaces are the most powerful in the world. We have automatic blooming mills and at the Krivoi Rog metallurgical plant you will see some of them. We do a great deal of work in raising the technical level of the personnel in the iron and steel industry and we do a great deal of research work in raising the level of iron and steel material. We increase our plants and increase the sizes of the furnaces. We also increase the length of the rolling mills. We make much use of the continuous casting method and we also introduce this method to other countries. I would like to say a few words about the aid that we accord to several developing countries in building up the iron and steel industry: the United Arab Republic, Ceylon, India, Iran and other countries. With the help of the Soviet Union, in India, for instance, the Bhilai plant has reached its capacity rapidly and at present the plant is being enlarged. The experience of the Bhilai plant and training of the personnel for that plant has made it possible for the Government of India and the Soviet Union to sign an agreement for aid to India in building another iron and steel plant in India. We also help other developing countries in building up their iron and steel industries. Here, at this symposium you will hear several reports made by Soviet specialists on this problem. I am sure that this symposium will increase the mutual contacts and understanding between iron and steel workers and economists taking part in it. The countries represented at this symposium will exchange technical and economic experience not only by means of the reports to be made but also by visiting various scientific research and designing institutes, training institutes and some iron and steel plants. I am sure that these enterprises will be very happy to be host of the participants of the symposium. Once more, allow me to greet the participants and express the assurance that the symposium will be successful and wish you a fruitful development of the iron and steel industries in your countries.

STATEMENT OF MR. I. V. ARKHIPOV

(Deputy Chairman, State Committee for External Economic Relations, Moscow)

Allow me on behalf of the State Committee of the Council of Ministers of the USSR for External Economic Relations, which on behalf of the Soviet Government is a national Committee on United Nations Technical Assistance, to welcome you upon arrival in the Soviet Union, at the opening of the Second Iron and Steel Symposium. The Soviet Union, as a Member of the United Nations Organization, is making its contribution by giving technical aid to the developing countries through the United Nations and its specialized agencies. The forms that this aid takes are the organization of group preparation of United Nations scholarship students from developing countries in various fields of science, technology, industry, transport, agriculture, medicine etc. This type of aid and co-operation is becoming greatly developed. Between 1959 and 1960, the Soviet Union held two seminars, whilst last year, there were 23 with over 500 people representing 95 countries participating. In 1968, in accordance with the United Nations and the specialized agencies, in the Soviet Union there will be 29 seminars, symposia and various study trips for United Nations scholarship students and specialists from the developing countries. Economic and technical co-operation between the Soviet Union and the developing countries on bilateral agreements is widely developed. In 1955 the USSR had agreements on economic and technical co-operation with two countries, Afghanistan and India. At present, the Soviet Union has such agreements with 35 developing countries. In accordance with agreements, the Soviet Union is under the obligation to assist developing countries to build and modernize over 650 industrial enterprises. Approximately 260 have already been commissioned. To finance the building of such enterprises, the Soviet Union accords the developing countries over 4 thousand million roubles of long-term credits on advantageous conditions. The whole world has heard of large enterprises, which went up with the co-operation of the Soviet Union, such as the Bhilai metallurgical plant in India, the Aswan high dam in the United Arab Republic, the oil refinery and machine building plants in India, the oil refinery plants in Ethiopia, a railroad in Iraq, roads in Afghanistan and many other enterprises and projects. As for the iron and steel industry, the Soviet Union co-operates with India, the United Arab Republic, Algeria, Ceylon, Iran, Turkey, Pakistan and other countries. For many of the developing countries having agreements with the Soviet Union for economic co-operation it has become important to set up and develop an independent national economy. One of the important roles played by the economic and technical co-operation between the Soviet Union and the developing countries is the co-operation in training national personnel. Over 100 study centres and technical institutes have been built or are being built with Soviet help in the developing countries. Over 70 have been commissioned. For instance, the Bombay Technological Institute, the Higher Technical Institute in Cambodia, the Technological Institute in Rangoon, Burma, the Polytechnical Institute in Guinea, the Institute of Oil and Gas and the Oil Technicum in Algeria and many others. For the past few years, Soviet specialists have helped to train over 150,000 qualified trained personnel in these countries. In the Soviet Union there are many people from the developing countries studying, over 30,000 specialists. To train foreign specialists in the Soviet Union, we have 150 industrial enterprises that help to train the foreign specialists. In carrying out economic and technical co-operation with the developing countries in Asia, Africa and Latin America, the Soviet Union is fulfilling its international duty guided by the principles of complete equality of both sides; respect for territory and integrity and state of independence, national sovereignty and non-interference in the internal affairs of those countries. This co-operation helps the development and strengthening of the national economy of the developing countries.

Soviet organizations do the utmost to have the enterprises and objectives built with Soviet help in the developing countries, to put these on a high technical level with modern equipment and to serve the national interests of those countries. Co-operation with the Soviet Union is highly evaluated by state and political leaders and the people of the developing countries. Soviet organizations have been evaluated by members and leaders of programmes of the developing specialized organizations of the United Nations and have been thanked for their help in carrying out seminars and symposia in the Soviet Union. Soviet scientists and specialists are always ready to exchange opinions and experience with other countries.

We are very glad to know that we can help the development in the technical aspects and the national economy of other countries. We are sure that the Ministry of the Iron and Steel Industry in the Soviet Union, which is entrusted to carry out this symposium will do all in its power to carry out this symposium as successfully as other seminars and symposia are carried out in this country.

Many of you are visiting the Soviet Union for the first time. We would like the participants of this symposium to make use of their visit in order to acquaint themselves with our country, with the life of our people, how they work, and the customs and traditions of the multinational Soviet people.

And finally, I would like to promise you that the State Committee of the Council of Ministers for External Economic Relations, which has taken the most active part in preparing the symposium, together with colleagues from the Soviet Iron and Steel Ministry, will do everything in their power to leave you satisfied with the symposium and to make your visit here most fruitful and pleasant.

We are sure that you will go home with the best impressions of your trip to the Soviet Union. Allow me to wish you success in your work. Thank you very much.

STATEMENT OF MR. I. G. ISAEV
(Deputy Mayor of Moscow)

I am very happy to have this opportunity, on behalf of the Moscow City Council to greet you, participants of the Second Interregional Iron and Steel Symposium. Representatives of many countries, scientists and engineers of the iron and steel industry have come here in order to discuss pertinent problems of developing and improving the production of iron and steel, the most important problems in this industry and to help in these problems. We are happy to note that this Interregional Symposium is being held in Moscow. The Soviet capital is a city of science and culture. It is an extremely large industrial centre. It is enough to say that here in Moscow over 181,000 scientific workers are engaged. This includes almost 48,000 doctors and candidates of science. The colleges and universities of Moscow have an enrolment of over 600,000 students. You also know that here in Moscow we have the Lomumba Friendship University where many young people from the developing countries are acquiring a profession. We have many scientific research institutes in Moscow, including scientific research institutes in the iron and steel industry. Almost everything that is done here in the scientific research institutes and various other enterprises is used for the welfare of people. Moscow has contacts with many foreign countries and cities. Every year there are various international exhibitions held in Moscow in various branches of economy. There are many meetings and discussions between scientists of various countries. Today we are very happy to welcome the representatives of the iron and steel industry in Moscow. Although Moscow is more than 800 years old, we can say that the city was really transformed and started developing only after the Great October Socialist Revolution in 1917. I am sure that even over the short period of time that you will be here in Moscow, you will be able to notice that Moscow is more than a city, that it is a tremendous construction project. No matter where you go you will see construction cranes, as a sort of symbol of present day. Every year, the people of Moscow receive 120,000 apartments, hundreds of stores, medical enterprises, children's enterprises.

We sincerely hope that your visit here to Moscow will help in solving many of the problems facing the symposium and I hope you will enjoy your visit. I hope you will feel the hospitality of the people of Moscow and that you will be able to see its sights. There is much to see here in Moscow. You will have the opportunity to visit theatres, museums where you will see world-famous works of art, and you will be able to see for yourselves how the Soviet people live and how the capital is developing.

Allow me to express the assurance that this interregional symposium will help in furthering progress in science and technology and in bettering the understanding between peoples and serve the interests of strengthening peace all over the world. Once more on behalf of the City Council of Moscow I wish all of you, guests and participants in the symposium, success in your work.

CLOSING STATEMENT OF THE DIRECTOR OF THE SYMPOSIUM, MR. E. E. WARD

It is not for me, but for the participants to determine whether the symposium was successful. From talking to them, however, and from the remarks we have heard in this hall, I think we can conclude that this has been a very useful symposium and to me as a representative of UNIDO this is indeed a very encouraging thing. I am very proud that the work flowed along as steadily as it has. We came here to discuss the latest developments of the steel industry in certain sectors with particular application to the developing countries and it has been a great pleasure for me to see the way in which our work has been directed towards that end, and this is, to a great degree, the result of the active participation of the participants from the developing countries themselves. They have shown here quite clearly what their real needs are and they have not hesitated to ask what the significance of this or that development to their particular problems is. In other words, they did not let the discussion drift away into a dialogue between the developed countries having to some extent similar problems. This was, of course, the purpose of the symposium.

A symposium is supposed to be an exchange of views in order to open up the field and to enable this free flow of information to take place. Sixty-eight papers were prepared for the symposium. Most of these have been introduced and discussed here, but I think the main value of this symposium will go beyond that. These papers will be taken away and read more carefully and there will be, probably, correspondence between authors, which may even carry us up to, hopefully, the third symposium because it has been very difficult in this time to digest the rich intellectual food that has been laid before us. Now, from the point of view of UNIDO, the symposium has been extremely valuable because it has enabled us to get a better idea of what the problems facing developing countries are.

It is our job, with the limited amount of money at our disposal, to try to select the problems that are important. We do not want to study problems of the iron and steel industry just because they seem interesting to us. We want to know what the problems of the developing countries are, and so the symposium will enable us to build our work programmes for several years ahead. It also enables us to render what assistance we can in our technical assistance programmes more effectively because we have the necessary background to know how to approach the various problems. So, it gives me great pleasure to be able to speak again at the end of the symposium with the feeling that we have accomplished a very useful task.

This is a symposium in which many hands have contributed, but I cannot leave without once again expressing our gratitude to the host country for the way in which they have prepared the symposium. They have worked for many months to make the necessary arrangements for our work; they have contributed at every step in the formulation of the programme; they have arranged the plant visits to show us what they have; they have opened the research institutes to us and this has been an immense factor giving a sense of reality to our programme.

Once again, on behalf of UNIDO, I would like to thank the host Government for the great assistance they have given us. I would also like, once more, to mention the Chairman and the Vice-chairmen and I am sure that I am expressing the feeling of all of you if I say how sorry we are that Mr. Lempitski, our

Chairman, was unable to participate in the closing stages (this was because of an accident, which was incurred in actually working for the symposium) and I wish him a speedy recovery. I would also like to thank the Vice-chairmen for the efforts they have made in enabling our meetings to go smoothly.

CLOSING STATEMENT OF THE CHAIRMAN OF THE SYMPOSIUM, MR. V. V. LEMPITSKI

I thank you all for the work you have carried out jointly and hope that the activities of the Second Interregional Symposium on the Iron and Steel Industry will be a contribution to the development of developing countries. I wish all the representatives of developing countries every success in the development and expansion of their national industries and in particular iron and steel industries. I wish all the participants of the symposium further great success in their work and life.

CLOSING STATEMENT OF THE DIRECTOR OF THE SYMPOSIUM, MR. I. N. GOLIKOV

I think we have fulfilled our task quite successfully. I remember what happened when we visited the town of Krivoi Rog. We were rather late for a concert organized for us and when our group was entering the hall all those sitting in this hall looked at us and began to applaud in our honour, which was unexpected and quite touching for us. I give you this example in order to show to you that deep sympathy for the representatives of developing countries is in the flesh and blood of all Soviet people. I think that the contacts we have established will contribute to further successful development of the iron and steel industry in developing countries and in the establishment of such relations when developed countries help developing countries.

ANNEX 3

LIST OF WORKING PAPERS PRESENTED TO THE SYMPOSIUM (BY SERIAL NUMBER)1/

ID/WG.14/1	The Liège experimental furnace	A. Poos Belgium
ID/WG.14/2	The effect of regional co-operation on the development of the iron and steel industry under the Economic Mutual Assistance Board	K. Plishtil A. Penkovsky L. Makh I. Shibaev EMAB
ID/WG.14/3	Economic conditions regulating the growth of Latin American steel production	A. Gomez Chile
ID/WG.14/4	Ironmaking plant of Chiba Works - its construction and rationalization	T. Nagai Japan
ID/WG.14/7	Processing of metallurgical slags at iron and steel plants	S. Klemantaski United Kingdom
ID/WG.14/8	Present status and future of the iron and steel industry of African countries	ECA secretariat
ID/WG.14/9	Present status and future of the iron and steel industry of the Asian countries	ECAFE secretariat
ID/WG.14/10	Continuous steelmaking	M. W. Thring United Kingdom
ID/WG.14/11	Water supply, re-use and disposal at an integrated iron and steel works in Great Britain	G. W. Cook United Kingdom
ID/WG.14/12	Forecasting iron and steel demand in developing countries	ECA secretariat
ID/WG.14/13	Possibilities of developing an iron and steel industry with other than fully integrated plants	R. Tietig, Jr. United Kingdom
ID/WG.14/14	Control of strip tension in electrolytic tinning lines	K. T. Lawson United Kingdom
ID/WG.14/15	Research for the iron and steel industry in developing countries, possibilities for regional co-operation	L. C. Correa da Silva Brazil
ID/WG.14/16	Economic advantages of the creation of iron and steel plants for small countries on a regional basis	ECA secretariat

1/ The principal papers discussed are being published in a separate volume entitled "Proceedings of the Second Iron and Steel Symposium", which will also be distributed as a United Nations sales publication.

ID/WG.14/17	Requirements of manpower and qualified staff in the creation of the iron and steel industry and training of personnel	O. Malukha Czechoslovakia
ID/WG.14/18	Pre-investment information for designing iron and steel plants in the developing countries	J. Hlavacek Czechoslovakia
ID/WG.14/19	SL/RN direct reduction process for the production of sponge iron and its melting to steel	H. Garbe W. Janke Federal Republic of Germany
ID/WG.14/20	World production, trade and prices of iron and steel	ECE secretariat
ID/WG.14/21	Availability of iron ore resources for iron and steelmaking	ECE secretariat
ID/WG.14/22	Application of low-shaft furnace for ironmaking with sub-standard raw materials	A. B. Chatterjea B. R. Nijhawan India
ID/WG.14/24	Electric arc furnace steelmaking for developing countries	T. V. S. Ratnam R. D. Lalkaka India
ID/WG.14/25	The IRSID continuous steelmaking process	P. Vayssiere J. Rouanet A. Berthet C. Roederer B. Trentini France
ID/WG.14/26	Injection of light petroleum naphtha into iron smelting furnace	A. B. Chatterjea B. R. Nijhawan India
ID/WG.14/27	Energetics of iron and steel works, evolution and application to developing countries	J. Astier P. Dancoisne France
ID/WG.14/28	Automation in the iron and steel industry	ECE secretariat
ID/WG.14/29	Factors affecting steel demand and its product pattern in developing countries	ECE secretariat
ID/WG.14/30	Demand for steel and prospects for regional co-operation in South-east Asia	Nippon Kokan K. K. Japan
ID/WG.14/31	The supply of steel in developing countries	ECE secretariat
ID/WG.14/32	Assistance of the advanced countries to develop the iron and steel industries in developing countries	M. N. Dastur India
ID/WG.14/33	Standardization of steel and steel products to facilitate co-ordination of national, interregional and international specifications and to promote trade among different countries	B. S. Krishnamachar India

ID/WG.14/34	Modern design of blast furnace	M. Iimori T. Tsutsumi Japan
ID/WG.14/35	New equipment for oxygen steelmaking plant	G. Urban H. Schirmer Federal Republic of Germany
ID/WG.14/36	Modern equipment for the rolling of steel	M. G. Sendzimir United States
ID/WG.14/37	Economic analysis as an instrument of the management system in metallurgical production	O. Fiala Czechoslovakia
ID/WG.14/38	Modern techno-economic indices and ways of their attainment in blast furnaces, steelmaking and rolling mills	W. H. Mieth Federal Republic of Germany
ID/WG.14/39[2/]	Efficiency of mechanization and automation in the iron and steel industry. Economic aspects of computer control of the oxygen steelmaking process	ECE secretariat
ID/WG.14/40	Experience and economic profit of continuous casting in steel plant	Y. Kawamoto Japan
ID/WG.14/41	Conversion of open-hearth shops into basic oxygen furnace shops at Fuji Iron and Steel Co. Ltd.	S. Toyoda H. Nakajima M. Maeda E. Hirao K. Nakajima Japan
ID/WG.14/42	Present status and future of the iron and steel industry of the Latin American countries	ECLA secretariat
ID/WG.14/43	Economies of scale in the steel industry	ECLA secretariat
ID/WG.14/44	Export-import Bank and its relationship in the development of an iron and steel industry	A. C. Cass United States
ID/WG.14/45	New development in the sector of tube manufacturing	J. Mietzner Federal Republic of Germany
ID/WG.14/46	Steel plant location: A guide for the developing countries	E. T. Culver J. Pearce United States
ID/WG.14/47	The financing of the iron and steel industry in a developing country: the case of Spain	L. Guereca Spain
ID/WG.14/48	Determination of the optimum capacity of the fully integrated iron and steel plant and its parts	H. R. Mills B. S. Soan United Kingdom

2/ Summary only issued.

ID/WG.14/49	Experiences and advantages in employing preheated cold charge in electric furnaces and their influence on new electric steel plant layout	F. Grossi et al. Italy
ID/WG.14/50	Continuously cast and rolled semi-finished material for light section and wire mills in developing countries	B. Tarmann Austria
ID/WG.14/52	Organization and establishment of semi-integrated steel production plants in developing countries	M. M. Sherover Venezuela
ID/WG.14/53	Waste gas cleaning systems for large capacity basic oxygen furnace plant	A. D. Rowe H. K. Jaworski B. A. Bassett United Kingdom
ID/WG.14/54	The value of the technical press in the development of a steel industry and its technology	R. L. Deily United States
ID/WG.14/55	Collection and processing of iron and steel scrap for iron and steel industry	K. N. P. Rao India
ID/WG.14/56	Is Latin American steel expensive?	A. Gomez Chile
ID/WG.14/57	Development plan for the iron and steel industry in Argentina	F. E. Aldinio Argentina
ID/WG.14/58	Establishment of steel plants in small developing countries	P. P. Manikam Ceylon
ID/WG.14/59	Modern technology of oxygen-blowing steelmaking process	F. Wegsoheider Austria
ID/WG.14/60	Modern equipment for oxygen steelmaking	K. Langer Austria
ID/WG.14/61 3/	Possibilities in the development of the iron and steel industry, other than fully integrated plants	G. R. Heffernan Canada
ID/WG.14/62	The iron and steel industry and industrialization of the developing countries	B. R. Nijhawan
ID/WG.14/63	Economics on transporting of raw materials in large bulk carriers	W. T. Hogan United States
ID/WG.14/64	Equipment for the continuous casting of steel for the needs of small-scale works	I. Mydlarz Poland
ID/WG.14/65	Modern light and medium rolling mills for the production of sections for a varied market	A. Mularz Poland
ID/WG.14/66	Review of the activities of the United Nations in the iron and steel industry in developing countries	UNIDO secretariat

3/ Summary only issued.

ID/WG.14/69	Interrelation between iron and steel industry and industries of consumers of its products	I. M. Denisenko
ID/WG.14/70	New methods of beneficiation and agglomeration of iron ores and concentrates for blast furnace process; their efficiency	P. V. Samochvalov
ID/WG.14/71	New theoretical developments in the field of steelmaking	V. I. Yavoisky
ID/WG.14/72	Improvement of the steel quality by treatment with synthetic slags	A. G. Shalimov
ID/WG.14/73	Recent achievements in continuous casting technology	A. I. Manokhin
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ID/WG.14/79	Ways of development of iron and steel industry in developing countries	P. A. Shiryayev
ID/WG.14/80	Technical assistance of the USSR in establishment and progress of ferrous metallurgy in developing countries: its main principles and arrangements, long-term credits and their repayment	M. I. Syrjakov
ID/WG.14/81	Modern designs of blast furnaces	A. E. Suhkorukov

ANNEX 4

LIST OF WORKING PAPERS BY MAJOR SUBJECTS OF DISCUSSION

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4.	Interrelation between iron and steel industry and industries of consumers of its products	ID/WG.14/69
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6.	Present status and future of the iron and steel industry of the Asian countries	ID/WG.14/9
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20.	The IRSID continuous steelmaking process	ID/WG.14/25
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1/ Summary only issued.

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