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Workshop on Iron and Steel Technologies
for Developing Countries*

Sao Paulo, Belo Horizonte, Brazil
10-20 October 1988

REPORT**

* Jointly organized by UNIDO, Instituto Brasileiro de Siderurgia (IBS) and Associacao Brasileira de Metais (ABM).

** The views expressed in this document are those of the experts and participants and do not necessarily reflect the views of the Secretariat of UNIDO. Mention of names of firms and commercial products does not imply the endorsement of UNIDO. This document has not been edited.

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Abbreviations

UNIDO	United Nations Industrial Development Organization
IBS	Instituto Brasileiro de Siderurgia
ABM	Associacao Brasileira de Metais.

EXECUTIVE SUMMARY OF FINAL REPORT

1. A major example of technical co-operation among African countries and Brazil emerged during the workshops organized by UNIDO, IBS and ABM, with the co-operation of other Brazilian institutions.

2. Twelve executives of African iron and steel companies and Government met more than twenty Brazilian executives from iron & steel companies, equipment manufacturers and plant engineering consultants, to identify opportunities for practical co-operation. The opportunities are shown in Table 1.

3. The workshop recommended that the following activities should urgently be set up by UNIDO, IBS or ABM and offered to all African countries interested in iron & steel industries:

   - Training of executives on Planning of Iron & Steel plants;
   - Creation of an African Iron & Steel Association;
   - Editing of an African Iron & Steel Technical Journal;
   - Creation of networks of individuals/institutions.

   The following problem areas are frequently affecting the iron and steel industries in Africa:

   - supply of spare parts and refractories;
   - maintenance;
   - sectoral and corporate planning;
   - managerial and operational training.

   Participants recommend that the Brazilian experience and potential for co-operation and investment should be made available to those African countries more directly affected.

TABLE 1

OPPORTUNITIES FOR TECHNICAL COOPERATION AMONG AFRICAN AND BRAZILIAN IRON AND STEEL INDUSTRIES

Fields of Cooperation	Angola	Algeria	Cameroon	Mozambique	Nigeria	Tanzania	Uganda	Zaire	Zambia	Zimbabwe
1. Training in Iron & Steel	x	x								
1.1 Operational	x			x	x	x	x		x	
1.2 Managerial			x	x		x	x	x	x	
1.3 Research				x						
2. Planning of I&S Sector	x		x	x		x	x	x	x	
3. Manufacture of spare Parts.	x	x			x		x		x	
3.1 Refractories				x	x	x				
3.2 Maintenance System	x									x
3.3 CAMMS		x								
4. Planning/design of Iron & Steel Plant										
4.1 Feasibility study			x						x	
5. Exploitation/Processing of iron ores	x					x		x		
6. Scrap collection	x							x		
7. Creation of Iron & Steel company				x		x		x		
7.1 Rehabilitation of I & S plant				x		x	x			
8. Upgrading of process engineering capability		x		x						
8.1 Creation of capital goods industries					x					
9. Information centre				x						
9.1 Environmental protection								x		x

INTRODUCTION

A major example of technical co-operation among African countries and Brazil emerged during the workshop on Iron and Steel Technologies for Developing Countries.

The Workshop was organized by UNIDO in co-operation with the Instituto Brasileiro de Siderurgia (IBS) and Associacao Brasileira de Metais (ABM) from the 11th of October to the 21st of October 1988.

ABM, Associacao Brasileira de Metais (Brazilian Soceity for Metals) is the most important technical and scientific professional association in Brazil. It was founded in 1944 and has 8,000 members, including metallurgists from other countries.

IBS, Instituto Brasileiro de Siderurgia (Brazilian Iron and Steel Institute), congregrates all iron and steel companies in Brazil as well as several enterprises related to the steel industry.

The objective of the workshop was to offer African and Brazilian executives the opportunity to identify areas for co-operation. The workshop was recommended by the Fourth Consultation on Iron & Steel Industry held in Vienna, Austria, in June 1986. The said fourth consultation stressed the following recommendations:

(a) that ways and means of improving production and operation of Iron & Steel industries in developing countries should be formulated;

(b) to exchange information on the progress of implementation of technical (development) models among developing nations of Africa on the one hand and between the individual countries and Brazil;

(c) to identify various fields of activities in the metallurgical sector in which inter-regional or biteral cooperation can be achieved.

The conclusions and recommendations of the Workshop as well as possible areas of cooperation are in Chapter 3.

Twelve participants from ten developing countries - Algeria, Cameroon, Angola, Mozambique, Nigeria, Tanzania, Uganda, Zaire, Zambia and Zimbabwe were at the workshop. In addition, a number of observers and representatives from the Brazilian iron and steel industry were in attendance. A list of participants appears as Appendix 1 to this report.

IBS and ABM of Brazil organized the workshop session, visits, contacts and provided the very important secretarial work without which the workshop would not have been possible.

Opening Ceremony and election of officers.

The workshop was opened by the representatives of the sponsoring organizations:

IBS - Mr. C.A. Roxo
ABM - Dr. Georges Leonardos, Vice President ABM
Dr. Professor V. Chiaverini, General Secretary
UNIDO-Mr. M. Nogueira da Silva

The opening address was made by Messrs. Dr. Leonardos nd Dr. Professor Chiaverini, who welcomed the participants and explained the purpose of the workshop. Mr. Milton Nogueira da Silva reported on the technical assistance activities of UNIDO to developing countries in the field of metallurgy and iron and steel development, in recent years.

Engineers Onokiok Ekong of Nigeria and Dr. T.Y. Senzani Chicogo of Mozambique were unanimously elected chairman and rapporteur of the workshop, respectively.

Country papers

Each country presented a paper on the status experience, problems and expectations of the iron and steel industries in their respective countries. Several Brazilian companies shared their experience in plant engineering and construction and iron and steel production.

The workshop devoted considerable time to discussing the papers presented both by the host country as well as by the other developing nations represented.

After three days of lively technical meetings, the workshop moved to practical activities, as a back up to the Brazilian experts presentations. The participants visited two small mills and one medium integrated steel plant namely "Montepino Rolling Mill," "Nossa Senhora do O Rolling Mill" and "Aliperti's Integrated Metallurgical" all in Sao Paulo city.

The second phase of the workshop was in Belo Horizonte, where participants attended the Second International ABM Conference on Iron and Steel Technologies in Developing Countries, from 16 to 21 October.

Apart from attending the conference, the workshop participants had the opportunity to visit several iron and steel plants, in Minas Gerais, such as Cia. Siderurgica Pains, Cia. Siderurgica Belgo-Mineira, Cia. Siderurgica Mamermann (integrated, charcoal), usiminas, Acominas (integrated, coke) and others.

The workshop programme included lectures, panels, technical discussions, plant visits, bilateral conversations and a final meeting to draw conclusions and recommendations. A summary of the programme appears in the following page.

Final Report

The final report was drafted by Rapporteur, Mr. T.M.Z. Chicogo, of Mozambique, and submitted to the plenary for discussion and approval, especially concerning Chapter 3 - Conclusions and recommendations.
The approved draft was later revised by Mr. Nogueira da Silva, to fit UNIDO's reporting format.

CHAPTER 1

The Brazilian Iron & Steel Industry: State of the Art and Opportunities for Co-operation. Summary of papers and discussions:

1. During the workshop, Brazilian lecturers presented a series of papers describing the Brazilian iron & steel industry and identified possible co-operation with other developing countries in the transfer of technology in iron and steelmaking, particularly in charcoal based blast furnaces, energy optimising furnace (EOF), steelmaking from scrap, rolling mills, direct reduction with coal.

   The main conclusions of the papers on the status of technological development of the Brazilian Iron & Steel Industry are drawn out as summarized below.

   "TECHNOLOGICAL DEVELOPMENT OF IRON AND STEEL INDUSTRY: EVOLUTION, PRESENT SITUATION AND PROSPECTS".

   This paper analyzed the relations between the technological and production structure of the Brazilian iron and steel industry and its position on the world scene. The article shows that Brazilian advancement will generate an impact, not only on iron and steel economies of the developed countries, but also on that of the developing countries.

   A paper analysed the recent acquisition of domestic capability for self-sustained technological development and the new challenges for the next decade.

   The Brazilian iron and steel industry was presented as internationally competitive, based mainly on its production structure, its technological capacity and the low cost of steel production.

   Analysis of the post-war technological growth in steel production shows that development was based on the policy of import substitution. This policy has been adopted by many developing countries and, as the Brazilian case shows, is characterized by the following stages:

   i. Operational Apprenticeship Stage. The main objective of this phase is obtaining knowledge of operational technologies and production control management. Usually it is accompanied by the creation of operational teams.

   ii. Technological Absorption and Development Stage. This stage requires the organization of operational groups, and technical teams. These two groups are needed to introduce modifications and improvement in industrial technologies, during their installation or adaptation to local conditions of production. It was emphasized that acquisition to process engineering is fundamental in the consolidation of the technological capacity.

   iii.) Technological Innovation Stage.
   The main characteristic of this stage is total mastery of existing technologies. This mastery permits a country to undertake secondary innovations and the creation of new technologies. Technological research activities are of great importance at this stage.

On general, the technological learning process in Brazil has passed through all these stages described above and now faces the economic and market crisis of the world economy. There is a great demand for technology. It was noted that new challenges are facing the Brazilian and iron & steel industry. Therefore, the New Industrial Policy, based on the consideration of technological innovation as a propelling power, was recently introduced in Brazil.

The second part of the paper discussed the principal characteristics of the production and technological structure of the Brazilian Iron & Steel Industry, beginning with an analysis of coke-integrated plants, which basically produce flat rolled products and medium and heavy shapes; small steelworks, which fulfill the demand for light non-flat products and special steels. Most of these small steelworks are scrap-based and semi-integrated, though some of them are integrated with sponge-iron or charcoal pig iron.

Brazil has 43 steel companies in both private and government sectors. Five of them are coke-integrated, nine are charcoal-integrated, two are direct reduction-integrated and twenty-seven are semi-integrated. To these one can add the independent charcoal-based pig iron producers, who own 120 blast furnaces with a production capacity ranging from 25 to 400 tons per day.

The third part of the paper gave suggestions for the modernization of the iron & steel sector in Brazil. It assumed that there is an accelerated pace of change in the technological aspect of development of the Brazilian iron & steel industry and identified technologies which are considered important to be implemented, in order to eliminate the gap in relation to other countries and to increase the competitiveness of these products. These are as follows:

i) Ore reduction area which should be modernized through:
   - Coke plant with automation of combustion and dry quenching control;
   - Sister plant with profile box for high layer (600mm), 2 mixers with the secondary mixer having steam or hot water injection, a preheated mixture with continuously controlled humidity, etc.

ii) The paper concluded that to increase the national capability for self-sustained technological development in process and basic equipment engineering, it is necessary to create facilities for experimentation and in-depth research, this will undoubtedly open the way to progressive technological independence.

"SIDERBRAS - FROM 270 THOUSAND TONS/YEAR TO 16 MILLION TONS/YEAR."

This paper provided an account of the evolution and consolidation of the capabilities of the SIDERBRAS Group Companies in the execution of tasks related to the implementation and expansion of Steelworks of the Group, which produce medium and heavy section and flat products.

A summary of the National Steel Plan was given, describing Phases I, II and III.

Account was given of the implementation and expansion of Acominas (Aco Minas Gerais), CST (Companhia Siderurgica de Tubarao), CSN (Companhia Siderurgica Nacional), COSIPA (Companhia Siderurgica Paulista), USIMINAS (Usinas Siderurgicas de Minas Gerais) and the impact of investment policies.

In the 1930's the Brazilian Government decided to have a large scale steel production in the country. The National Committee of the Steel Industry was set up to conduct a thorough investigation of the problems faced by the economy. The Committee promoted many studies and debates that led to the creation of CSN in 1941 and which started operating in 1946. Further planning efforts gained strength in the 60's which could count among other things an agreement with the World Bank and elaboration of Babine report which resulted in government deciding to create the "Grupo Consultivo da Industria Siderurgica - GCIS". This group later worked in collaboration with Banco Nacional de Desenvolvimento Economico (BNDE) and conducted studies which led to

i) The creation of Conselho Consultivo da Industria Siderurgica) CONSIDER (1968);
ii) creation of Siderurgica Brasileira S.A. (SIDERBRAS) as a holding company of Brazilian Steel Industry (1973).
CONSIDER was responsible for the formulation of directives for the steel industry as a whole.

As far as organizational structure is concerned, the SIDERBRAS Group is composed of 12 companies: the holding, nine works, one service company and one associated company and has the following objectives:

- To promote and manage the interests of the Federal Union in the Steel Industry and associated activities;
- To programme the amount to be invested in the subsidiaries and in associated companies;
- To promote activities related to the steel industry in Brazil and in other countries, either through the subsidiaries or the associated companies;
- To co-ordinate and supervise the industrial and commercial policies of its subsidiaries;
- To provide and stimulate the development of human resources necessary to Brazilian Steel Industry activities;
- To perform other related activities at the request of the Ministry of Industry and Commerce.

In 1987 SIDERBRAS produced 15,78 tons of raw steel, accounting for 71% of national production. The remaining of 29% were produced by private companies.

The paper concluded that as a result of know-how accumulated over the years and of constant personnel development, SIDERBRAS can successfully transfer to other firms, technologies in the areas of plant and product engineering, personnel training and development, technical support, consulting, as well as tests and essays in its research laboratories.

"COMPARATIVE EVALUATION OF NEWLY DEVELOPED TECHNOLOGIES FOR APPLICATION IN MINI-STEEL PLANTS"*

This paper reviews and confirms the idea that mini-steel plants, integrated or not, are the best solution for iron and steel industry in developing countries, especially the African region, for both flat and non-flat products.

The better known ironmaking processes are discussed and classified into Indirect Processes, Direct Processes and Direct Smelting Processes. The importance of charcoal blast furnace for developing countries is demonstrated.

Development of the Direct Smelting Processes - all of them pig iron producers - is also analyzed. Steelmaking processes are classified as follows: Open Hearth Furnaces, Oxygen Processes and Electric Processes. The Open Hearth is being replaced by other steelmaking processes, especially by EOF (energy optimizing furnace).

1.17 The paper then shows that erection or expansion of steel plants in developing countries should meet the following conditions:

- make intensive use of domestic resources;
- be based on updated and proven technologies that demand relatively low investment;
- be tailored for the national or regional market, with an eventual surplus for export.

Recommendations and advice are given to developing countries to adapt the following technologies, which are well known, proven, updated and competitive:

- Iron making processes: small coke blast furnace, rotary kiln process (as the SL/RM process), gaseous reductant direct reduction (MIDREX AND HYL III) and direct smelting processes (COMBI SMELT and COREX);
- Steelmaking processes: orxygen steelmaking, especially the EOF process, and electric furnaces.

The importance of knowing about scrap availability is stressed, before dimensioning the iron making plant and defining the technological route for steel production. Further an indication is made of the steps to be followed in a comparative evaluation of different iron and steel processes. Such evaluation lead to the best technical and economical route for steel production under a set of specific site conditions. Nowadays, there exist well-known, proven and low investment technologies to be adopted by developing countries, even on small production scales. Attention to the development of continuous casting processes is strongly recommended. There are many improvements underway in billet continous casting , whereas the new thin strip continous casting promises may be a solution for the flat product mini mill of about 500,000 E/year. A complement for small-scale flat production is the HSRC (Hot Strip Reversing Compact) developed by Voest Alpine.

The paper concludes that it is hardly possible to make general solution to the problems of installing or expanding the iron and sector of developing countries. Each case requires individual approach but experience shows that new steel or ravamping have been most successful when established as part of a comprehensive national development programme in balance with the technical and economic aspects.

PAPER "PLANNING, DESIGN, ENGINEERING AND IMPLANTATION OF STEEL WORKS"*

This paper described the main steps in planning of steel plants for developing regions. The planning process takes into consideration factors of national importance as well as those of specific interest to the steel industry. The author presents a study case to show how all factors are considered in planning a steel works to supply long products to a market concentrated in a large city which is relatively isolated from the other markets. In designing a steelworks plant for Sao Luis, Maranhao (North of Brazil), the author works out a step-by-step method, as summarized in the attached table indicated as below:

PLANNING, DESIGN, ENGINEERING AND IMPLANTATION OF STEELWORKS

SCHEDULE OF PHASES

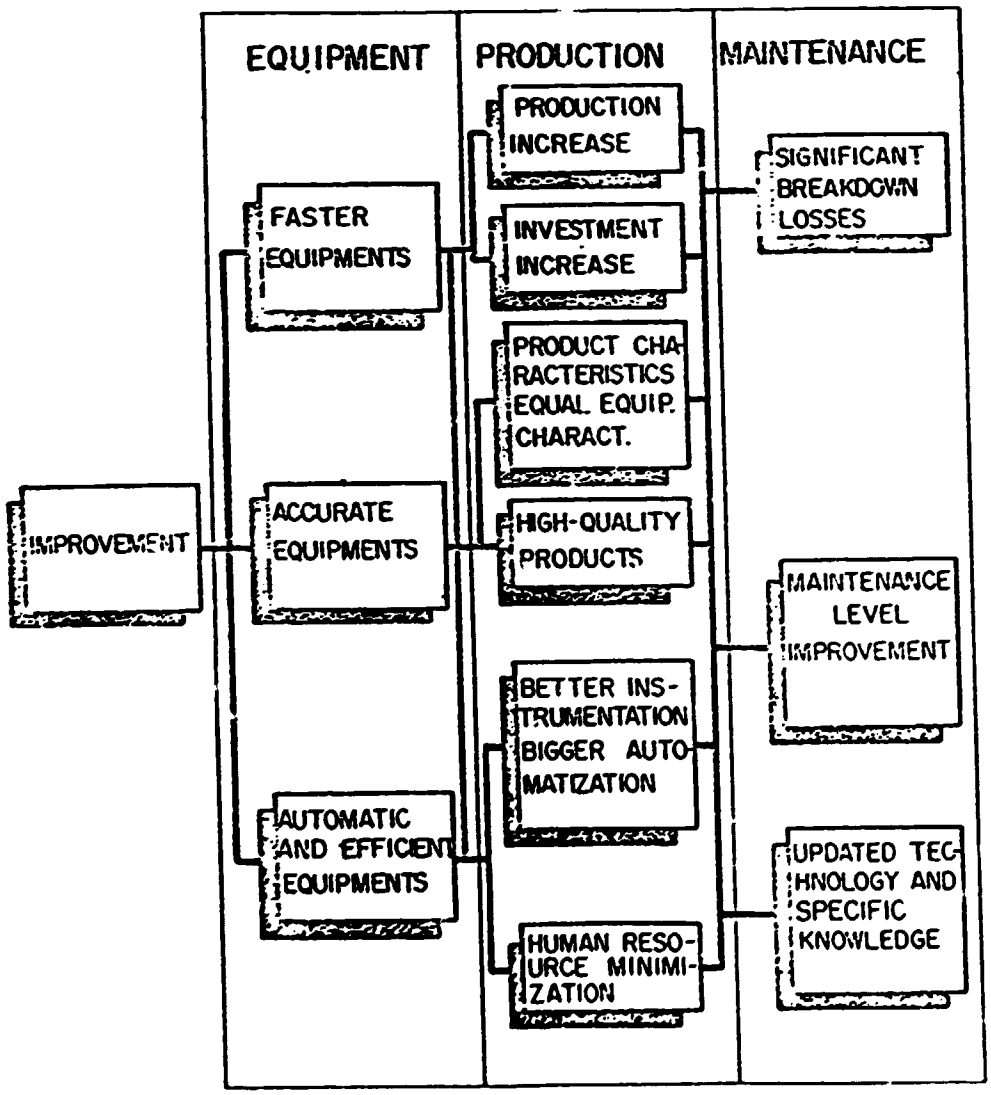
Phases		Steps	Inputs and Actions
MANAGEMENT	BASIC ENGINEERING	BASIC CONCEPTION OF THE PLANT AND THE BOSSINESS	DATA: ECONOMIC SCENARIOS; MARKET FORECAST; AVAILABILITY RESOURCES ANALYSIS: PRODUCTS AND MARKETS; SCALES AND TECHNOLOGY; PLANT'S LOCATION; INPUTS: ACCESS AND COST; INVESTMENTS AMOUNT AND SCHEDULE; FINANCIAL INPUTS AND OUTPUTS
		FEASIBILITY STUDY	TECHNICAL CONFIGURATION: RESOURCES AND RESULTS DECISION OF INVESTING
		BASIC DESIGN	ESPECIFY: EQUIPMENTS; WORKS; SERVICES; MATERIALS PLAN: PROCUREMENT; CONTRACTS DESIGN: LAY-OUTS; MOVEMENT; INTERNAL ROADS; FLUIDS
	EXECUTIVE ENGINEERING	DETAILED DESIGN	CHECK AND CONTROL: PROJECT; TIMING; FINANCES
		PROCUREMENT	APPRAISE THE PROPOSALS → CONTRACT AND BUY → INSPECT AND EXPEDITE
	INDUSTRIAL AND CIVIL WORKS ENGINEERING		IMPLANT → TEST → ASSIST START UP DRAW: AS BUILT

"BASIC CONFIGURATIONS OF MINI-STEEL PLANTS
ECONOMICAL AND INDUSTRIAL ASPECTS"*.

The paper presents COBRAPI's capability in engineering and consulting services. COBRAPI covers all stages of a project, from design through start-up and personnel training for industrial plants. As an example of how these methods are applied in the real world, the author elaborates on the planning, design of electric and oxygen plants formini-mills. The author discusses technical and industrial factors concerning scrap yards, charging system, plant layout, LD vessel design, secondary metallurgy, continuous casting and economies.

PAPER "CAPABILITY STRATEGY OF MAINTENANCE IN
BRAZILIAN IRON AND STEEL INDUSTRY"**

The author presents a view of maintenance activities in large Brazilian Iron and Steel Plants in recent years. It offers guidelines to accelerated technical development, higher productivity, optimizing investments and less operating costs. It also analyzes the impact on maintenance on equipment and production and vice versa, as shown below:



* Eng. Boaventura M. d'Avila Filho-Director of SETEPLA TECNOMETAL Engenharia, S.A.
** Celso Brasil Horta - COSIPA and ABRAMAN.

PANEL presented by ABDIB, Associacao Brasileira para o Desenvolvimento de Base (Brazilian Association for the Development of Basic Industries).

During this panel a group of experienced company executives discussed the capabilities of the Brazilian capital goods industry. Brazil is described as having one of the world's most modern and diversified capital goods industry. The consulting engineers are able to perform all stages from conception to start up of practically all industrial plants, inclusive iron and steel. The panel team distributed papers describing the Brazilian capabilities in:

- Blast furnaces, including charcoal-based
- arc furnaces
- secondary steelmaking
- vacuum technology
- continuous casting
- rolling mills
- materials handling
- computer control
- auxiliares

PANEL presented by ABEMI, Associacao Brasileira de Engenharia Industrial (Brazilian Association for Industrial Engineering).

During this panel a group of engineering companies executives discussed the mastering of iron and steel technologies and engineering. The panelists summarized the progress made in iron and steel engineering capabilities in Brazil since the inception of the Volta Redondo plant in the 1940's. They stressed on the need for a firm commitment by the national government in establishing a clear policy towards mastering of engineering. Apart from the obvious training of engineers the policy must include incentives, a system of preferences and an approach to opening of technological packages.

"COMPARATIVE EVALUATION OF NEWLY DEVELOPED TECHNOLOGIES FOR APPLICATION IN MINISTEEL PLANTS"*

This paper offers a survey of practically all iron and steelmaking technologies that can be adopted by a mini-steel plant. Apart from the classical charcoal blast furnaces, scrap-electric furnace concept, the paper presents modern concepts such as COREX, EOF, COMBISUELT and others. The paper presents also a series of technical criteria for selecting the appropriate process in face of given iron ores, reductants, production scale, etc.

"ENVIRONMENTAL CONTROL IN THE STEEL INDUSTRY"**

This paper presents the problems, experience and challenges faced by the Brazilian iron and steel industry so far. A basis for a plan of action is also summarized.

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* UNIDO paper, prepared and presented by Eng. Sergio G. Scherer, Consultant.
** C. Alberto Roxo, IBS - Instituto Brasileiro de Siderurgia.

DISCUSSION OF THE BRAZILIAN PAPERS

The discussion of the papers describing the technological development of the Brazilian Iron & Steel Industry centered on the problems involved in its establishment. There is now evidence that certain developing countries are making impressive progress in the steelmaking capacity, but in Africa the development has not been significant, except for South Africa.

The idea was expressed that Brazil should make its successes and potential in developing its metallurgy be known in the steelmaking community of third world countries. It was suggested that UNIDO could facilitate such an effort.

It was stressed that the regional, economic and technical co-operation that SIDERBRAS Group, through its companies, has provided to neighboring countries, such as Paraguay, Venezuela, Perú and Bolivia, should be extended to cover other regions such as Africa and Asia. UNIDO is requested to support this transfer of technology.

The following areas of co-operation between Brazilian and African Metallurgy could be mapped, especially in such areas as reduction, blast-furnace gas, enrichment charcoal gasification, injection of pulverized coal and natural gas into blast-furnaces.

Examples:

- Refining and solidification techniques to reduce input consumption;
- Training of African metallurgists, research workers in economic-mathematical modelling of processes; productivity improvement and process performance of metallurgical industries;
- Training of researchers in the areas of environmental protection of metallurgical plants.

CHAPTER 2

IRON AND STEEL INDUSTRIES IN THE AFRICAN REGION - PROSPECTS AND AREAS FOR TECHNICAL CO-OPERATION

The papers presented under this heading reviewed recent developments in the iron & steel sectors of the African region.

"IRON AND STEEL IN ANGOLA - A PERSPECTIVE"*

This paper provided an account of the present and prospective reserves and deposits of iron ore in Angola, as well as the iron making technologies available.

A brief analysis of recent evaluation of reserves shows that there are occurrences of iron deposits in Angolan territory but the most important are those in the Kassinga and Kassala-Kitungo areas, where the Austrian Austromineral Company estimated the existence of about 255 million tons with a 62.7% content of iron ore and low phosphorus and alkaline percentages. The Government of Angola, in collaboration with the above cited company attempted at finalizing feasibility studies for ore extraction, but military insecurity problems are so complex that works were temporarily suspended, especially because the railway system has to be rehabilitated before production for export and internal market can be considered.

Angola's iron making technologies are formed by a scrap processing and smelting unit and a rolling mill plant with supporting infrastructure. The rolling mill has a capacity of 55,000 tons/year and was installed in 1971 and produce reinforced bars of 0 6 - 25 mm diameter.

The paperlisted the following technological problems in Angola:

- Training of operational technicians who should run the existing metallurgical installations, since national incependence led into exodus of foreign technicians.
- Shortage of scrap to feed the existingsmelting unit, since most of small scrap collectors left the country.
- Difficulties in establishing a maintenance system due to scarcity of spare parts.

"MAIN PROBLEMS OF ALGERIAN IRON AND STEEL INDUSTRY: COMPUTER AIDED MANAGEMENT SYSTEM AND SPARE PARTS PRODUCTION IN ARAB IRON & STEEL INDUSTRY."**

This paper described the development of iron and steel industries in Arabic speaking countries of North Africa and in the Gulf region. It described the Arab Steel Union is an international steel association aimed at co-ordinating efforts of its member countries; at accelerating economic and technical progress of its steel and iron sectors, the development of blast furnaces productivity.

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*Summary of country paper presented by Kiami Matadidi, Mining Engineer and General Manager of Angolan National Steel Company.

**Paper presented by Dr. Lies Goumiri of Algeria on behalf of the Arab Union of Steel & Iron.

The technical level of the steel and iron of this region is in general considered reasonable. In the case of Algeria, however, there is a tendency to widen the range of steel products and to increase productivity. The sector is facing the following problems:

- The establishment of a Computer Aided Maintenance System (CAMMS);
- Spare Parts Supply and Manufacture;
- The establishment of Engineering and Integration processes;

These three problems are common in other African metallurgical plants and could be tackled by countries through a co-operative effort.

"HIGHLIGHTS ON IRON AND STEEL INDUSTRY IN CAMEROON"*

This paper described the average consumption of steel in Cameroon is estimated at 120,000 tons/year of which about 50,000 tons are imported billets destined to the only existing rolling mill, which produces bars, rods, wires and small sections mostly for the construction sector of the Cameronian Economy. There are some small factors that produce various products such as nails, metallic bars, welded pipes, etc.

The paper forecasts that the demand of steel in 1990 will be 160,000 tons rising to 200,000 tons in the year 2000. It further shows that Cameroon has iron ore deposits estimated at 200 million tons of magnetised minerals with a 36% of iron content. However, the exploitation of the deposits through classical routes - coke blast furnace and oxygen converter - is believed to be financially and commercially unfeasible due to the small internal market and the depressed world market for steel and iron.

Having shown the developments and problems of the market, the paper concluded showing two projects under consideration:

- A scrap-based mini-steel plant to produce billets with an expansion possibility to 100,000 tons/year including a new rolling mill plant.

- An integrated iron ore and steel complex of about 50-60,000 tons/year based on wood charcoal in co-operation with a Brazilian steel company.

"MOZAMBICAN METALLURGICAL GOALS RECONSIDERED: SOME SOURCES OF PROBLEMS AND THEIR PERSPECTIVES"**

This paper stresses the role of iron and steel industry in promoting the efficiency of those sectors where Mozambique has comparative export advantages such as agro-industries, cement, transport and harbour services within the Southern and Eastern African economies. Before national independence in 1984, one integrated steel works, two pipe producing, three nail and wire drawing mills, two heavy engineering plants and various scrap processor units were established.

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* Extracts from the Country Paper of The Republic of Cameroon.
**Mozambique Country Paper Presented by Dr.T.M. Senzani-Chicogo and Eng. F.T. Clancesse.

The technology facilities of the mini-steel plant are: one electric arc furnace and cupola for the iron and steel foundry; Daniele rolling mill; and rod mill wire drawing mill Spanish, (Sebastian).

The main inputs for production are billets imported from Zimbabwe and plate and sheet for the heavy engineering works imported from Brazil, Japan and Europe. After independence, Mozambique was forced to drastically cut imports because of several factors and expensive imported crude oil. This resulted in a necessity to carefully consider the iron and steel production capacity of Mozambique. Mozambique requested UNIDO's assistance in upgrading the management capability, in a project recently concluded. The National Directorate of Metallurgy within the Ministry of Industry and Energy was created with the following immediate objectives:

- to establish a Mozambican steel holding company;

- to formulate directives for the steel industry (in conjunction with Mozambique's Economic Programmes).

The Directorate of Metallurgy is already responsible for:
i) macro-economic and project evaluation and analysis, ii) formulation of policies for the development of engineering projects in the steel industry.

The two units of Directorate of Metallurgy are now carefully scrutinizing a technological development model to cut down imports of spare parts in those export industries which give Mozambique a comparative advantage and reviewing investment strategies for the development of iron resources and integrated steel works in Tete province north of Mozambique. However, studies by the two units and Brazilian experts with UNIDO's support have concluded that in the area of newly developed technologies for application in mini steel plants in Mozambique the technological route for ironmaking could be:

i) Adaptation of a low shaft electric furnace using Tete iron ore, (containing Ti and V), Tete mineral coal and electric energy from Cabora Bassa hydropower plant.

ii) in a second phase, install a rotary kiln to produce sponge iron as hot discharged into low shaft electric furnace-Oxygen steel plant could also be considered.

A conclusion is made that Mozambique should undergo revamping of its rod and wire mill capacity, it should consider scrap-smelting arc furnace to produce imported billets, it should also pay attention to the possibilities of continuous casting for producing hot rolled flat products (500,000 to 700,000 tons/year) on the basis of a hot strip reversing compact mill developed by Voest Alpine. Thismill is starting production at NUCOR Steel Plant in the U.S.A.

Mozambique feels a dire need for co-operation in the following areas:

- Development of engineering capacity for spare parts manufacture and planned computerized maintenance system;
- Development of macro-economic planning for the iron and steel sector;
- Training of operational, technical and research workers for the iron and steel sector;
- Informatization of tenical information center for the iron and steel sector.
- Manufacture of refractories.

"IRON/STEEL INDUSTRY OF NIGERIA"*

The decade of the eighties marks a significant achievement in the development of iron and steel industry in Nigeria. It was during this decade that integrated Delta Steel Plant, three modern bar and wire rod mills located at Jos, Oshogbo and Katsina were commissioned: Ajaokuta Steel Plant is expected to be fully commissioned before the end of the decade. Iron and steel in Nigeria are produced by the above-mentioned steel plants and fourteen (14) private steel mills. The total installed capacity is 1.245 mt. of liquid steel, the rolling capacity is 2.731 mt. of rolled product.

Economic Situation

The Nigerian Economy is presently undergoing a general structural adjustment (SAP) to shift dependency from a mono-product (Petroleum) back to the more enduring agricultural products. While solving one problem, SAP is also creating others, including on the steel industry. The devaluation of the Naira that have led to increases in the costs of all factors of production and the defacto reduction of consumer purchsing power and reduced sales of industrial goods and services among other.

Demand and Supply

Steel demand in the country remains depressed due to the poor state of the economy, shift in development priorities of Government and high cost of building material among others.

Steel supply rose generally in 1987 even when domestic production declined marginally. The supply comes from domestic and imports. The bulk of steel import in 1987 was flat products that included steel plates and sheets. A flat steel producing company is yet to be established in Nigeria.

Steel Production

Domestic steel production has been on the decline since 1985. While installed crude and rolling capacities have remained constant and even increased marginally for rolled products in 1987; actual production has declined progressively due to lack of raw materials and low working capital, among other problems.

Summary of country paper of NIGERIA written by Eng. Tachia Tooti, General Manager, Chief Executive of Delta Steel Company, Nigeria. (Paper was presented by a colleague).

Prospects

The public sector steel mills in the country have entered a new phase of operations, with Government's privatisation/commercialisation programme. To ensure the success of the programme, Government has approved a huge sum of money for the provision of working capital, supply of spare parts and consumables on a loan agreement, and the building of a captive power plant to ensure steady power supply. It has in addition also promised to look into various other policy areas that are currently worsening the effective performance of the steel plants.

Opportunities

1. The country is grossly under-installed in foundry capacity. To satisfy the casting needs of the steel industry in terms of spare parts, it is imperative that many foundries be established.

2. Present domestic capacity for spare parts manufacture is very low and can barely satisfy up to one percent of requirements of the steel industry, let alone the entire industrial sector in the country. The opportunities available in the machine and fabrication shops, and machine tool industry is unlimited and investors would be most welcome to collaborate with Nigerian partners to establish industries in this area.

3. Opportunity exists for the manufacture of electric motors and generators, transformers and electrical switchgears, resistors, transistors, etc. to satisfy the due need of industry in general.

4. Production of industrial refractories, especially for iron and steel.

"IRON AND STEEL SECTOR IN TANZANIA: A SUMMARY"**

This paper stresses that Tanzania is a net importer of primary iron and steel products indicating that Tanzania in 1980 imported 95,000 tons and the projected demand for 1990 will be roughly 400,000 tons. This figure is based on the assumption that only 30% of the anticipated projects will be undertaken and that capacity utilisation of the metal-working industries will reach 65%.

The production and supply of iron and steel in Tanzania is undertaken by three subsidiaries companies of the National Development Corporation (NDC) which is a holding company entrusted with metal and engineering sector of the country. The companies dealing in iron and steel are Aluminium Africa Company (ALAF), National Steel ,orporation and the Steel Rolling Mills based in Tanga. Besides those, there are about 30 foundries in the country utilising cupola furnaces making cast iron products, with an installed capacity of about 7,000 tons/year though most operate at about 30% of their capacity.

Based on Tanzania Country Paper by A.Z. Mamuya.

The main production problems are:

- Shortage of raw maerials
- Obsolete plants
- Necessity of a lot of capital for investments in revamping of obsolete plants and in primary and secondary production of iron and steel.

There is a possibility of producing sponge iron by using coal, according to a study done by Fried Krupp GmbH and Lurgi for the iron deposits at Liganga and Mchuchuma regions. These deposits are estimated at more than 50 million tons. The development of Liganga deposits have been estimated to cost 2 billion U.S. Dollars and, for this reason, the government is proposing a technical and financial consortium.

"IRON/STEEL INDUSTRY OF UGANDA"*

This paper reviews the general economic situation of Uganda and then concentrates on industrial activities in the iron/steel. It shows that Uganda has an active steel industry based on scrap. Through scrap stocks are decreasing since scrap consumption is higher than scrap generation. The necessity of self-sufficiency points to local production based on local iron ore deposits. The following areas for co-operation were identified: rehabilitation of iron/steel plants; manufacture of spare-parts, manufacture of refractories and training of manpower and managerial personnel was made.

"IRON AND STEEL IN ZAIRE"*

This paper shows the technical configuration of Zaire's Iron and Steel Sector which is formed by:

- A semi-integrated mill comprising of one electric arc furnace of 50t; a four strands continous casting machine for billets of 100x100 mm and 140x140mm section, 2,6m to 6 m long; a rolling mill including a preheater furnace (35t) and three high stand rollers.
- A cold mill comprised: a cold rolling mill (quatro), a continuous cold shear and an anodizing unit (capacity 150,000 t/year).

The sector, over the period of its existence, have shown some problems due to the fact that the plants were originally designed to use local inputs at reasonable cost, namely the electrical power available at Inga dam and about 250,000 tons of iron ore as by-product from the projected bauxite mine depost. The bauxite project has been aborted and the steel mill was forced to use scrap as feedstock. Therefore, the plant was faced with the problem of scrap procurement whose reserves in the adjacent areas is about 100,000 tons with an annual fow of 20,000 tons. Taking this into consideration, Zaire's iron and steel sector will be faced with the problems of scrap supply supply in the very near future.

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*Summary of country paper of UGANDA presented by K.B. Tayebwa
**Summary of country paper presented by Ambassador Asal B. Idzumbuir. Sosider, Kinshasa.

The present situation of the industry is described in the paper as one faced by a number of problems, such as:

- Shortage of hard currency due to the deterioration of the national economy
- Shortage of spare parts and refractories and supplies due to unavailability of hard currency.

The paper indicates solutions to some of the major problems. In the medium term the government envisages to form a company with the purpose of collecting, processing and supplying scrap to the steel plant and on the long term, the government considers the possibility of investigating the iron ore deposits of the upper Zaire region whose content is estimated at 45-69% Fe and reserves of about 10 billion tons. The dense forest near the iron ore deposits may be considered as a possible renewable energy source for the adoption of charcoal based blast furnace technology developed in Brazil. The forest could be exploited on a rotating basis or as reaforestation. The hot mill has been tested for the rolling of non-ferrous metals, but it has been suggested that it could be used to produce cold coils from blooms of small thickness. If successful, these efforts will avoid the import of coils and alleviate the shortage of hard currency and the savings used to locally produce a number of inputs such as ferro-alloys, refractories, etc.

The paper informs that international cooperation is being given by UNIDO for the rehabilitation of the sector and that attempts are being made to establish bilateral co-operation with Brazil.

"IRON AND STEEL IN ZAMBIA"*

The papers shows that Zambia has no iron and steel making facilities. However, because of the impact steel can have an overall national economic development, feasibility studies are underway to set up an integrated iron and steel plant in the country. Zambia has six major foundries for the production of spare parts for the existing imported machinery in the large mining sector. However, these foundries operate below their capacity due to:

- shortage of raw materials;
- lack of skilled manpower
- low demand for their products.

The paper concludes that Zambia's annual demand for steel products is roughly 100,000 tons of crude steel or 80,000 tons of final steel. These demands are satisfied by imports, but worsen the problem of Foreign Exchange shortages.

"IRON AND STEEL IN ZIMBABWE"**

This paper presents an overview of the technological and production structure of the Zimbabwean iron and steel industry and its position on the African region. The acquisition of domestic capability for self-sustained technological development is analyzed from 1938, when a group of enterprising businessman created a small steel cooperation, to modern times when ZISCOSTEEL was formed in 1957 and began an ambitious expansion programme.

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*Extracted from the Zambian Country Paper.
**Summary of country paper presented by the Zimbabwean delegation.

Structure of the Zimbabwean iron and steel industry is composed of:

- Sintering units.
- Blast furnaces with a capacity for 2,000 tons per day and the other a 800 tons/day.
- Steel plant which comprises of hot metal mixers with a total capacity of nearly 2,000t liquid iron, two 50t oxygen furnaces (LD converters) and two-strand continuous casting machines.
- The rolling mill which consists of eleven soaking pits, 5 rolling mills, eachwith coooling banks and finishing sections.

Further the paper shows that the iron and teel sector of Zimbabwe has, over the years, grown and expanded to a capacity of one million tons of liquid steel per year and is strategically located, close to basic raw materials sources, which enable it to offer steel products at very competitive prices in regional and international markets.

CHAPTER 3

CONCLUSIONS, RECOMMENDATIONS AND AREAS OF CO-OPERATION

The following main conclusions, based on the information presented in the papers and points raised during the working sessions, were approved by the participants of the workshop.

3.1 SITUATION OF IRON AND STEEL TECHNOLOGIES IN THE DEVELOPING REGION OF AFRICA AND BRAZIL.

The situation of iron and steel technologies in both Brazil and the African region was described as being characterized by the following aspects:

- in the African region, a high level of disparity has been identified between the level of technological know-how and the sophistication of the technologies adapted in the iron and steel industries. This has contributed to problems associated with spare parts availability and maintenance.

- Limitation of resources in developing countries of Africa are contributing to the low level of technological development in the iron and steel sector.

- The workshop concludes that there is a high level of technology in the Brazilian iron and steel industry which has successfully been integrated with down and upstream industries of the country.

The workshop recognises that success of the Brazilian industries was made possible by deliberate favourable government policies such as incentives for local production and prohibition of imports of products that are produced or manufactured locally.

Minimills have contributed as much as 20% of the total output of steel production in the iron and steel industries of Brazil. It was noted that 100% of minimills are completely in the hands of private sector and specialise in production of long products which account for 50% of the total produced.

During the last ten years, the discovery of raw materials for iron and steel making have been on the increase in most of the developing countries of Africa and Brazil.

3.2 CURRENT TECHNOLOGICAL SITUATION

A few examples: Sintering is one of the most predominant and versitile process for preparation of blast furnace changes in the Brazilian and those African countries that possess well integrated mills. It was noted that some African countries, Nigeria, for example, has made considerable advance in mastering the technology of direct reduction processes. At present its experience could be shared with other regions of developing countries of Africa.

It was felt that the results of operation of these processess are of considerable interest for those developing countries that are on the early phases of establishing the iron and steel industries.

For those developing countries that possess ores with low Fe contents, the Brazilian technology in iron oressing such as i) magnetic floation for producing high-quality concentrates, ii) Beneficiation of oxidised quartetes by magnetic roasting, iii) Magnetic separation in multi-grade separators, iv) Floation and magnetic floation with separation of tailings out of the first stage of magnetic separation, v) Pelletization of concentrates.

It was noted that the oxygen converter and rotary vessels as developed by Brazil offer a versitile iron and steelmaking capabilities. African countries with cheap hydro-generated electric power, a high interest should be in the technology of electric arc furnaces and charcoal blast furnaces as complementary process. For the charcoal blast furnaces it was agreed that such a process, however, will have to be carefully studied and limited to regions not subject to "desert encroachment". It was pointed out that in dealing with current reaforestation and ecology issues should be taken into account and Brazilian experience.

There is a steady trend towards the use of continuous casting systems in billet and slab production in the iron and the steel sector industry of Brazil. Presently, continuous casting system accounts for 50% of steel production.

3.3 ECONOMIC ANALYSIS AND FINANCING TECHNOLOGY OF STEEL PROJECTS

Economic and financial analyses of new or existing steelmaking facilities is one of the most important instruments in planning the exaploitation and processing of local ore resources of developing countries into final products. Therefore, projects that require financing should be considered from national and international trade perspectives.

Presently in developing countries' steel sector, there are three types of projects which require a good economic and financial assessment:
i) restructuring projects, ii) expansion projects and iii) greenfield projects. There is a tendency for financing of the above project mixes, though finding financial backers (sources such as equity capital and self generated capital) will continue to prove difficult considering the overcapacity factor of the steel sector of most developing countries. However, financial institutions such as local banks, foreign banks and multinational banks can provide different types of loans or grants, especially export credits which is an important source of financing.

3.4 RECOMMENDATIONS

The participants of the workshop made recommendations for possible actions to be taken by UNIDO, in co-operation with other United Nations bodies as well as governments of participating countries. Especially, the workshop recommended to UNIDO:

- Assist African nations to edit a technical journal on Iron and Steel Technology.
- Update the UNIDO report on the state of the art on charcoal-based pig iron industries and technologies in Brazil with emphasis on environmental protection.
- Assist the African regional bodies to form an association of iron and steel producers.
- Assist in creating networks of individuals or institutions concerned with iron and steel field especially to exchange information and experience in issues such as environment, spare-parts manufacture and maintenance, economic analysis, design and preparation of investment projects. A focal point of communication for environmental issues could be Zimbabwe. Focal point for spare-parts and maintenance system could be Algeria.
- Organize a course for decision makers of the African iron and steel industry of the developing countries. The course could be entitled "Strategic Development and Management in Iron and Steel Industries".
- Strengthen domestic capabilities of African countries to perform plant design, engineering and equipment manufacturing.

3.5 AREAS OF CO-OPERATION BETWEEN DEVELOPING COUNTRIES

For developing countries, the workshop made an overview of the trends of its technological and production structures and, specifically, recommends:

BRAZIL

- Should assist developing countries in drawing up gradual integration of the steel industry, to capital goods manufacture.

ABM

- Should provide space in its journal "Metallurgia International" for disseminating information/experience of the African countries in the field of metallurgy.

PARTICIPATING COUNTRIES

- Should continue to keep in touch, especially through sharing information on initiatives, research and progress of its metallurgical industry.

APPENDIX I

WORKSHOP ON IRON AND STEEL TECHNOLOGIES FOR DEVELOPING COUNTRIES

UNIDO, IBS, ABM Sao Paulo/Belo Horizonte, Oct. 11-21, 1988

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APPENDIX II

WORKSHOP PROGRAMME

OCTOBER	MORNING	AFTERNOON
11-Tue.	Opening & Country Papers	I/S Technologies
12-Wed.	I/S Technologies of Mini-Steel	Basic Configurations
13-Th.	Panel Brazilian I/S Equipment	Panel Brazilian I/S Engineering
14-Fr.	Visit Montepino & N.S. do O.	Visit N.S. Aparecida Plant
15-Sa.	Free	Travel to Belo Horizonte.
16-Su.	Free	
17-Mo.	Attendance at ABM International Iron & Steel Conference.	
18-Tu.	ABM International Conference.	
19-We.	ABM International Conference	
20-Th.	Visits: Usiminas, Mendes Junior. Acesita, CVRD, Belgo-Mineira, Acominas.	
21-Fr.	Visits: Mannesmann, PMB, ALCAN, FORJAS, Acesita, Pains.	

APPENDIX III

LIST OF WORKING PAPERS

PRESENTED TO THE WORKSHOP BY MAJOR SUBJECTS OF DISCUSSIONS

The Brazilian Iron and Steel Industry: State of the Art and Opportunities.

1.	Development of the Brazilian Capital Goods Industries in the Steel Sector	by CONFAB INDUSTRIAL.
2.	Environmental Control in the Steel Industry	by Carlos Alberto de O. Roxo, Deputy Secretary on Environmental Affairs - IBS.
3.	Electric and Oxygen Plants	by Carlos A. Ruppenthal Milani, Head of Basic Engineering Dept. COBAAPI-SRR.
4.	Steel Desulfurization in Laddle & Pig Iron Desulfurization in Torpedo Car	by Eng. Kenji Shibata Eng. Carlos Roberto Costa M. Dedini S/A Metallurgica.
5.	SIDERBRAS - From 270 Thousand Tons/Year to 16 Million Tons/Year.	Presented by SIDERBRAS
6.	Sublance for LD Control Automation & Submerged Blowing in the LD Converter	by Iuti Tateyama, M. Dedimis, S/A Metalurgica.
7.	Planning Design, Engineering and Implantation of Steel Works	by Setepla Tecnometal Engenharia, S.A.
8.	Information on the Company and its Activities in the Steel-Making and Metallurgical and Mechanical Sector.	Setepla Technometal Engenheria, S.A.
9.	Comparative Evaluation of Newly Developed Technologies for Application in Mini-Steel Plants	by Eng. Sergio W.G. Scherer, UNIDO Consultant.
10.	Brazil Iron and Steel Industries: Evolution, Present Situation and Prospects	by Eng. Georges Leonardos/ABM.
11.	Iron and Steel in Angola - A Perspective.	by Kiami Matadidi Angolan National Steel Company.

12.	Main Problems of Algerian Iron & Steel Industry: Computer Aided Management System and Spare Parts Production in Arab Iron & Steel Industry.	by Dr. Lies Goumiri Algeria.
13.	Highlights of Iron and Steel Industry in Cameroon.	Extracts from the Country paper of the Republic of Cameroon.
14.	Mozambican Metallurgical Goals Reconsidered: Some Sources of Problems and their Perspectives.	by Dr. T.M. Senzani-Chicogo and Eng. F.T. Clancesse.
15.	Iron/Steel Industry of Nigeria.	by Eng. Tachia Tooti, Delta Steel Co.
17.	Iron/Steel Industry of Uganda.	by K.B. Tayebwa.
18.	Iron and Steel in Zaire.	by Ambassador Asal B. Idzumbuir.
19.	Iron and Steel in Zambia.	Zambian Country Paper.
20.	Iron and Steel in Zimbabwe.	Zimbabwean Delegation.