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UNITED NATIONS

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LARGE SCALE STEEL PLANT PROJECT PLANNING AND CONSTRUCTION: THE ORINOCO STEEL PLANT, VENEZUELA

by

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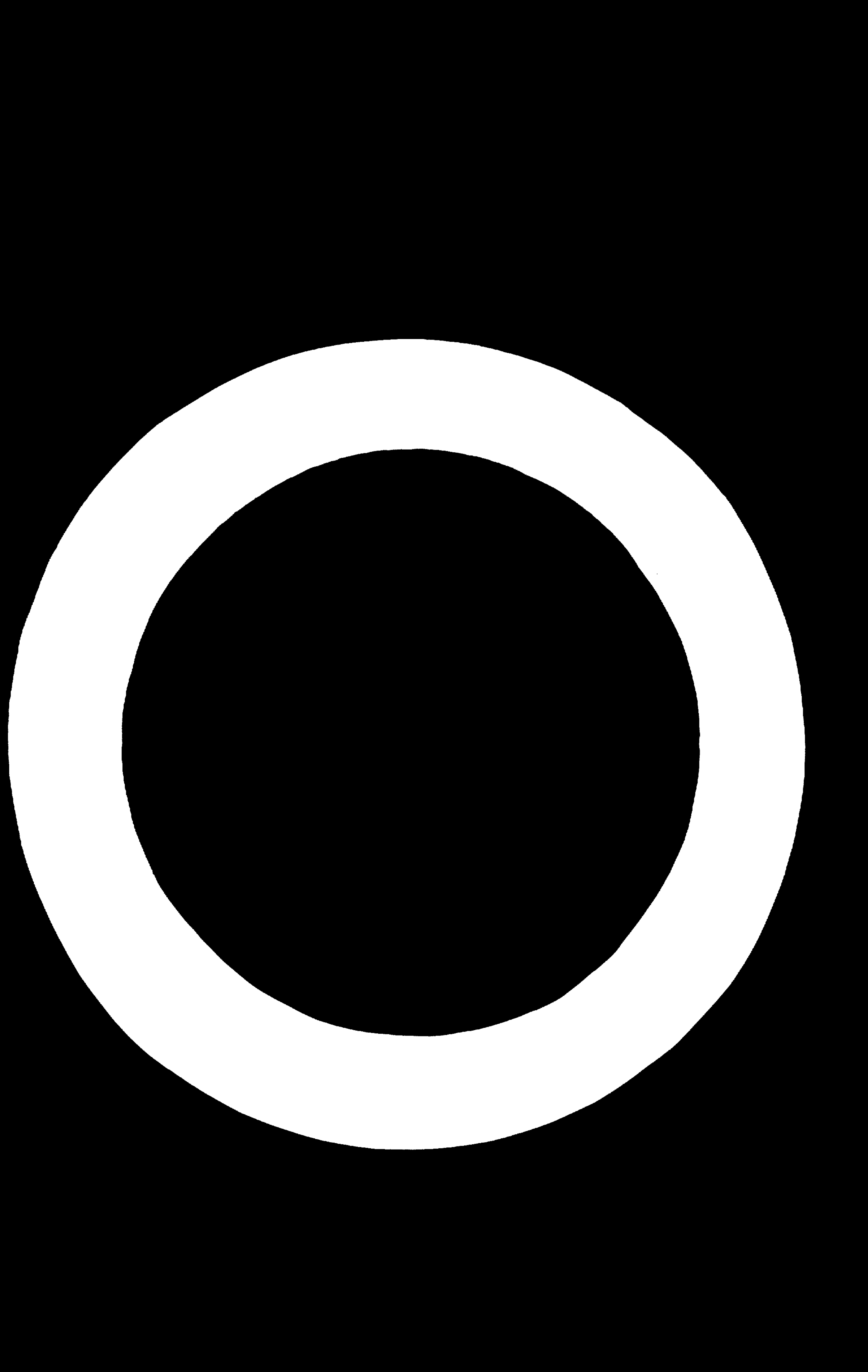
Innocenti, Milan, Italy



UNITED NATIONS ECONOMICS AND SOCIAL COUNCIL

Centre for Industrial Development

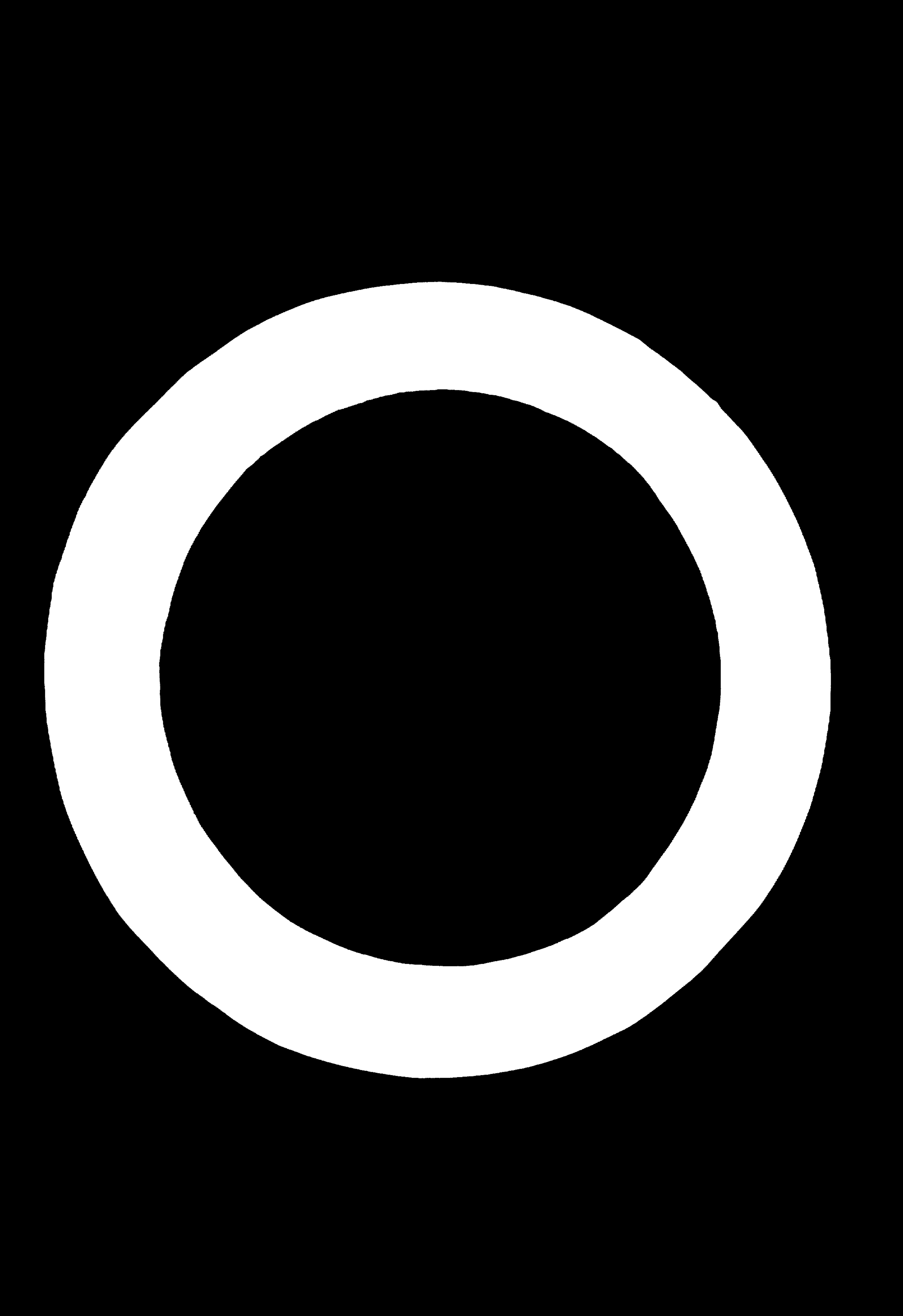
INTERREGIONAL SYMPOSIUM ON THE APPLICATION OF MODERN TECHNICAL PRACTICES IN THE IRON AND STEEL INDUSTRY TO DEVELOPING COUNTRIES

Prague - Czechoslovakia - November 11 to 16, 1963

Large Scale Steel Plant Project Planning and Construction

THE ORINOCO STEEL PLANT - VENEZUELA

Presented by Massimo Conni



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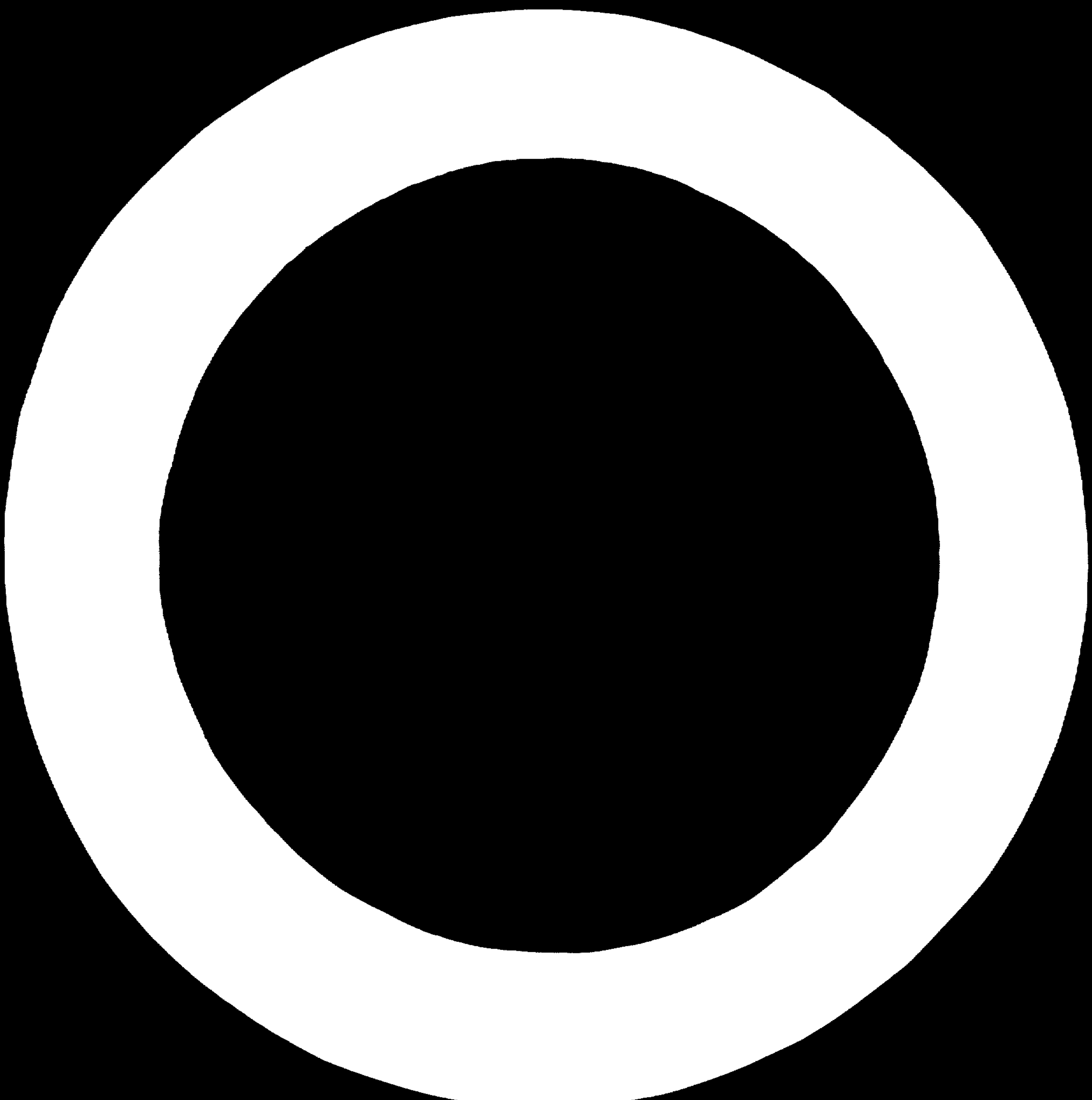


Large Scale Steel Plant Project Planning and Construction

THE ORINOCO STEEL PLANT

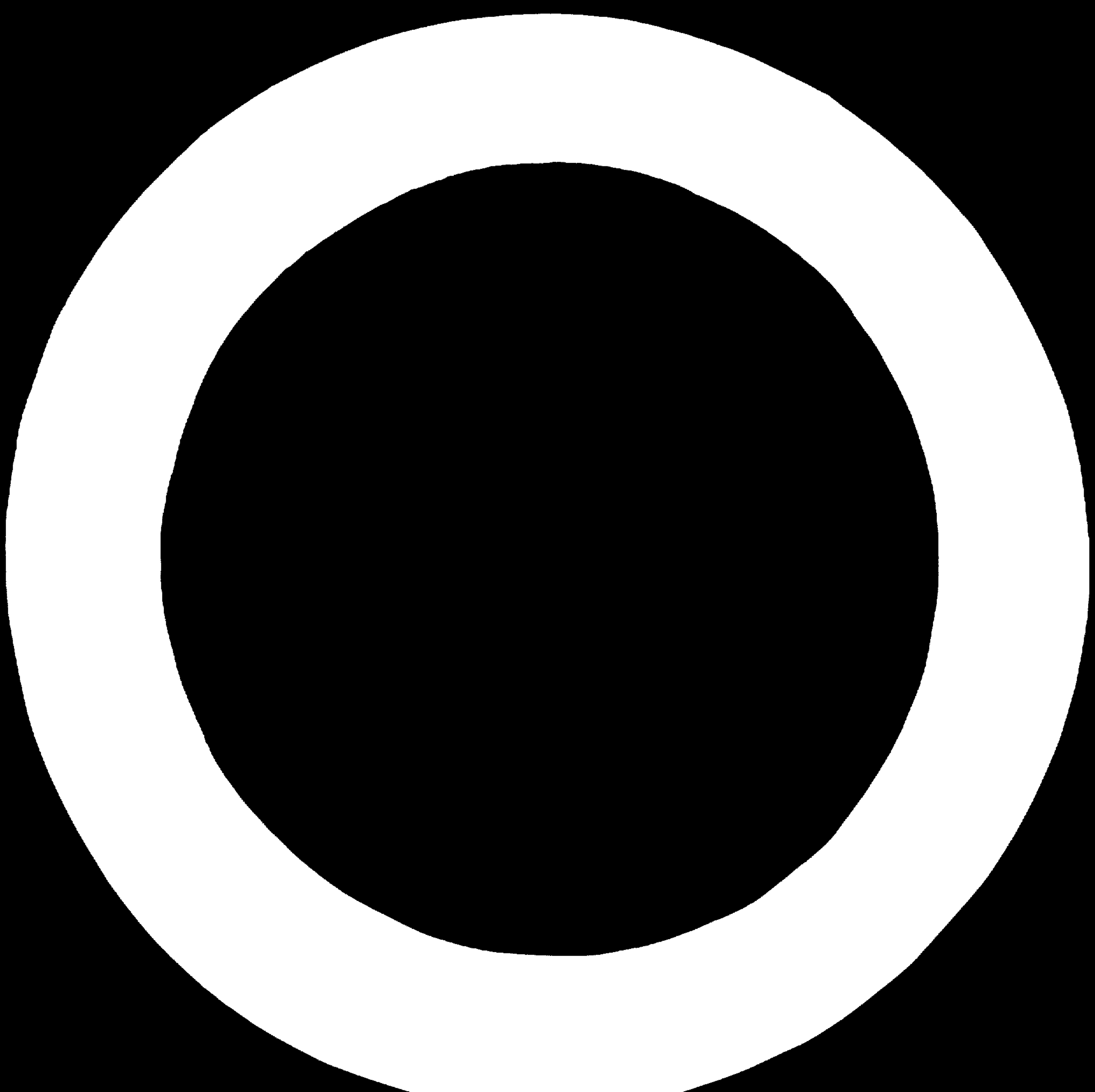
VENEZUELA

1. INTRODUCTION

The engineering and construction of an integrated steel plant is a matter which concerns all the technical fields. From the fundamental knowledge of the technological processes to the various engineering fields, such as civil engineering for the huge foundations and buildings work, mechanical engineering for the large equipment installed, electrical and electronic engineering for electric installations which are getting more and more complex, there is no field which is not covered. Therefore, the construction of a steel plant is the result of the effort of many Organizations and Companies, under a single general coordination.

The Venezuelan Plant is the result of the cooperation of many Organizations under the coordination of Innocenti Corporation of Milan (Italy) who has acted as General Contractor, and it is also a great example of international cooperation, because besides the Italian industries - which have supplied most of the materials - important American and European industries have joined in this project.

Though the technical problems are the most remarkable factors in such big undertakings, also other problems (such as those regarding the organization, transportation, personnel, etc.) deserve to be illustrated since they are closely connected with the final result. The Orinoco Steel Plant deserves then to be illustrated under all these aspects, so that the Venezuelan experience may be useful for other similar plants.



II. THE PLANT

I will begin by illustrating the Plant briefly, in order to give an idea of its size and to facilitate the understanding of the documentary film which is going to be featured here. However, I will restrict myself to the essential points, particularly because this Plant has already been extensively illustrated in the international technical press and a detailed description of it will be distributed here.

The Orinoco Steel Plant is an integrated plant; its productive cycle starts from the iron ore and ends with the finished products, but pig iron is produced with low shaft electric reduction furnaces instead of the conventional blast furnaces. This process has become feasible due to the following:

a. the abundance of hydro-electric power which is available at a low price (the electric furnace operation will consume about 1,600 million KWh/year, while the rest of the Plant operation will consume about 200 million),

b. the excellent quality of the ore (containing about 60% of Fe), which keeps the power consumption within acceptable limits (from 2,000 to 2,200 KWh/ton of hot metal);

c. the availability of the local coal which is not suitable to produce metallurgical coke but rather gas coke. (Since the studies and tests on this coal have not yet been completed by the Venezuelan Authorities, the coke oven battery has not been built and the Plant is now fed with coke imported from abroad).

1. Production Departments

The iron reduction plant consists of a battery of nine electric smelting furnaces of the Thisland-Hole type, each of 33,000 KVA. One single furnace can produce about 220 tons of iron per day. The furnaces are served by a Robins-Messiter system for stocking and reclaiming raw materials and also by a Dwight Lloyd type 100 m^2 sintering strand for ore fines which can produce over 3,000 tons of sinter per day.

Steel is produced in open hearth furnaces. The steel shop consists of four 250 ton, basic roof, fuel-oil fired furnaces with all its auxiliaries. The shop capacity is rated at 750,000 annual ingot tons.

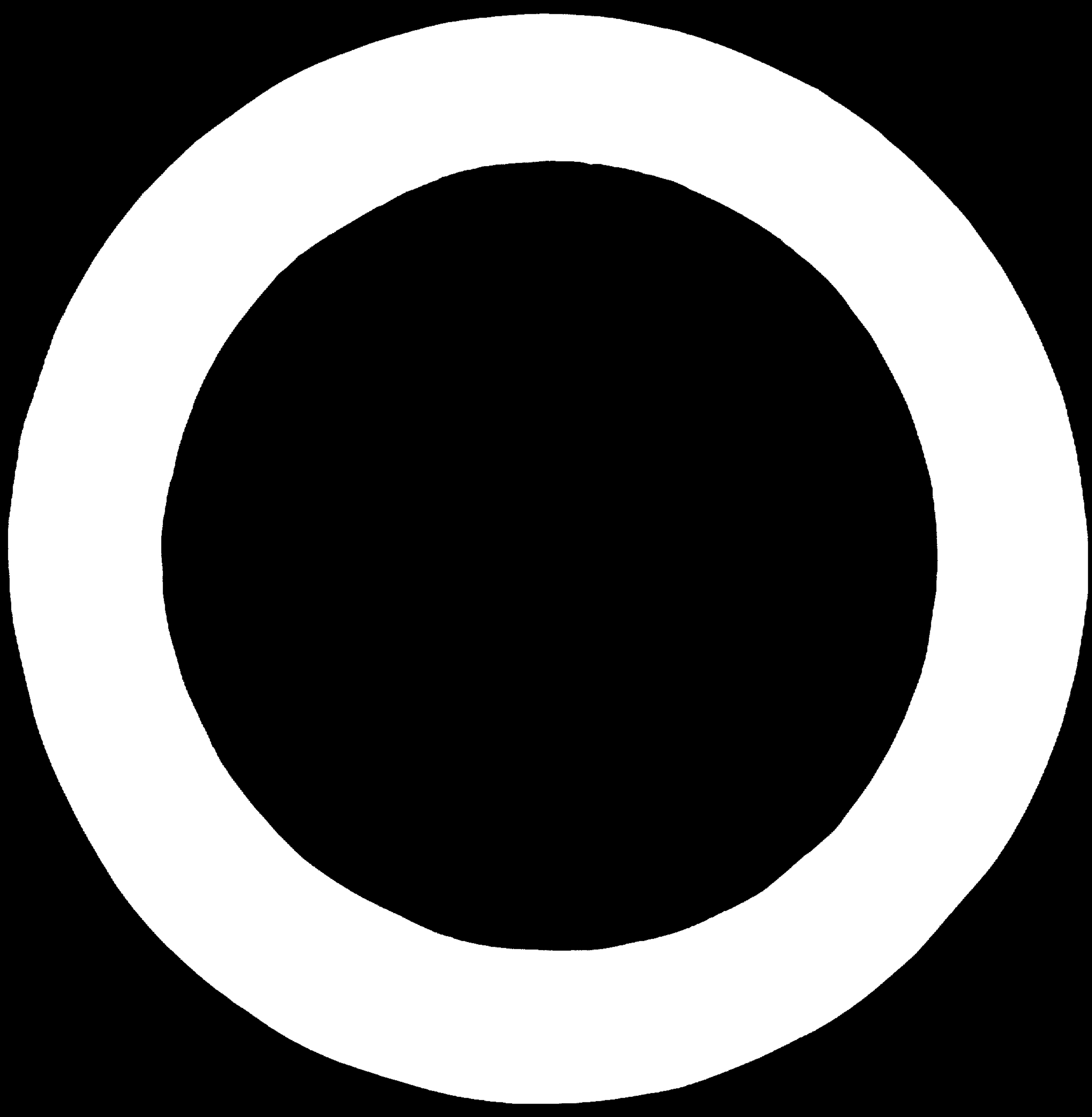
The rolling mills consist essentially of the following:

a. one blooming mill with 1,100 mm dia. rolls for blooms, billets and slabs. It is fed by a battery of eight soaking pits, each of 125 ton capacity,

b. one 800 mm two-high reversing mill with three stands for the production of billets, heavy sections and rails. The steel from the blooming mill is fed directly to this mill without reheating;

c. one 300 and one 500 mm mills for the production of reinforcing bars and miscellaneous sections. They are fed with billets produced on the 800 mm mill.

With these three mills (800, 500 and 300) it is possible to produce the whole range of sections;



d. one seamless pipe mill consisting of one large pilger mill, one medium pilger mill and one push-bench, with a total capacity of 295,000 tons/year of seamless pipes most of which will be used by the oil industry. With these three units it is possible to cover all pipes ranging from 1/2" to 16".

The production departments also include:

a. a wire drawing and wire products plant, fed with wire-rod produced at the 300 mm mill. This plant has a capacity of about 27,000 tons/year of barbed, galvanized and black annealed wire;

b. an iron foundry, designed to produce 20,000 tons/year of ingot moulds and stools for the melt shop requirements as well as 30,000 tons/year of cast iron spun pipes and miscellaneous castings.

2. Auxiliary Services

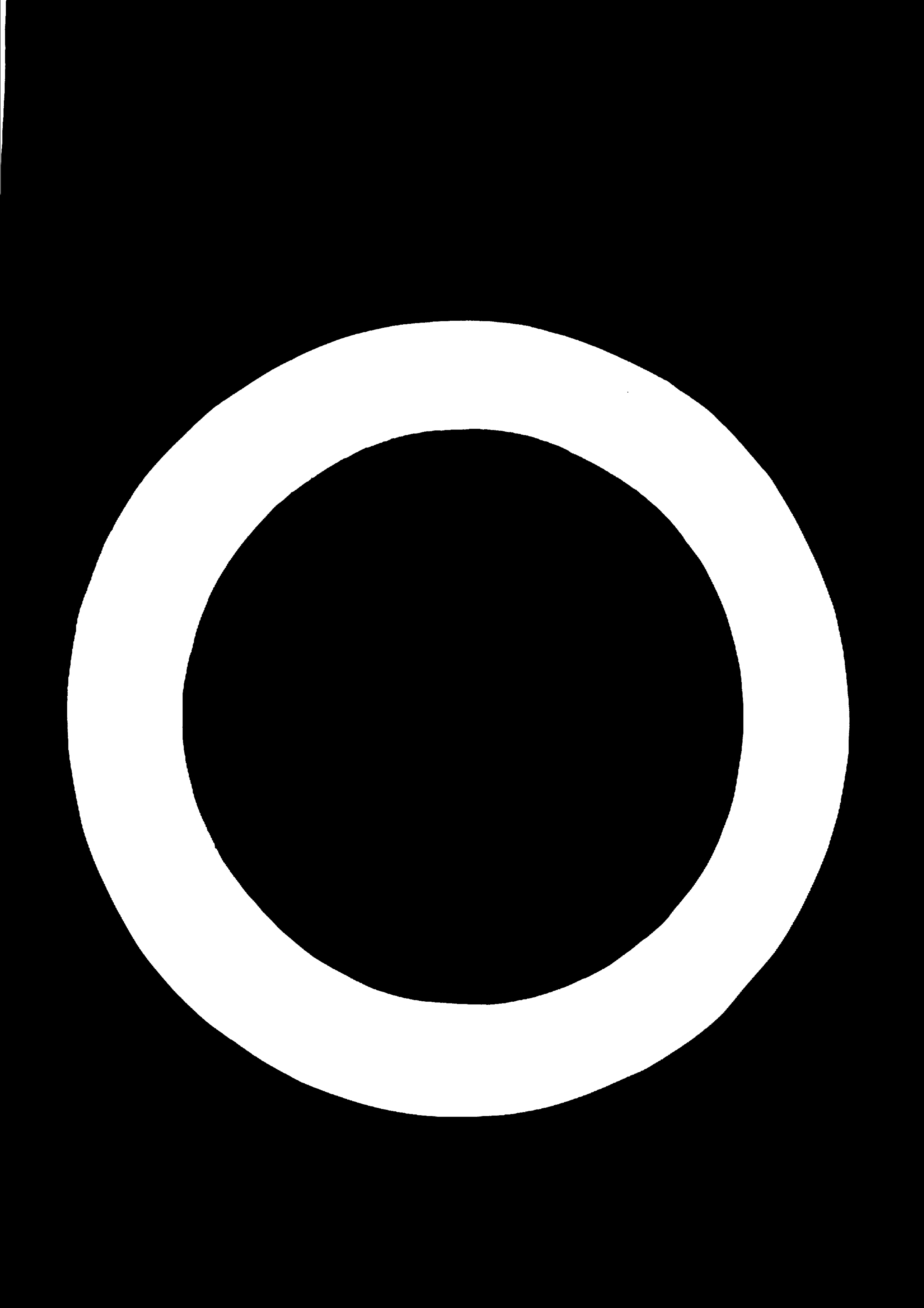
The cooling water requirement for the various facilities amounts to about 18,000 to 20,000 m^3/hour. A large water intake structure and pumping station has been built on the Orinoco River. It is equipped with a system of sluice gates, grids and filters, and with a set of submerged pumps. Water flows to the Plant through large pressure lines. The various departments are fed by a ring distribution system which includes an elevated water tank of 3,500 m^3 capacity.

The electric power reaches two transforming substations built at two opposite ends of the Plant. One of them - consisting of five 55,000 KVA transformers, each at 115/22 KV - feeds the electric pig iron furnaces; the other substation with two 40,000 KVA transformers each at 115/13.8 KV, feeds all the other facilities of the Plant. A steam-electric generator plant with two turbine-boiler units, each at 8,000 KVA, ensures the power supply for the essential services in case of emergency.

The maintenance shop is equipped with a large number of machine-tools which normally are not found in similar steel plants. This has been provided on account of the Plant location which is far from industrial centers, so that as many repairs as possible can be made with its own means.

A central laboratory for chemical and physical tests is part of the facilities.

The foundations and the buildings are worth mentioning. Considering the nature of the soil, all the foundations have been built on piles; putting them one after the other they would measure about 120 Km (75 miles). The departmental buildings are all made up of steel structures: tubular structures are used for the light buildings (pipe mill, wire plant, foundry and warehouses) whereas normal structures with solid webs are used for the heavy buildings (electric furnaces, steel shop, rolling mills). The roofing consists of bright aluminum sheeting; considering that the Plant is located in a tropical region, this type of roofing provides comfortable indoor conditions due to its high reflecting property.



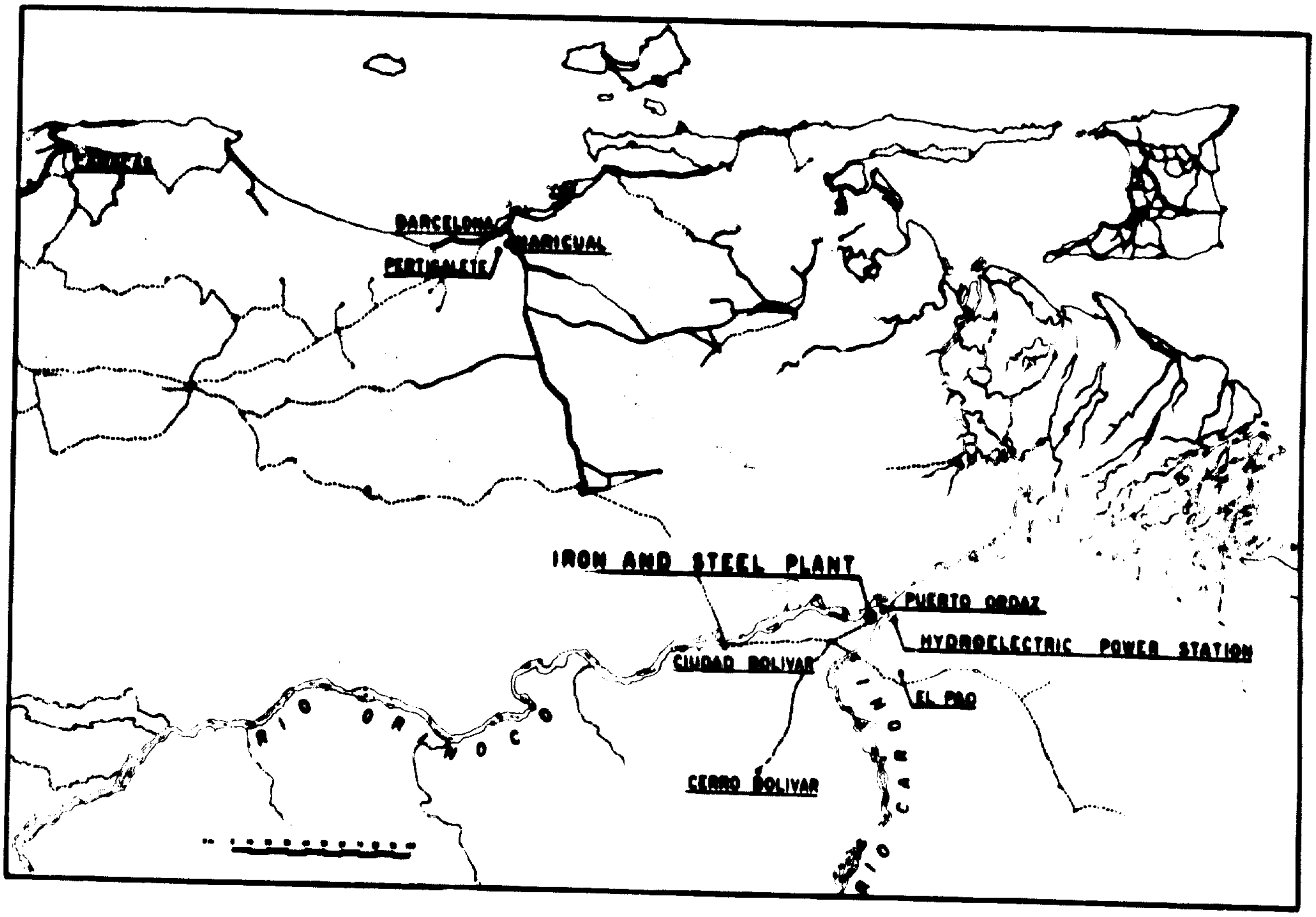


Fig. 1 – MAP OF VENEZUELA

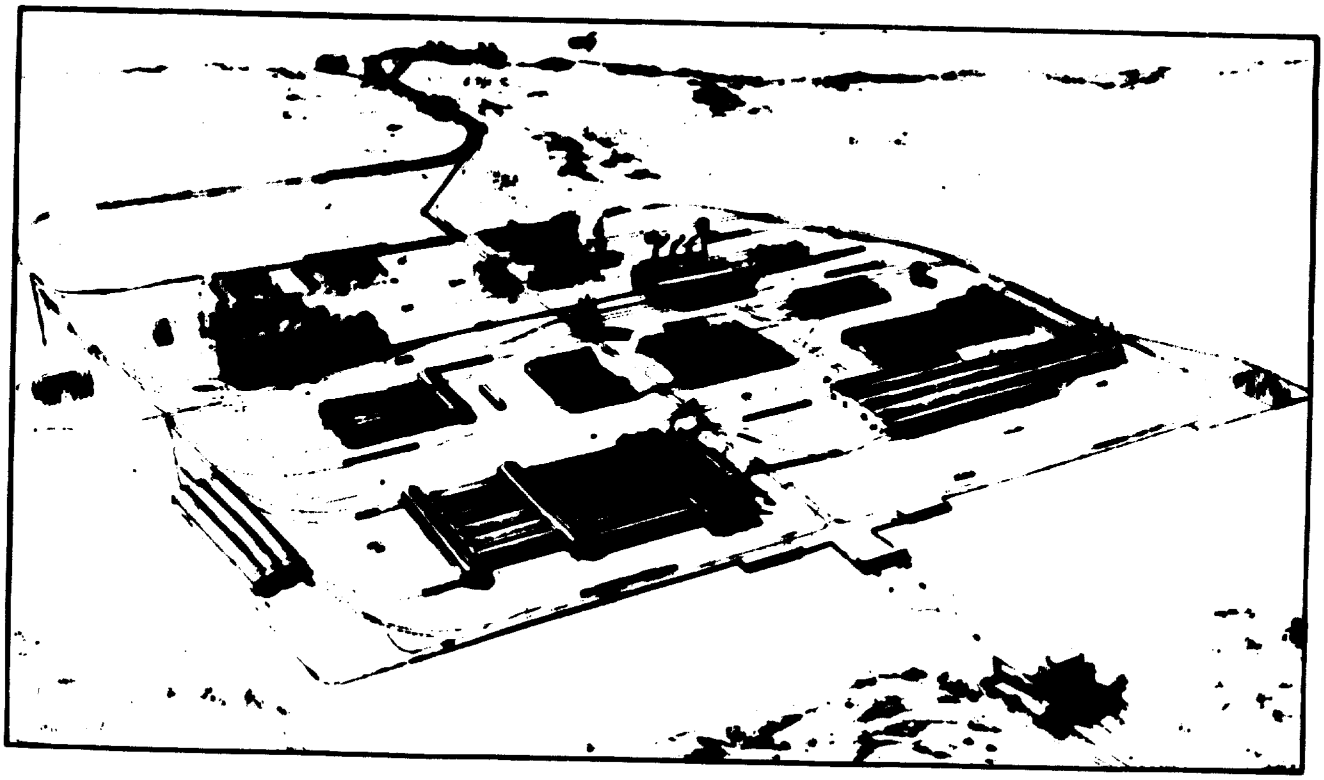


Fig. 2 – PERSPECTIVE VIEW OF THE WORKS

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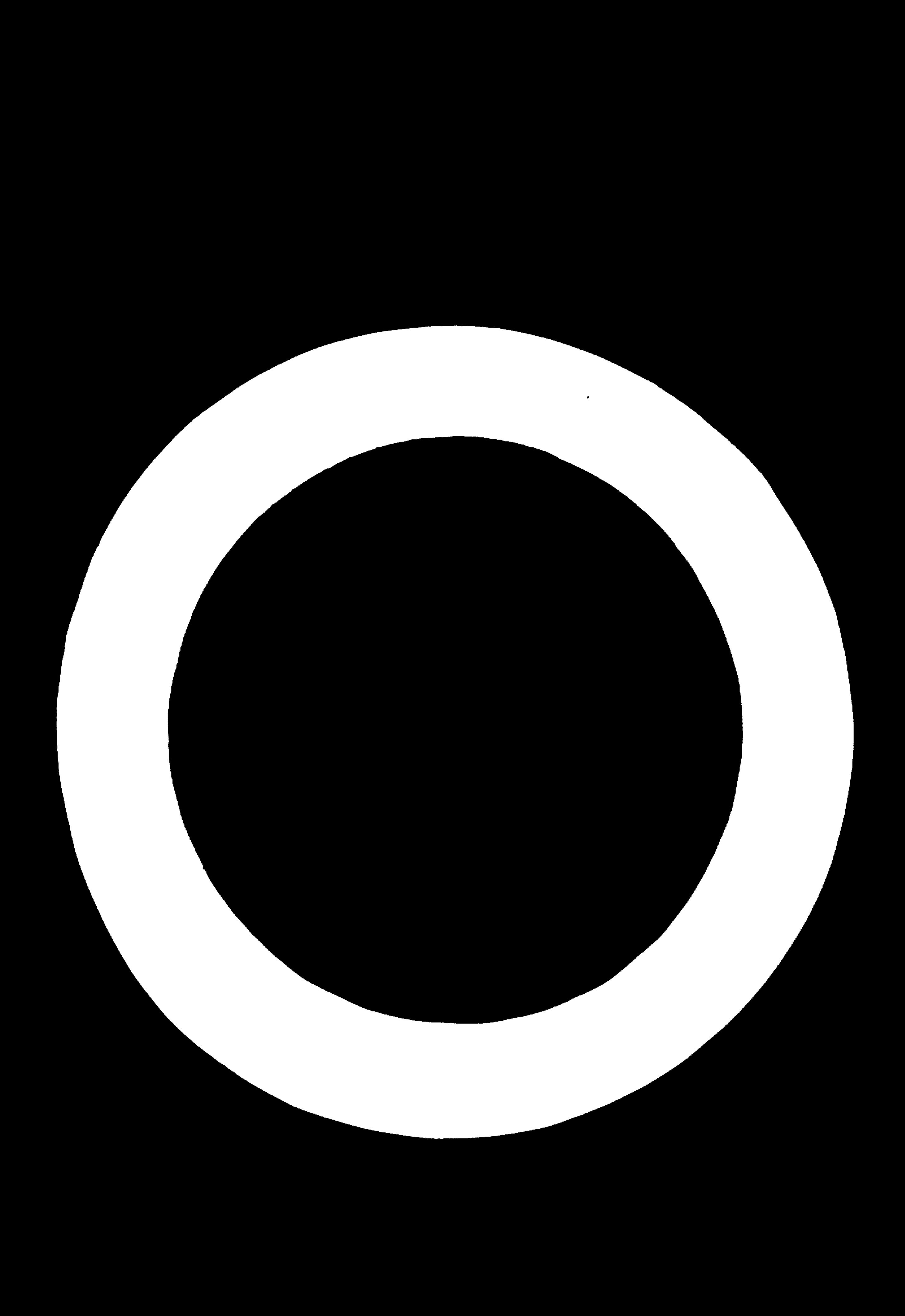


3. Location of the Plant (Fig. n° 1)

The Plant is built on the right bank of the Orinoco river about 250 Km (156 miles) from the sea and 500 air Km (310 air miles) from Caracas. Several factors have led to the selection of this site, such as: the proximity to Puerto Ordaz (the shipping point for the Cerro Bolivar ore located on the river about 12 Km (7 miles) downstream); the navigability of the Orinoco river which permits the arrival of raw materials and the shipment of finished products by water; the proximity to the large Caroni water power plant; and finally the industrialization program of this area. The ore is transported up river from Puerto Ordaz on barges, limestone and other raw materials, also water borne, arrive from other regions of Venezuela coal comes on ocean going ships.

4. The Layout (Fig. n° 3)

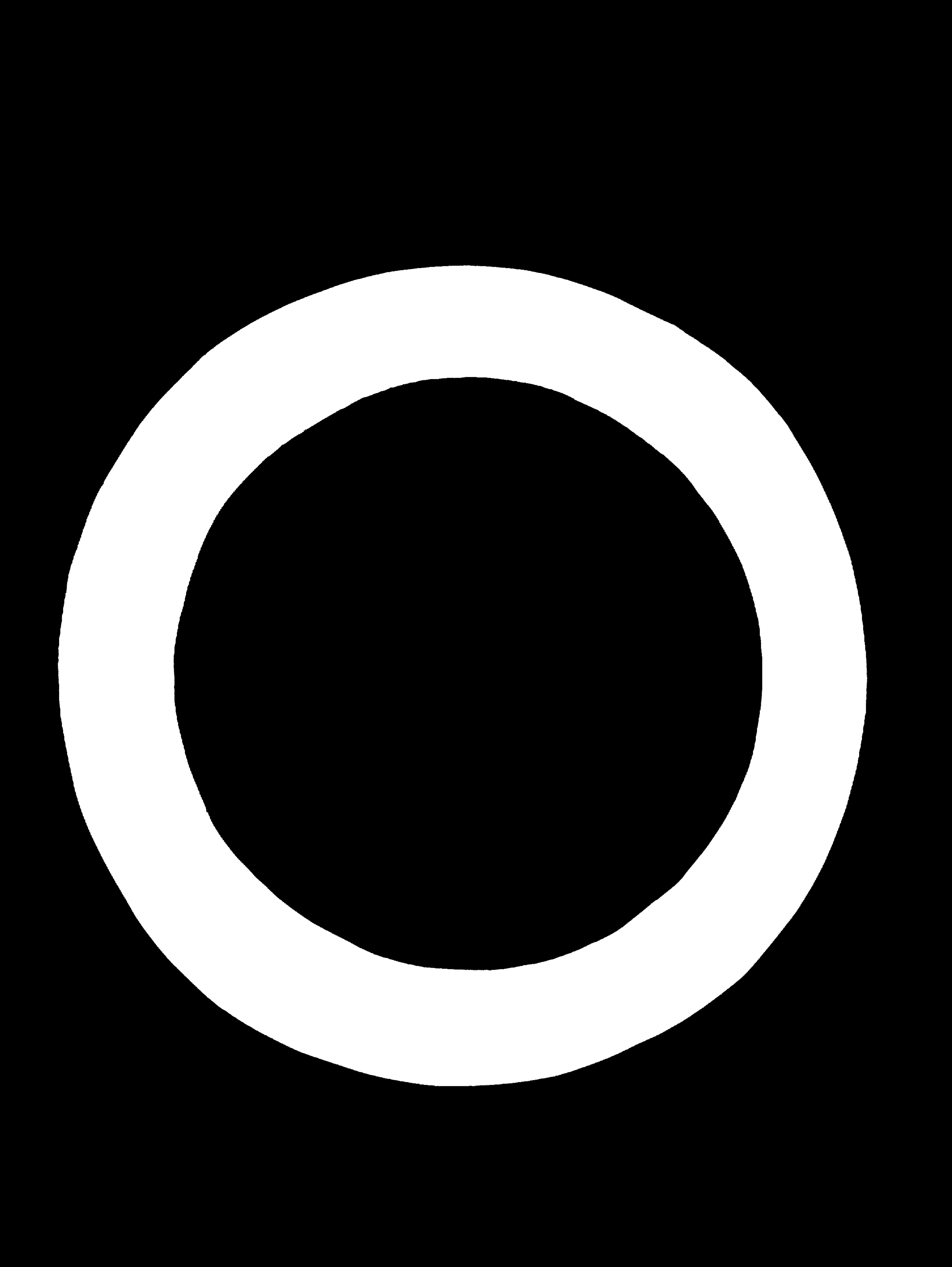
The Plant covers a total area of 2 Km^2. It has a railway system of about 50 Km (31 miles) and a road system of 25 Km (15 miles). All the raw materials are unloaded at a large pier on the Orinoco river and moved to the storage yards by belt conveyors.

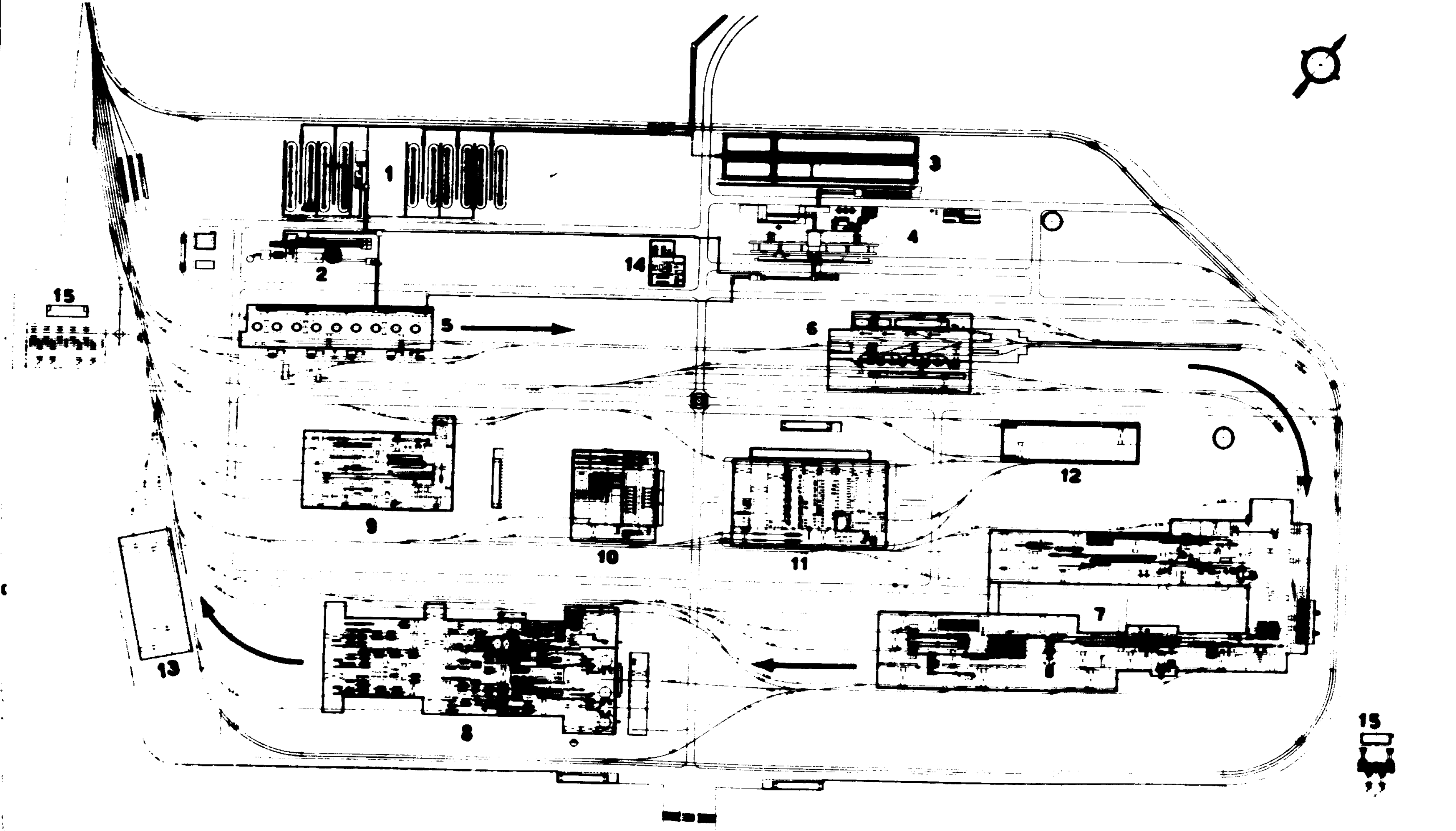
As it can be seen from the plan, on the first alignment there are the ore, limestone and coal yards and on the second alignment there are the sinter and coke plants. The electric furnaces, the steel shop, the rolling mills and the pipe mill are arranged in a "U" shaped pattern. Ore, sinter, limestone and coke are transported by means of conveyors to the pig iron plant. The handling of materials (from pig iron to ingots, rolled sections and pipes) always takes place in only one direction, with no retrocessions. The spare parts warehouse, the maintenance shop, the wire plant, and the foundry are arranged inside the "U" where no future expansions of the production departments are anticipated. The finished product warehouse is placed far from the circuit of the Plant.

III. FUNDAMENTAL DESIGN CRITERIA

From the beginning of the design of a steel plant the possibility of future expansions must be considered. The layout of the plant must then be planned to enable the inclusion of new operating facilities in the production cycle and to permit the expansion of those already installed. The fundamental equipment and some installations must be designed from the beginning for the future capacity of the plant. This involves some initial expenses larger than those which would be strictly necessary, but enables the future expansion of the plant with the least trouble and without interruption of the production.

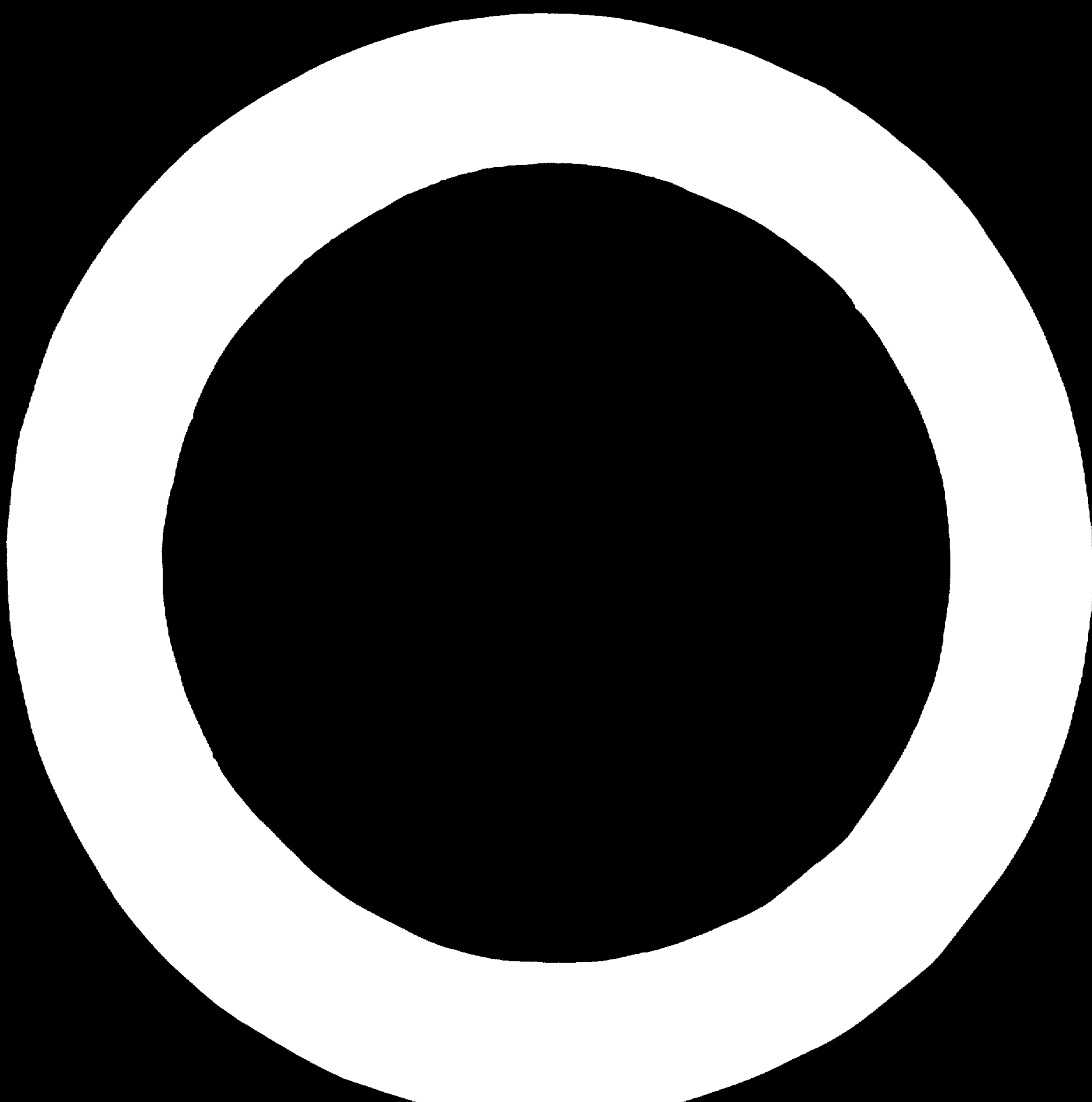
For instance, the layout of the Venezuelan Plant - which in its present stage has a capacity of 750,000 tons/year - has been designed to bring its capacity up to 1,500,000 tons/year. According to this layout the increase in hot metal capacity can be reached with either more electric furnaces or blast furnaces. The space available permits the extension of the ore yards and the installation of a second sinter plant as well as coke oven batteries. The increase in steel production can be obtained by installing a new oxygen steel shop. Rolling facilities for flat products can be easily included in the cycle. The increase of the utilities, such as the water intake structure, the sewer system, the electrical and hydraulic facilities, has already partially been achieved and can be easily completed in the future.





1 IRON ORE AND LIMESTONE YARD
2 SINTERING PLANT
3 COAL YARD
4 COKE OVENS
5 PIG IRON ELECTRIC FURNACES
6 OPEN HEARTH
7 ROLLING MILLS
8 PIPE AND TUBE MILL
9 FOUNDRY
10 WIRE DRAWING PLANT
11 MAINTENANCE SHOP
12 MAIN WAREHOUSE
13 FINISHED PRODUCTS WAREHOUSE
14 THERMOELECTRIC POWER PLANT
15 ELECTRICAL SUBSTATIONS

Fig. 3 - GENERAL ARRANGEMENT OF THE WORKS



As a general rule, it will never be possible to give sufficient attention to the future expansion. However, some general rules can be given, viz:

- to place the service units, such as power plants, sub-stations, maintenance shops, warehouses, etc., out of the production cycle,

- to leave large spaces between each production department,

- to bear constantly in mind that technological improvements advance rapidly and often beyond the forecasts that can be made today.

IV. ORGANIZATION

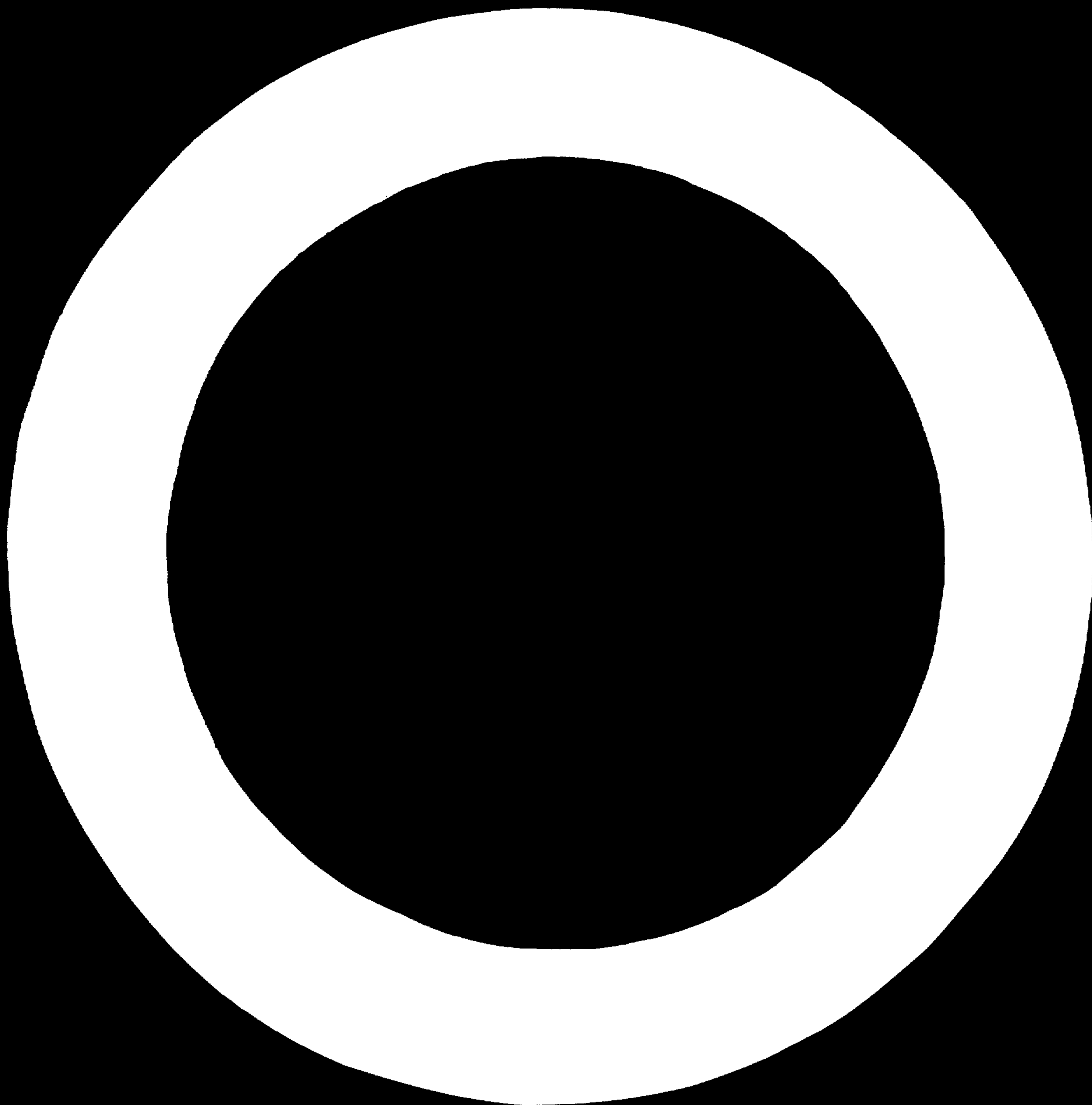
While the construction design was being developed in the Milan Offices of Innocenti Corporation and orders for the materials and equipment were being placed, a special Field Management in Venezuela supervised the execution of the civil engineering work and erection. Considering that this area is nearly deserted, provisions had to be taken for living quarters for the management personnel and all the employees, and also for the construction of the offices. The lodgings for the personnel of the Sub-Contractors were built near the above mentioned quarters and in a short time a village of pioneers arose in the middle of the savannah. The essential facilities for the personnel (restaurants, laundry, sanitary facilities, bar and recreative facilities) had to be organized in a short time. During the construction of the Plant the actual number of people working on the spot ranged between 2,500 to 3,000 men.

The problem concerning the transportation of the required materials and equipment is always of fundamental importance. For the case in point, the location of the Plant along a navigable river has greatly simplified this problem, since all the materials were unloaded in the near vicinity of the Plant. Just to quote a figure, it is worth saying that the construction of the Plant has required the transportation of over 350,000 tons of materials and about 180 ships have been used to this purpose.

V. THE START-UP AND OPERATION

The construction began in the last half of 1957. In July 1961 the pipe mill was regularly operating using purchased billets and blooms. In November 1961 the first electric reduction furnace was put into operation giving the first Venezuelan hot metal produced with Venezuelan ore. However, it was in July 1962, with the placing into operation of the first open hearth and of the blooming mill, that the production cycle, from ore to finished products, was completed. After one year's operation the Plant has already reached a production level of about 350,000 tons/year, approximately half of its final capacity.

American personnel of Koppers Company - who has been entrusted with the assistance in the operation of the Plant - Italian warranty inspectors of Innocenty, and erectors of the various Firms which have supplied the equipment, represent the backbone of the operating personnel working closely together with the Venezuelan personnel.



VI. GENERAL REMARKS ON THE ENGINEERING AND CONSTRUCTION OF A STEEL PLANT IN DEVELOPING COUNTRIES

The Venezuelan undertaking has furnished much experience on the problems that must be faced and solved in the construction of a steel plant.

1. Preliminary survey and leadership of the design

In industrial Countries a Company that is willing to build a new plant has its own management personnel already available, who, besides the preliminary technical-economical survey, can also be entrusted with the leadership of the design. Threfore the cooperation of Consultants and Engineering Companies is limited in general to specific fields even if these are of great importance.

On the other hand, the Countries that are now beginning their industrial activity generally have no management personnel. Therefore they must apply to Consultants and Companies of Engineers and Constructors that take upon themselves the liability of all the work required to complete the plant, which consists of general coordination, engineering, construction and direction management, and start-up of operations.

These are the two aspects, which can be regarded as extending from one extreme to the other.

International Organizations, such as the World Bank, the I. L. O. (International Labor Organization), the United Nations, along with their experts are very helpful for this type of undertaking. The objectivity and the authority of the advice that they may give, the experience they have already acquired in other Countries represent an excellent guide to start an industrial concern. The Countries which are developing would then act very wisely if they availed themselves of the technical assistance that these Organisations can put at their disposal.

2. Procedures for the Execution of the Construction

Two fundamental aspects may be taken into consideration:

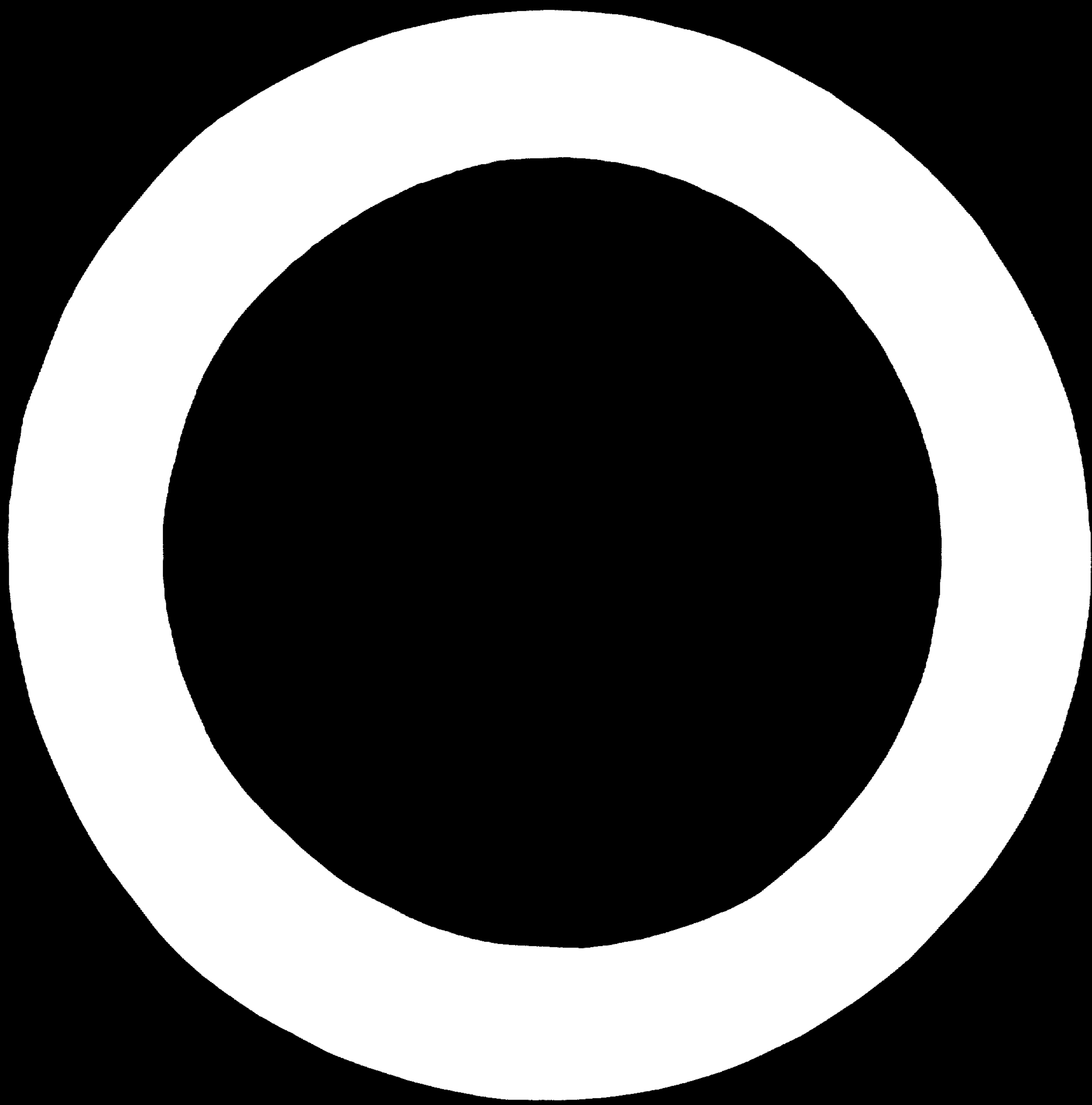
a. the "turn-key job" according to which the General Contractor binds himself for a definite amount to hand a completely erected and operating plant over to the Client;

b. the "cost + fee" according to which the General Contractor undertakes some specific engagement for a definite fee (design, management of the construction, coordination, etc.), while all the costs are supported by the Client.

Intermediate solutions - such as for instance the exclusion from the stipulated lump sum price of the civil engineering work, of erection and transportation - can also find advantageous application.

3. Construction Schedules

It is not possible to build a steel plant in a developing Country in the same time that would be required to build it in industrial Countries. More difficulties in transportation and erection, the distance of the field from industrial centers and from the General Contractor's office, the difficulties in lodging the personnel (that is why it is impossible to plan a concentration of a large number of men dur



ing a short period of time), all these are handicaps that bring about delays in the completion of the work.

A steel plant built in developing Countries involves an extra cost for interests to be paid on capitals. Considering the extremely heavy financial charges involved by such undertakings (the cost of the Venezuelan Plant amounts to about 350 million dollars), it is necessary to attach the greatest importance to the strict observance of the construction schedules.

4. Sub-Contractors

Most of the construction and erection works are in general entrusted to Sub-Contractors. The careful selection of them is of fundamental importance. No firm rules can be given, but in general the smaller is their number and the more equipped they are, the better. At any rate, they must be rigidly coordinated by the General Contractor.

To meet the lack or insufficiency of local mechanical shops, the General Contractor, and in any case the various Sub-Contractors, should be equipped with sufficient technical equipment to provide for all needs, either for erection or for unavoidable repairs and adjustments. A field maintenance shop must then be installed at the start of the construction. (A field maintenance shop adequate for the erection requirements, a plant for the production of oxygen in cylinders and other similar facilities were installed at the beginning in Venezuela).

The Sub-Contractors shall then use, for obvious reasons, the largest possible number of local labour. (in Venezuela the law prescribed 75%). Their management personnel shall therefore be in a position to guide the inexperienced personnel.

5. Roads, Warehouses, Lodgings

A part of the road system envisaged for the plant must be constructed from the beginning in order to facilitate the local transportation of materials. The plant warehouses are one of the first things to be built: they must be complete of all their loading and unloading facilities in order to shelter delicate equipment which cannot be immediately installed. (In Venezuela the first two buildings erected were the general warehouse and the finished products warehouse which were extensively used for storing materials and equipment).

If proper and suitable living quarters for foreign and local personnel cannot be found on the spot, they must be built from the beginning of the construction. The utmost care and attention must be paid to them, because they must last for years and it is necessary that all the lodgings be adequate and comfortable.

6. Operating Personnel

The Company owner of the plant has at once to face the problem of training its own personnel, from staff to labour. The importance of the technical preparation of the personnel at all levels is fundamental for the succes of the undertaking. After a careful selection the Company shall send abroad for one or two years all the personnel to be appointed to responsible positions. This will serve to form not only qualified technicians, but also a body of men closely linked together by moral solidarity and habit of working in teams with discipline.

While the operating personnel, such as rolling mill operators, foundrymen, crane operators, etc., can be formed in a relatively short time (the Venezuelan workmen after a reasonable time gave successful results in these jobs), to form electricians, millwrights, pipefitters, in one word the maintenance personnel, much more time is required. (In Venezuela, at present, most of these jobs are still filled with foreign personnel).

As a general rule, it is advisable to entrust the start-up and the operation of the plant to a Company which can supply a suitable organization to face all the problems dealing with the operation (production, business, organizational problems). The local organization which is coming into existence shall be placed at the side of the above mentioned Company, so as to be able to take the command in the shortest possible time, which in general can be estimated at not less than four to five years.

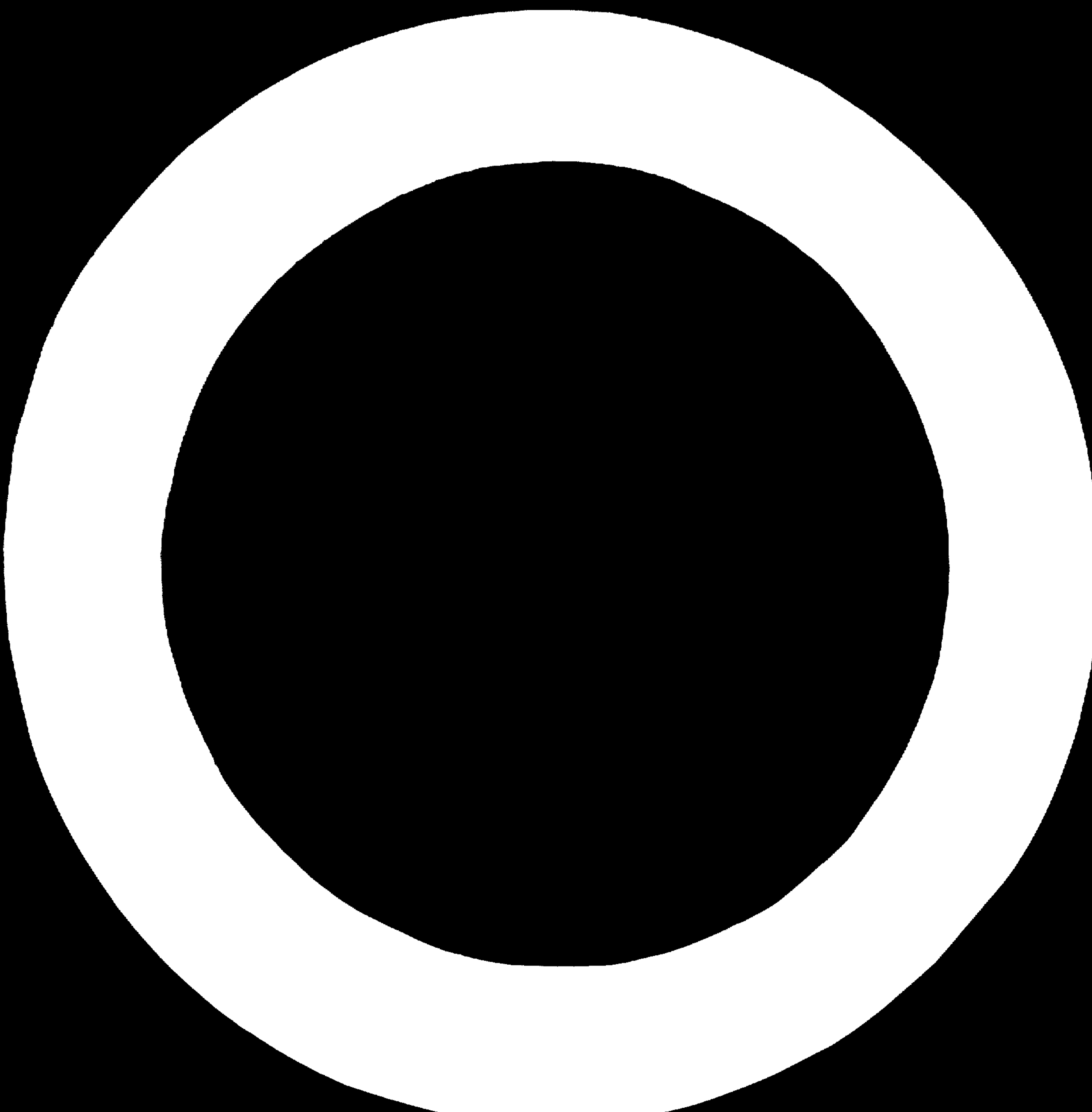
VII. CONCLUSION

In spite of the huge technical, organizational and financial problems that must be solved, the construction of an integrated steel plant is only the first step of an industrial undertaking. To make a comparison, it is not sufficient that the shipyard builds an excellent ship: a crew is needed to steer her across the oceans, and also a Company to manage this industrial concern. The assistance of consultants, designers and constructors comes to an end one day and the men of the Nation which is willing to become an industrialized Country, must be able to go ahead alone by their own means.

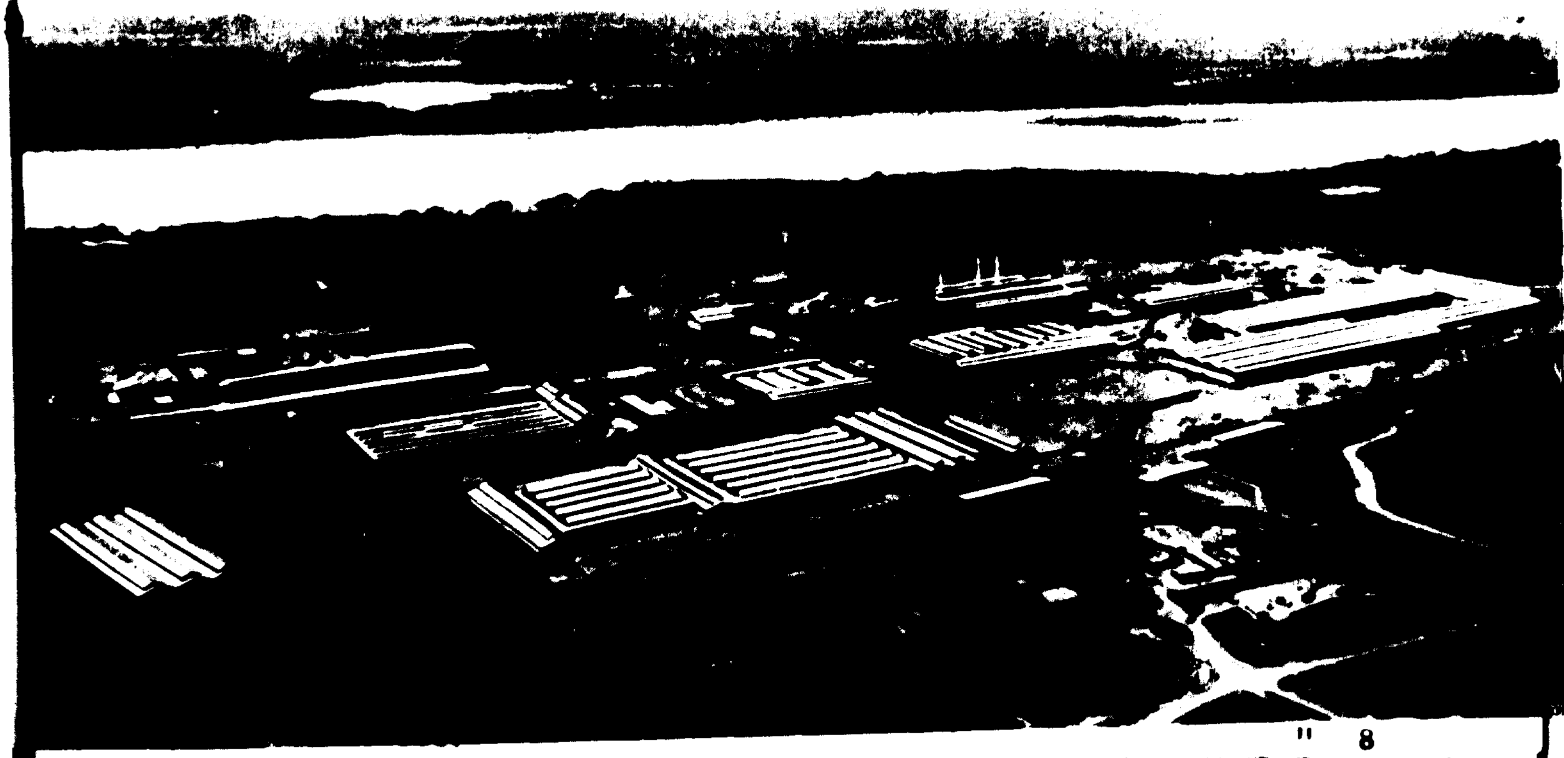
The efforts made for the training of qualified men will never be sufficient: in this case too, like in every undertaking, the human factors is decisive.

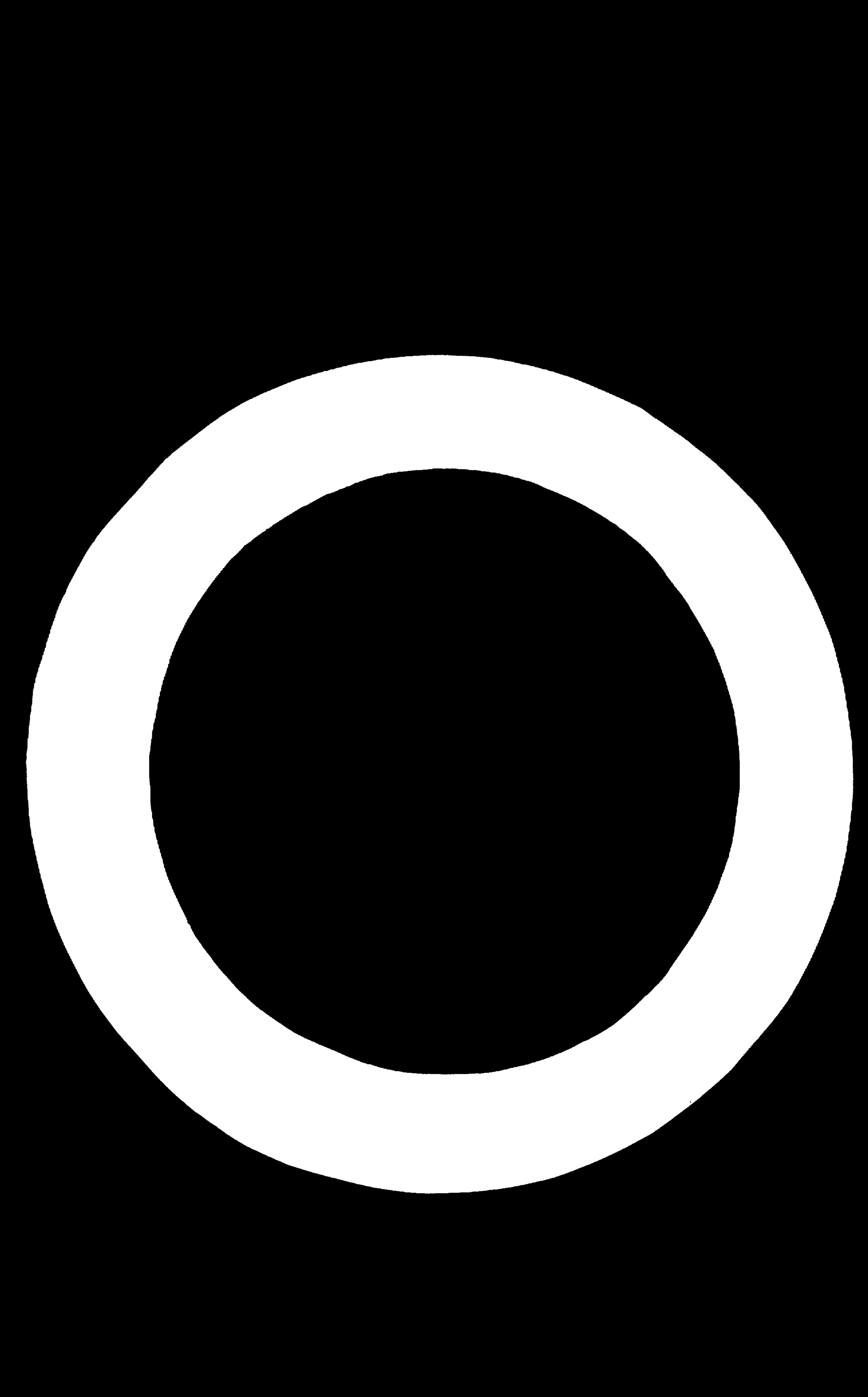
Enclosed: "The Venezuelan Steel Works", reprint from "Iron and Steel Engineer", May 1959

September 1963



PANORAMIC VIEWS FROM NORTH AND SOUTH OF THE "PLANTA SIDERURGICA DEL ORINOCO"





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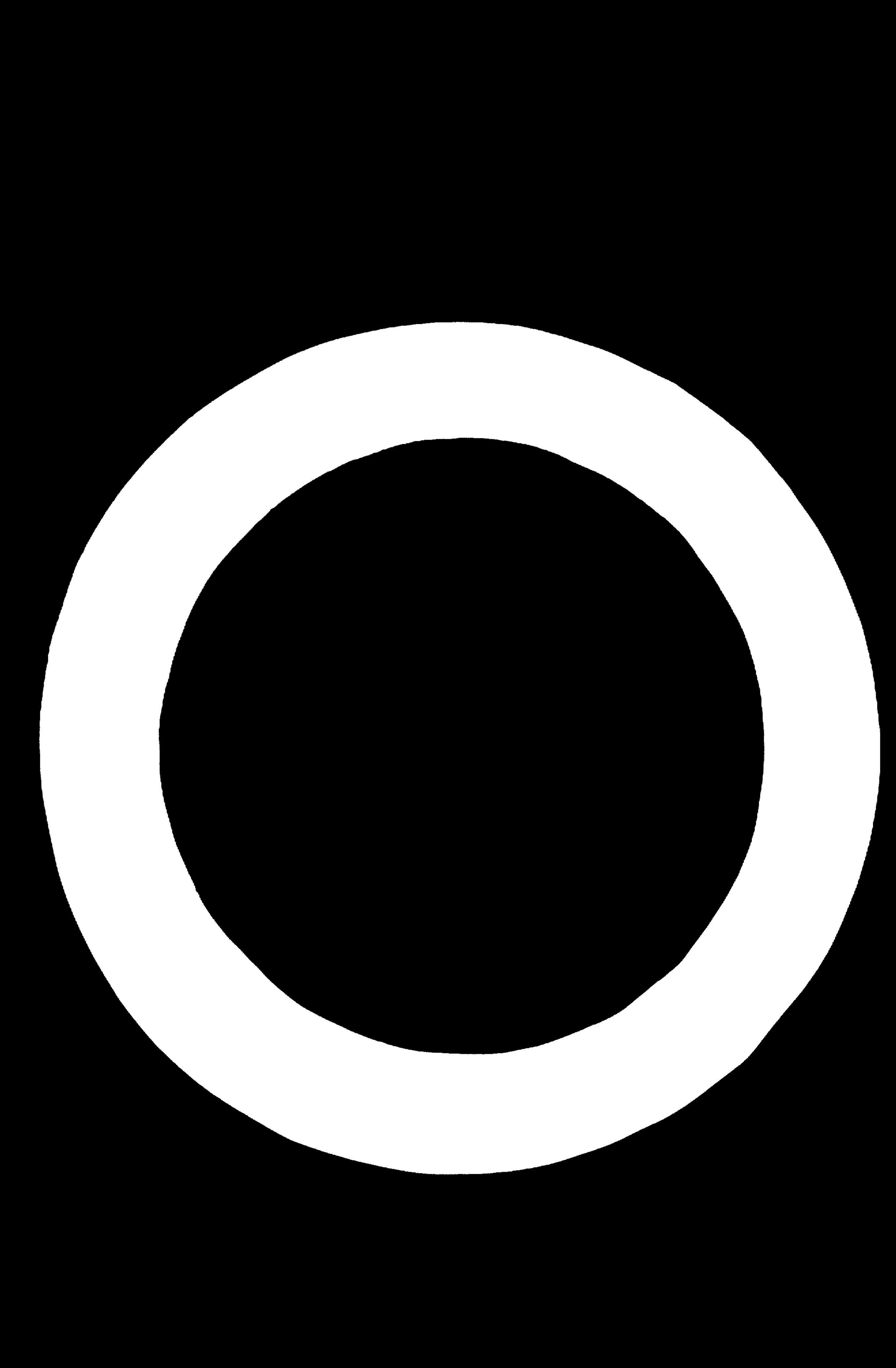
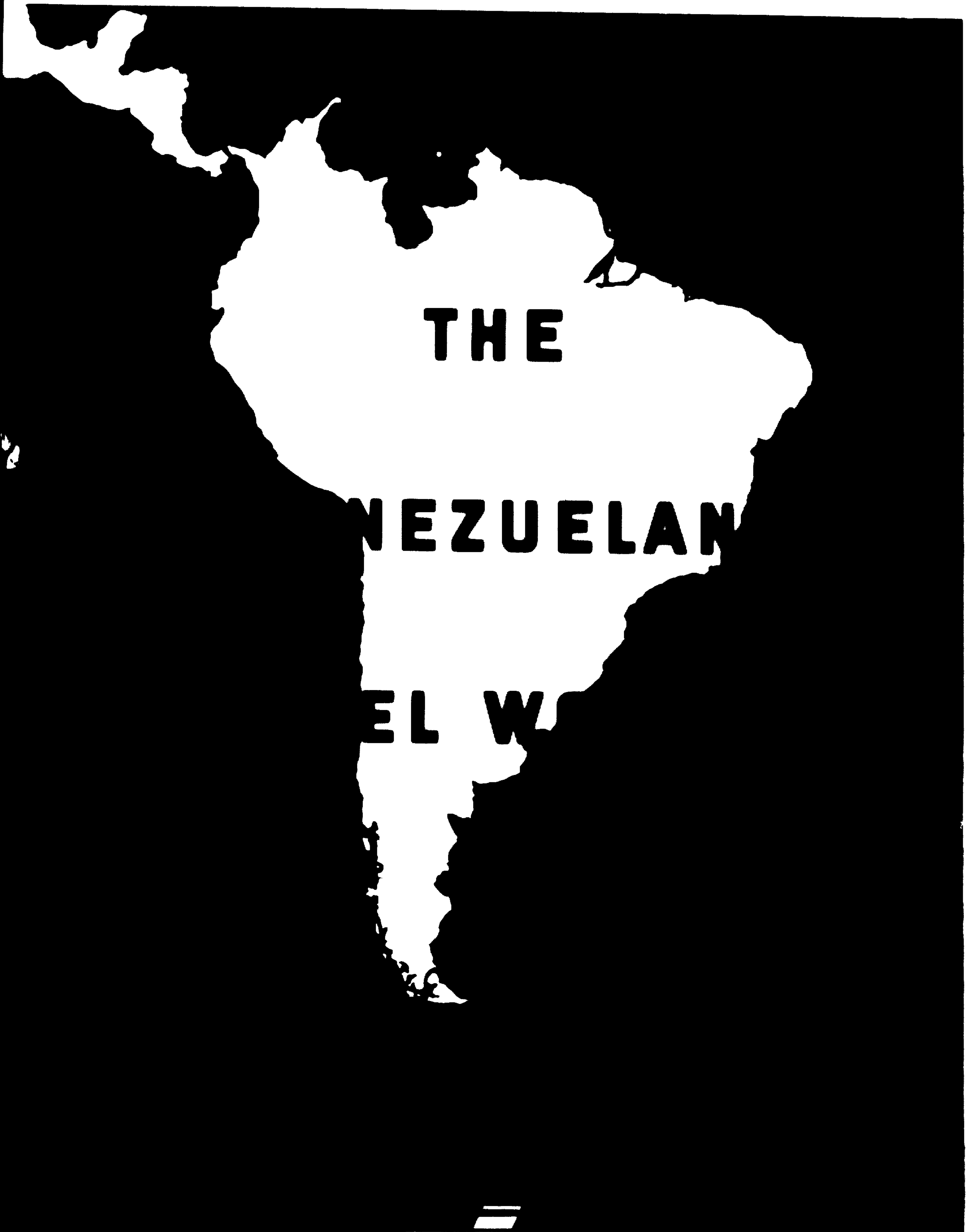
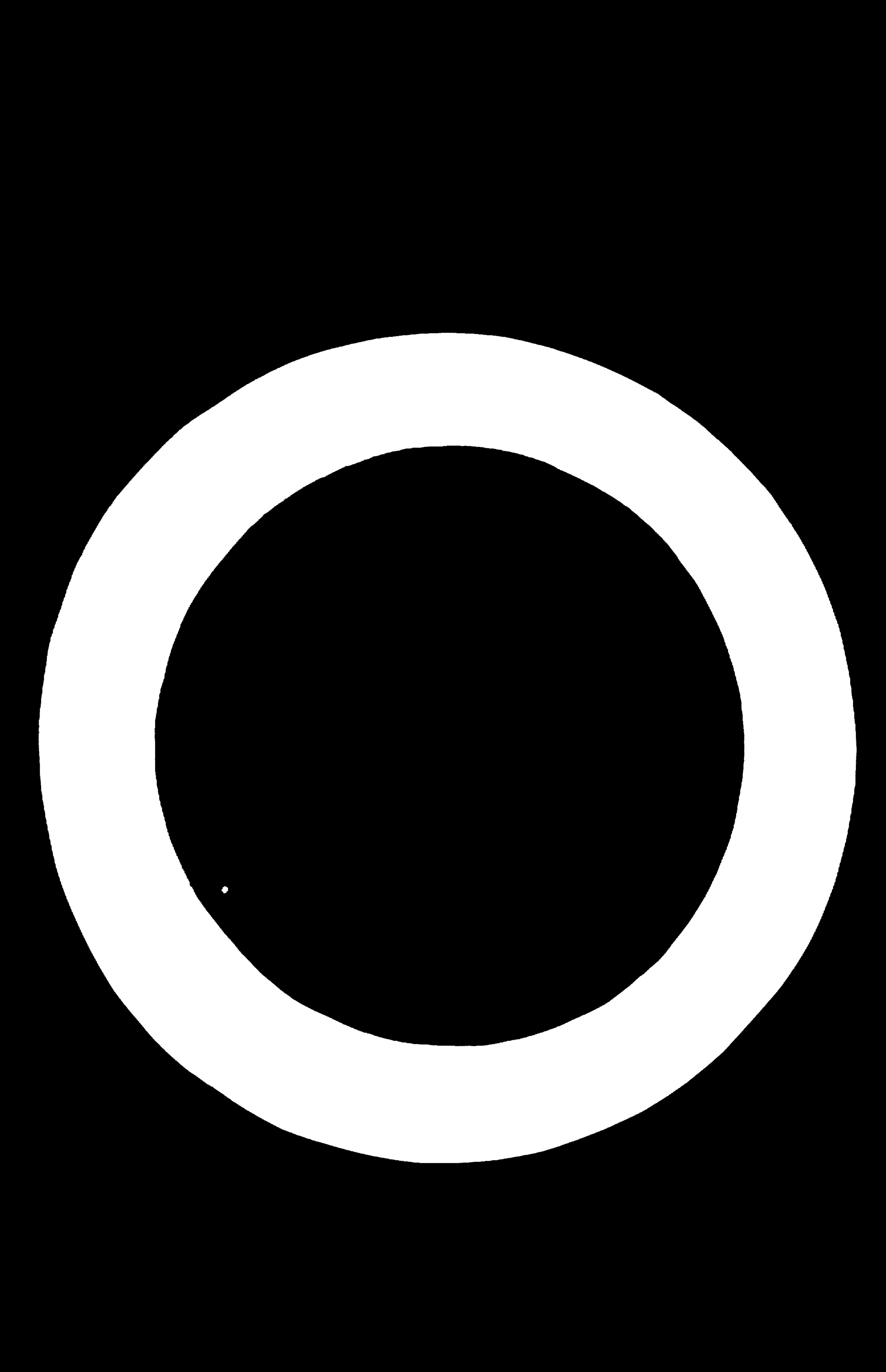


M. GONNI





THE VENEZUELAN STEEL WORKS

by Dr. M. Genni
Manager,
Engineering and Construction Div.,
Innocenti S. G.
Milano, Italy

Some of its unusual features are electric reduction furnaces instead of blast furnaces, a permanent pier designed for 13 m (42.5 ft) changes in water level, and tubular structures for some mill buildings.

THE consumption of steel products in Venezuela (mostly seamless tubes, reinforcing rods, structurals and merchant bars) has soared during these last years from almost insignificant values up to about 700,000 metric tons (775,000 net tons) per year. This market demand and the availability of iron ore, coal and electric power have been the reasons for the establishment of the Venezuelan Steel Works. Its present capacity is about 750,000 tons (825,000 net tons) per year of steel ingots. Future capacity is planned up to 1,500,000 tons (1,650,000 net tons) per year.

The Venezuelan authority in charge of this project is the Instituto Venezolano del Hierro y del Acero.

The project has some unusual features. Pig iron is made with low shaft electric reduction furnaces instead of conventional blast furnaces; this installation will be the largest of this type ever built. A permanent pier on the Orinoco River near the works site is designed in such a way as to accommodate the level changes of the river ranging up to 13 m (42.7 ft) between high and low waters. The supporting structures for some light buildings (seamless pipe mill, warehouses, wire drawing plant, iron foundry) are of tubular design.

The Venezuelan steel plant is also a striking example of international co-operation, promoted and coordinated by Innocenti S. G. of Milano, Italy. The Innocenti Company will supply directly pipe mills and rolling mill facilities, but it is the general designer and the prime contractor of the entire Works, the whole coordination of the project being entrusted to it.

Firstly, in this project there is a major participation of the Italian industry in the fabrication of the large structural steel buildings and in the manufacture of mechanical and electrical equipment as well as the other main facilities. Then there is the broad participation of American industry. U. S. manufacturers will furnish a 44-in. blooming mill, electric equipment (drives and controls), the open hearths, soaking pits and heavy crane engineering. The operating technique of the U. S. steel industry is present in the general conception of some fundamental departments of the Works.

There is also the participation of some outstanding European concerns.

The civil engineering works are being carried out by Venezuelan and Italo-Venezuelan sub-contractors.

The general inspection of the project has been entrusted to Ramseyer & Miller, Inc., Consultants to the Iron and Steel Industry, New York. Venezuelan engineers of the Instituto Venezolano del Hierro y del Acero actively participate in the work.

Figure 1 — The plant is located on the Orinoco River in Venezuela.

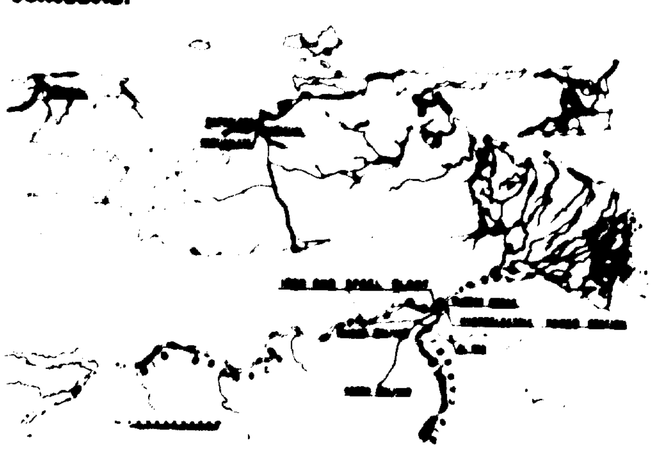


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Figure 2 — Plant occupies about ¾ sq miles.

Before describing the project a brief outline of the raw materials to be used and of the processes selected to make pig iron and steel will be given.

MAJOR IRON AND STEELMAKING MATERIALS

Iron ore—In Venezuela several deposits of iron ore have been found. Involved in the operation of the plant are two mines: Cerro Bolivar in concession to U. S. Steel Corp. and El Pao to Bethlehem Steel Co. The ore from the first mine will be used for hot metal making, the one from the second mine will be used as addition oxide in the open hearth furnaces. Both of these ores are hematites very rich in iron content as seen from these percentage analyses:

	Cerro Bolivar	El Pao
Fe	58.00 to 61.50	61.55 to 65.00
SiO_2	0.45 to 1.43	1.43 to 1.00
P	0.105 to 0.04	0.077 to 0.05
Mn	0.02 to 0.04	0.08
S	0.019 to 0.041	0.043
Al_2O_3	0.74 to 1.92	4.68 to 2.00
I. L.	5.00 to 7.28	2.00
H_2O	5.08 to 9.33	1.00 to 5.98

Coal—The Venezuelan authorities intend to use their own coal coming from the mine of Naricual (near Barcelona) which they are now equipping for operation. It is a recent bituminous coal with a high content of volatile matter. Properly processed it may give a coke suitable for electric reduction furnace operation but not for blast furnaces.

Power—The required power will come from a large hydroelectric plant (initially equipped with four 70,000-kva groups) which will exploit the Caroni River through a huge dam. In September, 1958, this project was now at an advanced stage of realization.

Limestone—Limestone comes from Pertigalate quarry. It contains 54 per cent of CaO and practically no MgO.

HOT METAL AND STEEL MANUFACTURING PROCESS

The quality of the coal which does not allow for the making of blast furnace coke, the wide availability of low cost electric power, the high Fe content of the ore and the desire to exploit domestic raw materials have led the Venezuelan authorities to select electric furnaces for the ore smelting process.

As for the steel, when the layout of the plant was established, preference was given to the open hearth process for the present first stage of the plant. The alternative of an oxygen converter plant has been taken into consideration for future enlargements, which will consist mainly of facilities for manufacturing flat rolled products.

SELECTION OF THE PLANT SITE

The plant is located on the right bank of the Orinoco River at about 250 km (155 miles) from the sea and at a distance from Caracas of about 500 km (311 miles). The selection of this site, Figure 1, made by the Venezuelan Government, was determined by several factors:

1. Vicinity of the iron ore mines.
2. Wide availability of hydroelectric power and vicinity of the Caronì power plant (about 10 miles).
3. Navigability of the Orinoco River for high tonnage vessels. In fact, supply of the raw materials as well as transportation of the finished products can be done through this waterway.
4. A government policy in regard to the development of the country south of the Orinoco River. In particular, a residential area for 25,000 to 30,000 inhabitants will be developed in the vicinity of the plant.

THE PLANT

The plant site, Figure 2, is a rectangular area of about 2 km x 1 km (1 24 x 0.621 miles) at 45, 40 m (149 ft) above the minimum level of the river.

There will be on the Orinoco an autonomous pier for unloading raw materials (iron ore, coal, limestone) subsequently transported to the storage yards along belt conveyors. The finished products, on railway cars and trucks, will be transported to the pier for shipping to the points of consumption.

Production program—The breakdown of the rolled steel program is given below:

	Metric tons per year	Net tons per year
Reinforcing rod and wire rod	125,000	138,000
Medium and small sections	60,000	66,100
Structurals and railway materials	20,000	22,100
Rails	50,000	55,100
Seamless steel tubes	295,000	325,000
Total finished products	550,000	606,300

To the aforesaid products should be added those of an iron foundry:

Ingot Molds and stools	About 20,000	22,000
Spun iron pipes	About 30,000	33,100

and those of a wire drawing plant:

Black annealed wire, galvanized wire, barbed wire and nails (the corresponding wire-rod is included in the above mentioned breakdown for the rolled products)

About 27,000 29,800

General arrangement of the plant—As may be seen from the plan, Figure 3, along a first alinement there are the stockyards for ore, limestone and coal. Along a second alinement there are the sintering plant and coke oven plant.

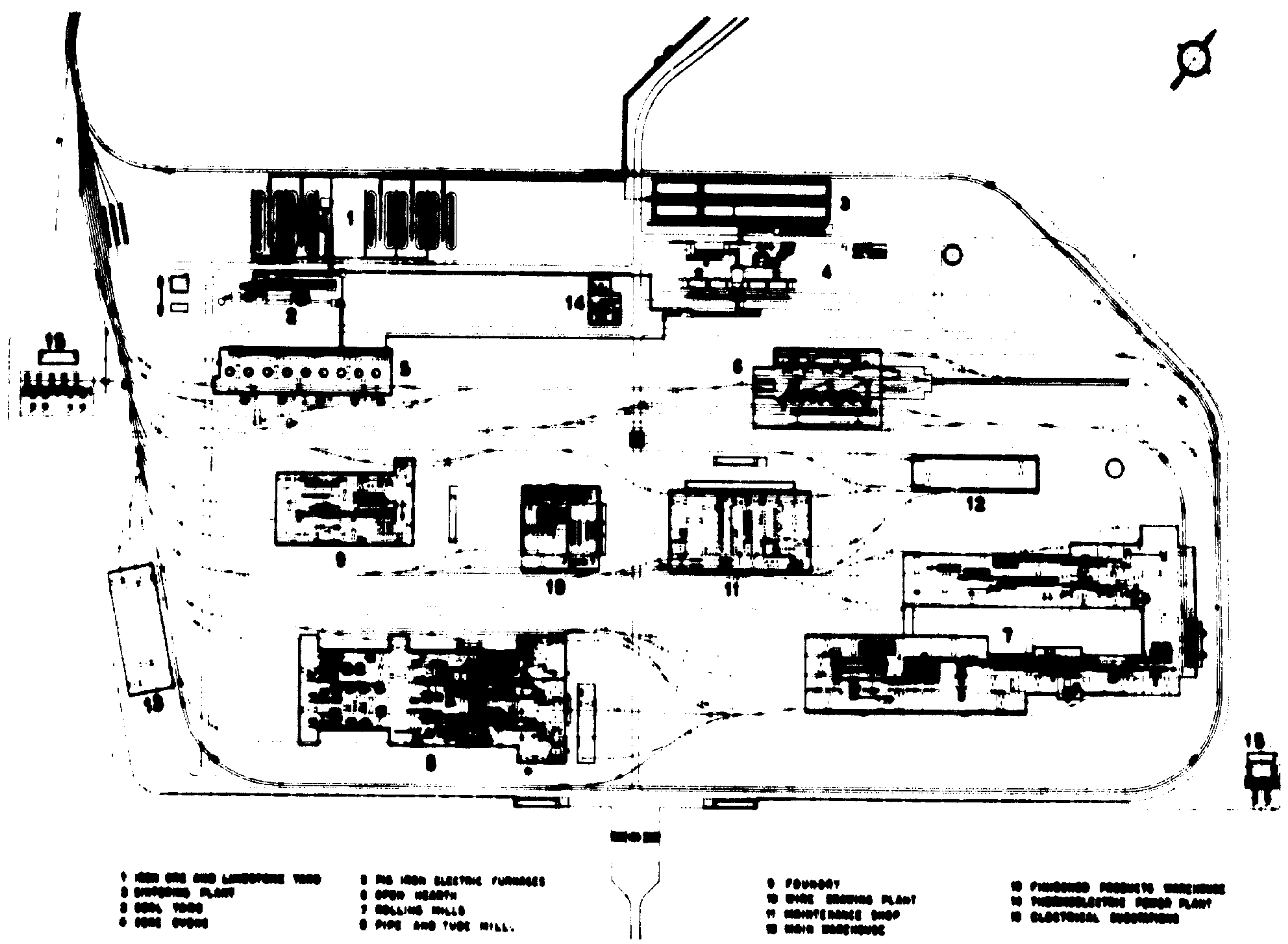
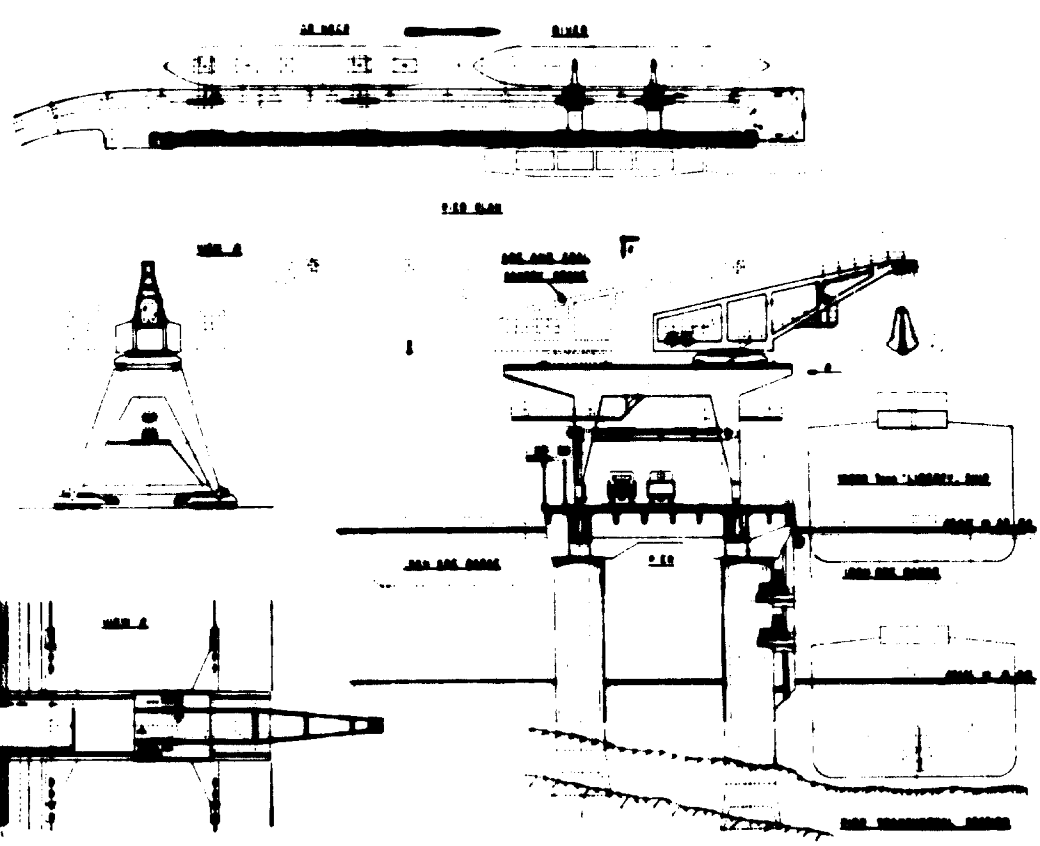


Figure 3 — General arrangement of the plant provides for future expansion.

Figure 4—The plant's pier on the Orinoco is large enough to dock two 10,000-ton freighters at the same time along the side toward the center of the river.



Iron ore, sinter, limestone and coke are conveyed by belts to the electric reduction furnaces.

Electric furnaces, steel shop, rolling mills and the seamless tube mill are arranged along a continuous flow line that in a rectangular plan takes the shape of a "U."

The flow of materials (liquid pig iron, ingot steel, rolled products, tubes) is one-way throughout without any backward motion; this in particular was made possible by the soaking pits—blooming mill arrangement at a right angle.

Within the "U" flow line, where expansions of the operating departments are not contemplated, the general warehouse for spare parts, the maintenance shop, the wire drawing plant, the iron foundry and other service departments are located. The finished product warehouse is located outside the flow-line of the plant so that the shipping operations are independent of the inner plant traffic.

Outside the plant area there are also two electric receiving substations at 115,000 volts for the electric reduction furnaces and for the other services. This location is for safety reasons.

MAIN DEPARTMENTS

Pier on the Orinoco River—On the Orinoco erection was underway in September, 1958, of a large reinforced concrete pier, Figure 4, for loading and unloading. Located parallel to the river bank, it is 25 m (84.2 ft) wide and about 300 m (687 ft) long. Its connection with the bank is through an ample curved reinforced concrete accessway. The big columns are built with compressed air caissons, and the beams are cast on the spot.

The river level between the rain season (May to October) and the dry season (November to April) has a difference of 13 m (42.6 ft); thus the pier, in order to permit the docking of vessels at any level, had to be designed quite high.

It is possible to dock two 10,000-ton freighters at the same time along the pier side toward the center of the river, plus one barge along the bank side even during low water periods.

The iron ore, railway borne from the Cerro Bolivar mine to Puerto Ordaz, is loaded into barges which are pushed by towboats along the river for some 15 km (9.35 miles) up to the pier. However, the possibility of receiving the iron ore through a direct track connection with the aforesaid railway is foreseen.

The pier is equipped with two 22-ton (24 net ton) unloading gantry cranes. Their average unloading capacity is 380 to 400 tons (420 to 400 net tons) per hour each, referred to the iron ore (capacity under favorable conditions is 500 to 550 (550–605 net) tons per hour). With regard to limestone and coal, however, the above values drop to 200 to 250 (220–275 net) and 140 to 180 (155 to 200 net) tons respectively. The two belt conveyors from the pier to the plant are built for the capacity of 1100 (1200 net) tons per hour each (referred to iron ore). On the pier there are also three 10-ton (11 net) loading cranes for the finished products.

For the plant operation a small fleet is also necessary: five to six 8000 to 10,000-ton freighters for coal and limestone, the same number of 3000-ton freighters for transporting the finished products, and one tug and one barge for the iron ore.

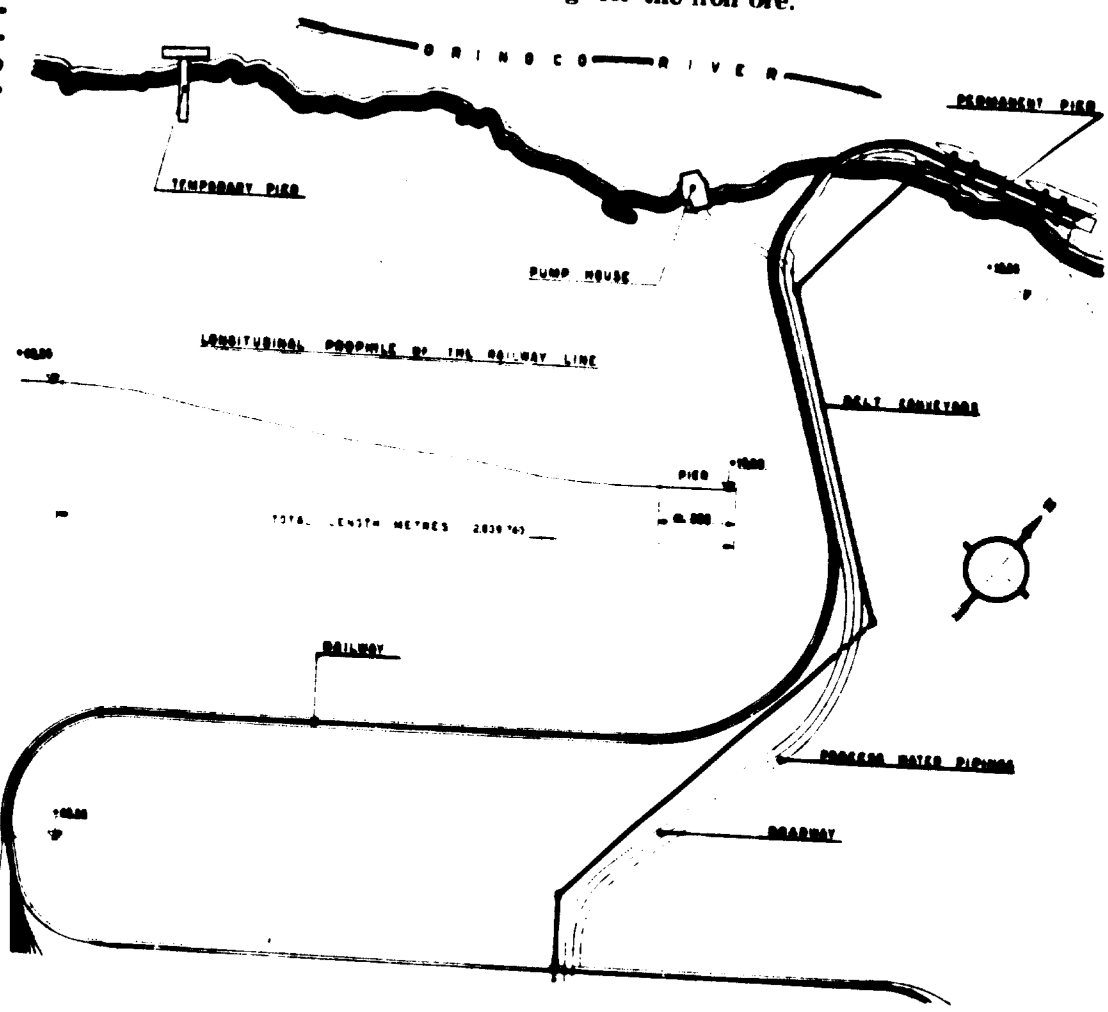


Figure 5 — A belt conveyor system transports ore, limestone and coal from the pier to the storage yards.

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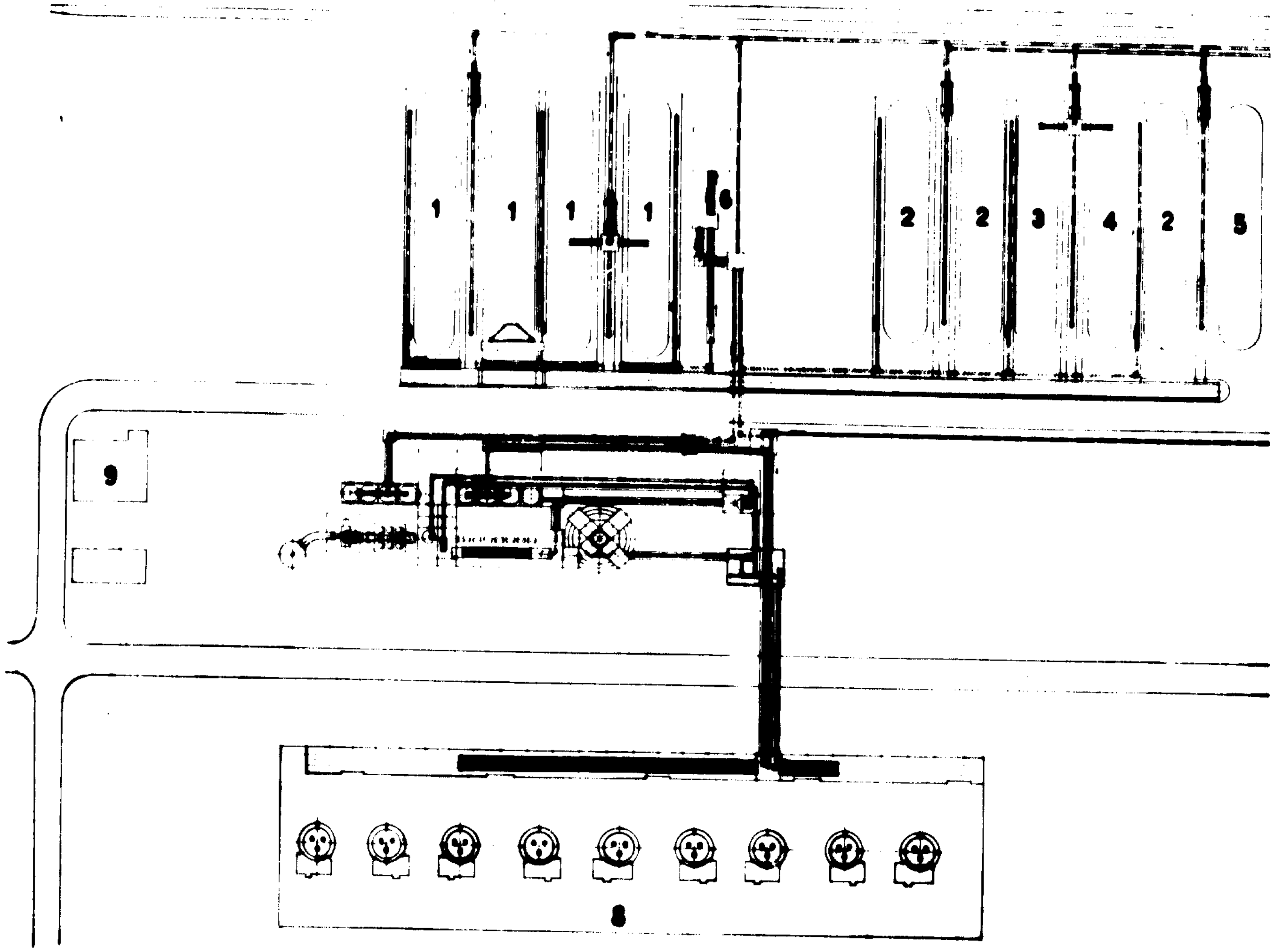


1 CERRO BOLIVAR IRON ORE
2 LIMESTONE
3 DOLOMITE
4 SILICEOUS SAND
5 EL PAO IRON ORE
6 IRON ORE SCREENING AND DRYING PLANT
7 SINTERING PLANT
8 PIG IRON ELECTRIC FURNACES
9 ELECTRODE PASTE PLANT.

Figure 6 — Ore and limestone storage yards and sintering plant are fed by belt conveyors.

Belt conveyors—A belt conveyor system, Figure 5, runs right along the pier; from the root of the pier it heads to the plant site arriving at a switching station in the yard area. From here one conveyor, at the right side, feeds the ore and limestone yards and another conveyor, at the left side, feeds the coal yard.

Iron ore and limestone storage yards—Though in September, 1958, only one type of iron ore was available, the ore storage, Figure 6, and reclaiming was done with a traveling-belt conveyor and stacker blending system adapted to the peculiar requirements of the plant. The considerations which led to this choice are the following:

1. Ore, during the rain season (lasting four to five months), absorbs a lot of water. The belt reclaiming machine is much more efficient than the conventional grab bucket system. In fact, while the latter during its grabbing tends to press the ore making more difficult the subsequent operations of handling and screening, the belt machine, working on the transversal section of the ore storage pile, sends loose material to the subsequent operations.

2. The ore yard is located on a back-filled area. The conventional equipment of the ore bridge, besides requiring piling, thick foundation slabs, etc., might cause movements of the ground owing to the unevenness of height of the ore storage piles. It was decided to avoid this.

3. Ore, though coming from the same mine, presents variations in composition and screen analysis. From the sintering tests carried out for this purpose, it also showed differences in behavior among the various samples tested. That is why the homogenisation of the ore is always recommendable. Moreover, it is likely that in the future other ores may be used.

The operating cycle is the following: the ore, arriving from Puerto Ordaz already crushed down to a maximum size of 5 in., is stored through a system of conveyors and a stacker in two oblong storage piles as it arrives from the pier and at the same rate of unloading from the barges. There are a couple of piles being formed, another couple being reclaimed. Each storage pile contains about 15,000 (116,500 net) tons; in total 4 x 15,000 = 60,000 tons (66,000 net tons) can be stored. Considering the mine vicinity, this amount is held sufficient for the plant operation.

Ore, after reclaiming by the belt machine, is conveyed to a crushing and screening plant which crushes the size above 3 in. and then separates the two sizes of −8 mm (−5/16 in.) and of 8 to 75 mm (5/16 to 3 in.).

When the ore has absorbed a great deal of water, as happens during the rain season, the screening operation is extremely difficult (at least according to information coming from steel plants utilizing Cerro Bolivar ore). Then provision has been made for three rotating dryers through which the wet ore passes before going to the screening station.

The two sizes of ore (−8 mm (−5/16 m) and 8 to 75 mm) (5/16 in. and 5/16 to 3 in.) coming out of the screening station are conveyed to the sintering plant and to the electric reduction furnaces respectively.

The other raw materials, limestone, dolomite, silica and El Pao iron ore (in large lumps for the steel shop), are stocked with the same system (however without homogenization) and reclaimed with mechanical shovels.

The transportation to the steel shop of limestone and El Pao ore is done by trucks; the handling of limestone, dolomite and silica to the sinter plant and the electric furnaces is done through belt conveyors.

Ferroalloys will be carried from the pier to the plant with railroad bin cars which empty into proper trenches. From here ferroalloys will be stocked and then removed with movable cranes.

Sinter plant—The size of iron ore which will be used directly in the electric reduction furnaces, is 8 to 75 (5/16 in. to 3 in.) mm (which represents about 35 per cent of the total amount). The remaining 65 per cent of fines having a size under 8 mm (5/16 in.) will be sintered. For this purpose a large sinter machine is installed. The sinter produced will be dry-cooled on a rotating cooler.

The raw materials are handled through a belt conveyor system to a battery of 12 bins: six of these are for the ore fines, two for the coke breeze and the others for limestone, sand and mill scale.

The raw materials are fed from these bins by proportioning feeders to conveyor belts for transporting the proper mixture to a primary rotating drum which pre-mixes the feed materials with the return fines [−8 mm (−5/16 in.) size]. The mix is then passed to a secondary rotating drum and is then fed to the sintering machine.

At the discharge end the sinter is screened; the fines, [−8 mm (−5/16 in.) size], whose amount is expected to be around 50 per cent of the total, are recirculated. After cooling, a portion of the 8 to 20-mm (5/16 to 25/32 in.) size is also recirculated to form the hearth bed [with a proposed thickness of some 6 cm (2.4 in.)] for protecting the grate bars.

Self-fluxing sinter will be produced to improve the smelting process in the electric furnaces.

A set of cyclones for dust separation is interposed on the collecting main ahead of the exhauster.

The sinter having a size above 8 mm (5/16 in. is taken by belt conveyors to the electric furnace storage bins.

Coke oven plant—The study of this subject was still under way in September, 1958. Our exposition is limited to some points already fixed, taken from a preliminary report on the coal and on the coke plant made by Dr. Ferrara of Vetrocoke S.p.A., Torino (Italy).

In the Naricual mine several seams have been found. From the viewpoint of the coal used, the tested qualities may be grouped in two categories: agglomerating and nonagglomerating.

Some samples, taken from two seams (which have been envisaged for the future program of exploitation) showed the following analysis:

	Per cent (dry basis)
First seam (agglomerating)	
Ashes	4.60
Volatile matter	43.70
Fixed carbon	51.70
Gross heating value	7,885,000 cal

	Per cent (dry basis)
Second seam (non-agglomerating)	
Ashes	4.27
Volatile matter	42.00
Fixed carbon	52.73
Gross heating value	7,800,000 cal

The blends of the two qualities, which have been envisaged as probable for the oven charge, are 50 to 50 or 1/3 to 2/3. Both produced coke suitable for electric reduction furnaces. The first blend—more probable—produced coke with a yield of 60 per cent (of which 55 per cent in lump size to be employed in the electric furnaces and 5 per cent fines for the sintering) and 350 Nm^3 per ton (11,200 cu ft per net ton) of coke oven gas at a net heating value of 4800 cal per Nm^3 (136 cal per cu ft or 540 Btu per cu ft).

For obtaining a coke mixture, each of the two coal qualities shall be stored individually so that they may be blended in the needed proportions; then the agglomerating properties of the mixture shall be emphasized by increasing the charge density and adding other possible materials. In any case a long stay in the yards is to be avoided to prevent oxidation of the stored coals.

The foregoing samples of Naricual coal show considerable similarities to certain coals of the Lorraine field where the problem has been since long solved on an industrial scale.

The preliminary studies would have led to a conventional by-product coke oven battery with pre-compressed charge (pilonnage). This type of ovens would give the maximum possible flexibility, allowing also the use of blends with high grade coking coals.

The coke plant will be completed by coal storage with central stock stacker, equipment for the charge preparation, coke screening station, recovery of coal chemicals limited initially to tar and ammonium sulphate, and gas exhausters, electrical services, etc.

The whole handling system, from the coal storage to the coke transportation to the electric furnaces, is done through belt conveyors.

A joint technical committee consisting of representatives of the Venezuelan authorities, of the mine management and of Innocenti will soon re-examine the whole problem which, from the Venezuelan side, will be extended to the mine proper.

Meanwhile, some facilities were being provided

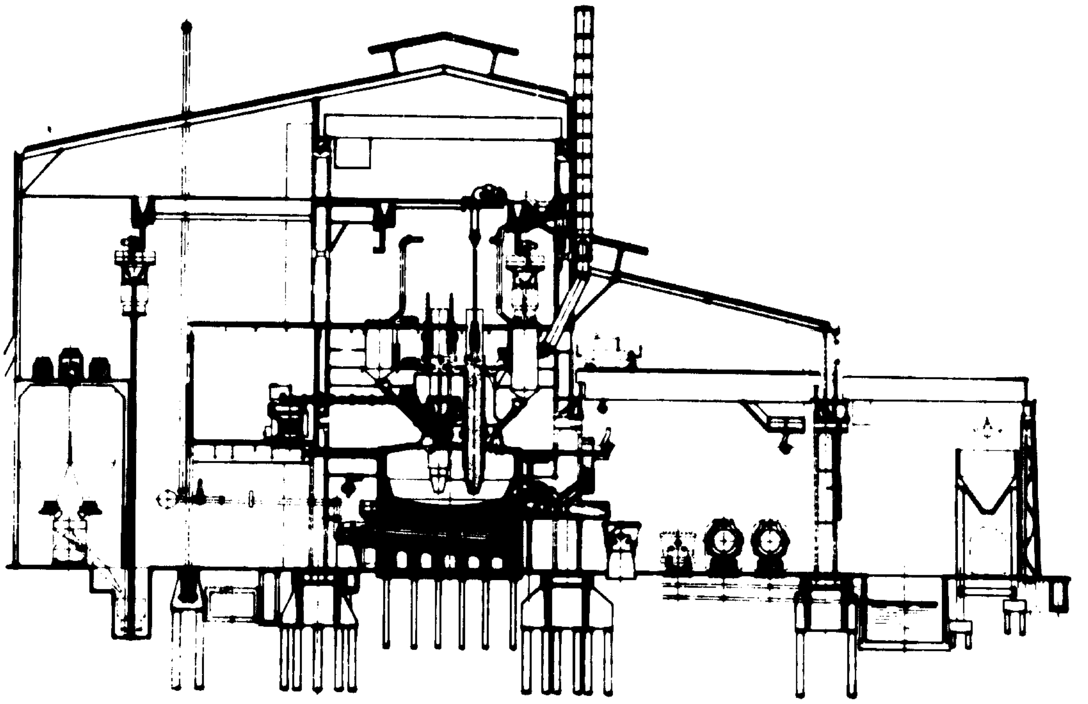


Figure 7 — Nine Tysland Hole type electric reduction furnaces will produce hot metal for the steelmaking facilities.

in September, 1958, for starting the plant operation with imported coke.

Electric reduction furnaces—This is the biggest installation in the world of electric reduction furnaces of the Thysland Hole type, consisting of nine units, rated at 33,000-kva each and with an estimated single production capacity of 200 to 220 tons per day of pig iron.

The furnaces, Figures 7 and 8, are of the low shaft type; three self-baking continuous electrodes, having a diameter of 1.5 m (4.91 ft), pass through the roof of each furnace. The hearth is made up of rammed dolomite with underlying layers of magnesite brick. The side wall lining is made up of fireclay brick material. The inner diameter of the shell is 11.5 m (37.8 ft). The height from the hearth line to the roof skewback is about 5 m (16.4 ft).

Each furnace is fed by a transformer of 33,000 kva stepping down the voltage from 22,000 volts to the furnace operating voltages ranging from 240 to 170 volts in 18 taps; the hourly electric average load is about 20,000 kw. A 15,600-kva capacitor battery raises the line power factor up to 0.9.

The furnaces and their services are installed in a structural steel building 290 m (951 ft) long and 71 m (233 ft) wide; the area under the roof is 20,500 sq m (215,000 sq ft). The weight of the structural building is about 11,000 tons (12,100 net tons).

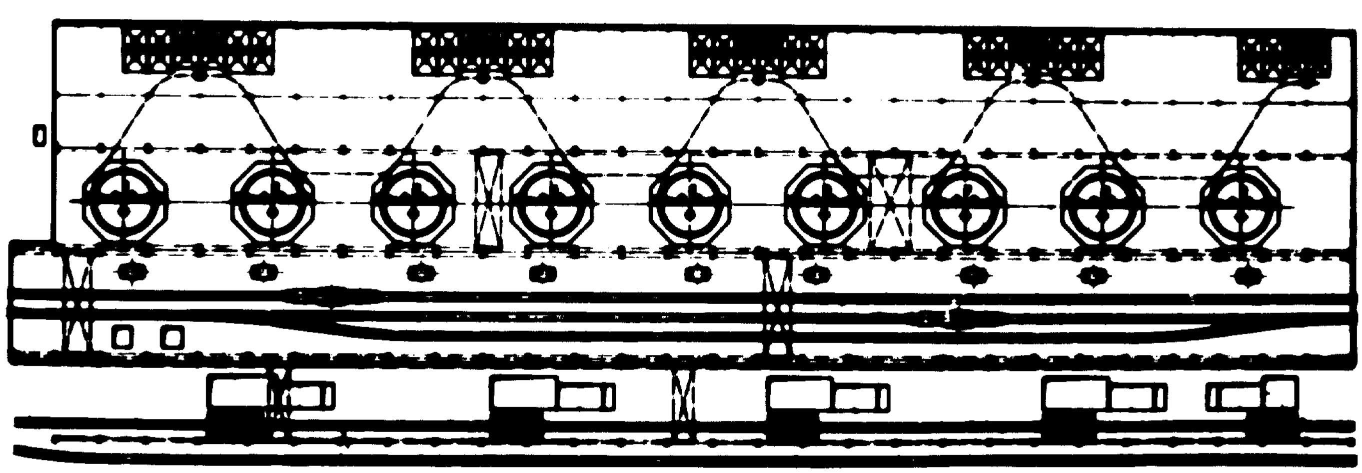
There are five sets of stock bins for the raw materials, one for every two furnaces; each set has a capacity of 2000 cu m (70,500 cu ft) and is equipped with a scalecar and monorail grab for hoisting the materials and dumping them into the nine feeding bins of each furnace, the nine bins having a total capacity of 180 cu m (6,350 cu ft). From these bins the charge is fed by gravity through charging chutes to the furnace shafts. Each monorail can perform 12 runs per hour, that is about twice as much as necessary.

In the furnace bay are two 7.5-metric ton overhead traveling cranes and a 40-metric ton one for the furnace maintenance. In the tapping bay are two 120/40-metric ton d-c overhead cranes.

The hot metal, which is tapped every four to five hours into ladles, is poured from these into mixer-type hot metal cars by which it is transferred to the steel shop.

For making one ton of hot metal the following ma-

Figure 8 — Plan for the electric reduction furnaces.



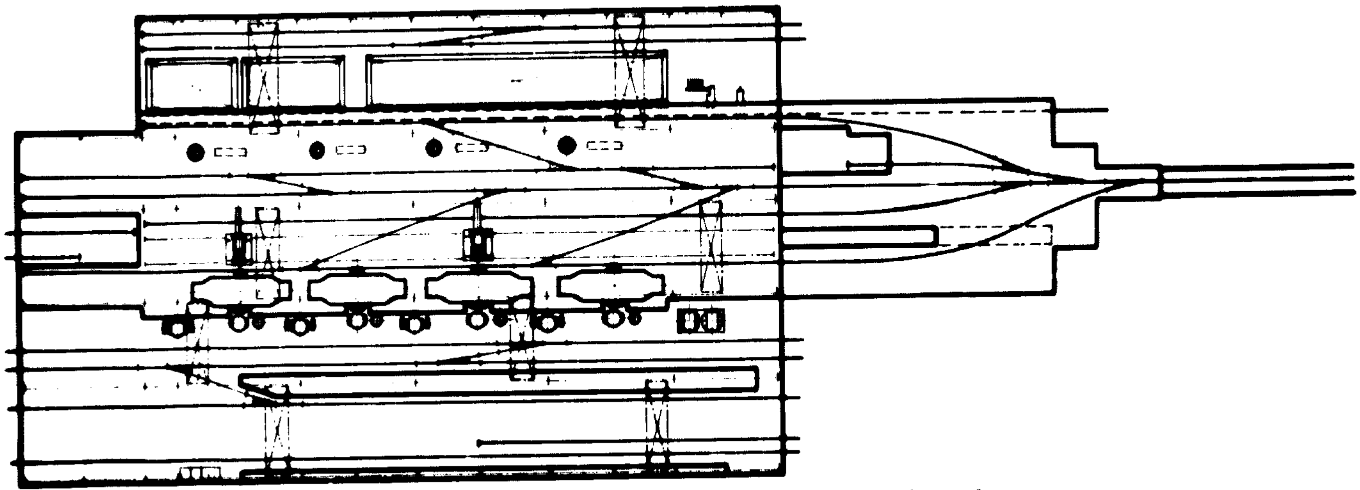


Figure 9 — The meltshop has four 250-ton open hearths.

terials are required:

Iron ore	about 1600 Kg (3540 lb)
Coke	about 400 Kg (880 lb)
Limestone	about 235 Kg (517 lb)
Silica	about 85 Kg (188 lb)
Electric power	2300 to 2400 kwhr

As for the size, sinter and ore must be in the range of 8 to 75 mm ($^5/_{16}$ to 3 in.); coke is fed separately in the two sizes of 6 to 25 ($^1/_4$ to 1.0 in.) and 25 to 50 mm (1.0 to 2.0 in.) in order better to control the porosity and the electric resistance of the burden.

Electrode paste is manufactured in a nearby plant rated at 8000 metric tons per year.

Slag is granulated under water pressure in a completely conventional installation located outside the furnace building and serviced by two 10-ton traveling cranes. It consists of one granulation basin and a set of bins for every two furnaces.

Adjacent to the furnace building there is a 2-chain pig casting machine rated at 2500 tons per day. Should it be necessary, the hot metal produced daily may all be poured into the pig machine.

Steel shop—Figures 9, 10 and 11 show an open hearth shop equipped with four 250-ton (275 net ton) furnaces. The building, crosswise, is divided into five bays: scrap and raw material stockyard, lean-to, furnace bay, pouring bay, mold yard. The total area of the building is 25,000 sq m (269,000 sq ft). The spacing of the furnaces, center to center, is 34 m (111 ft). Lengthwise the building is divided into seven sections: one for ladle repair, four for the furnaces, one as a bracing section of the building structures and one for lifting the hot metal onto the charging floor.

After the fourth furnace, between the sixth and seventh column, there is in the building structure a 8.5-m (27.9 ft) span strongly braced which acts as the fixed point of the whole building in relation to thermal

Figure 10 — Transverse section of the meltshop.

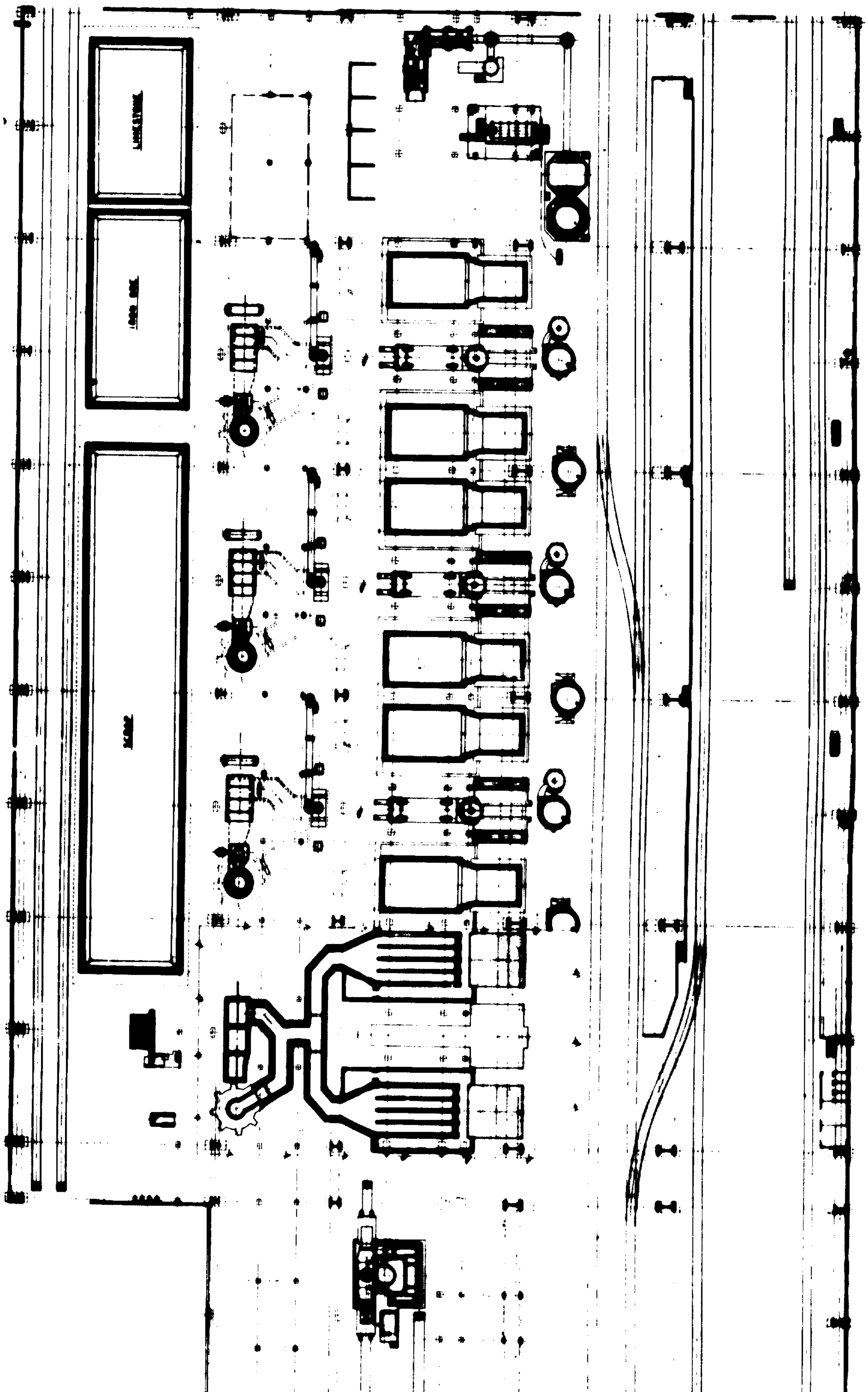
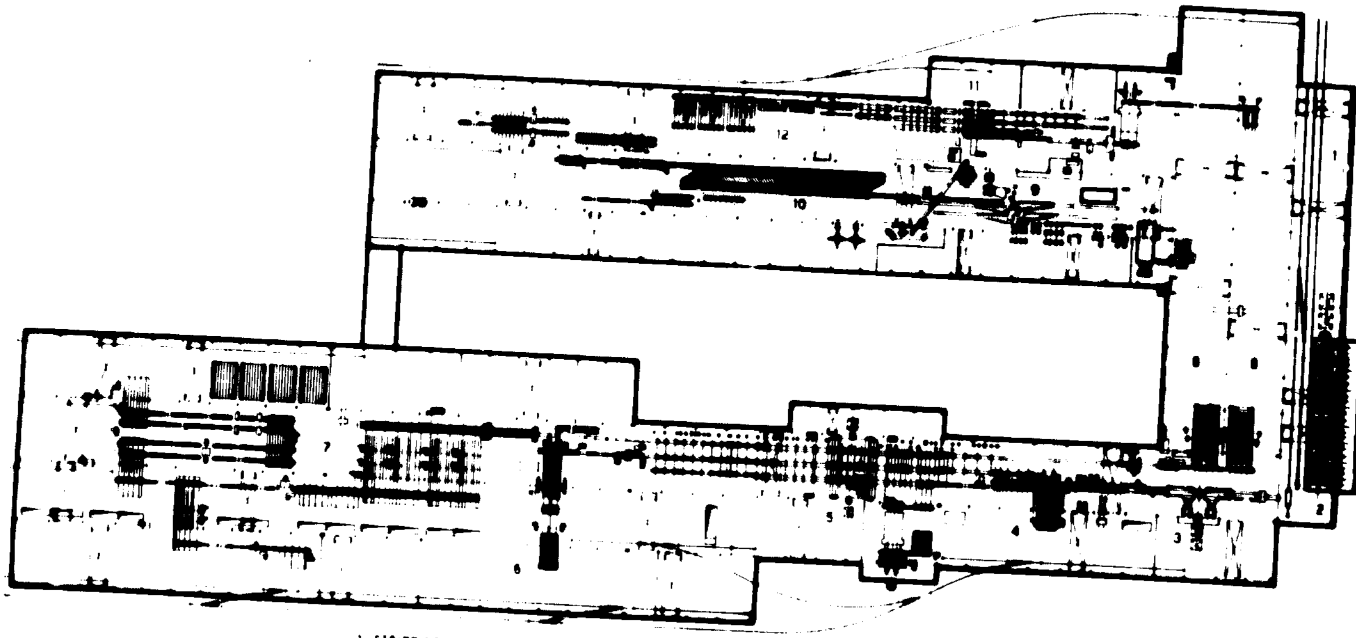


Figure 11 — Ground floor plan of the melt shop.



1 STRIPPING BAY
2 SOAKING PITS
3 BLOOMING MILL
4 STORAGE OF BLOOMS AND SLABS
5 800 mm BILLET AND RAIL MILL
6 STORAGE OF BILLETS FOR THE PIPE MILLS
7 RAILS AND STRUCTURALS FINISHING FACILITIES
8 STORAGE OF BILLETS FOR THE ROD AND MERCHANT MILLS
9 300 mm ROD MILL
10 ROD MILL FINISHING FACILITIES
11 500 mm MERCHANT MILL
12 MERCHANT MILL FINISHING FACILITIES

Figure 12 — In the rolling mill building, the stripping and pit furnace bay is perpendicular to the blooming mill bay and the rod and merchant mill, and section mill bays.

expansion. The eventual set of new furnaces will be arranged symmetrically to the present one.

From the mixer-type car (which is spotted on the ground floor) the hot metal is poured into the transfer ladle (placed in the bottom of a pit) and thence lifted to the charging floor by the hot metal cranes.

The main lifting facilities are two 390/60/20 metric ton ladle cranes, two 160/40 metric ton hot metal cranes, two 10 metric ton charging machines, two 25 metric ton mold yard cranes and two 15 metric ton stockyard cranes.

The open hearth furnaces, rated at 250 metric tons (275 net tons), can actually tap almost 300 metric tons (330 net tons). Bath area is 97 sq m (1040 sq ft); bath depth is 670 mm (26.3 in.)

The main roof and the two port roofs of each furnace are fully basic and suspended. The uptakes are basic too. The two regenerative chambers have a cross section of 9705 x 7050 mm (31.8 x 23.1 ft) and a checker height of 5520 mm (18 ft); their roof is flat, suspended and built of fireclay bricks.

The furnaces are fired with cold coke-oven gas for 60 to 70 per cent and fuel-oil or tar for the balance, or with 100 per cent oil.

For each furnace there will be a set of instruments and controls and a waste heat boiler at 30 kg per sq cm (420 psi) and 350 C (662 F) with an expected steam output of six to seven tons per hour.

The steels to be made are mainly of the following type: A 00, Aq 34, Aq 42, Aq 50 (Italian specifications) for structurals, shapes, rod, wire rod; steel for rails; and GB–J 55, N 80 (API specifications) for pipes.

Owing to scarcity of scrap in Venezuela, for the steelmaking process a quite high percentage of molten pig iron is to be charged. However, as a compensation for this high hot metal charge, there is its quite low silicon content due to the low silica content in the ore.

The open hearth is provided with its own servicing facilities (fuel oil distribution system, gas boosters, ladle heating and repair, oven for drying the ladle stoppers).

Access to the charging floor is through a ramp having a 2.5 per cent slope ending at the head of the open hearth building in a wide track shunting platform in reinforced concrete structure. The area covered by this platform is utilized as warehouse for refractory material. The purchased scrap is stored in the open air, its cutting and preparation take place in the roofed storage bay. The charging boxes may be filled at the ground floor and brought to the charging floor through the ramp, or may be directly filled at the charging floor.

An oxygen plant supplies oxygen for bath decarburization, scrap cutting and other uses.

Rolling mills—The general layout is shown on Figure 12. The stripping and pit furnace bay is perpendicular to the blooming mill bay and to the rod and merchant mill and section mill bays. Billets for these two mills are cooled and stored in two bays parallel and adjacent to the stripping bay. The whole building covers an area of about 110,000 sq m (1,180,000 sq ft).

Stripping—The stripping and pit furnace bay is 27.40 m (90 ft) wide. The stripping zone is about 100 m (328 ft) long and is provided with three tracks. There are two stripper cranes for big-end-down and big-end-up ingots (hoisting capacity 30 metric tons (33 net tons), stripping 300 tons). There is sufficient room to store about 7000 (7700 net) tons of cold ingots.

The ingot dimensions are:

7.5 metric ton normal type	760 x 760 x 1900 mm	(29.9 x 29.9 x 74.8 in.)
5.5 metric ton rail type	690 x 690 x 1830 mm	(27.2 x 27.2 x 72.0 in.)
9.5 metric ton slab type	670 x 1150 x 1950 mm	(26.4 x 45.2 x 76.7 in.)

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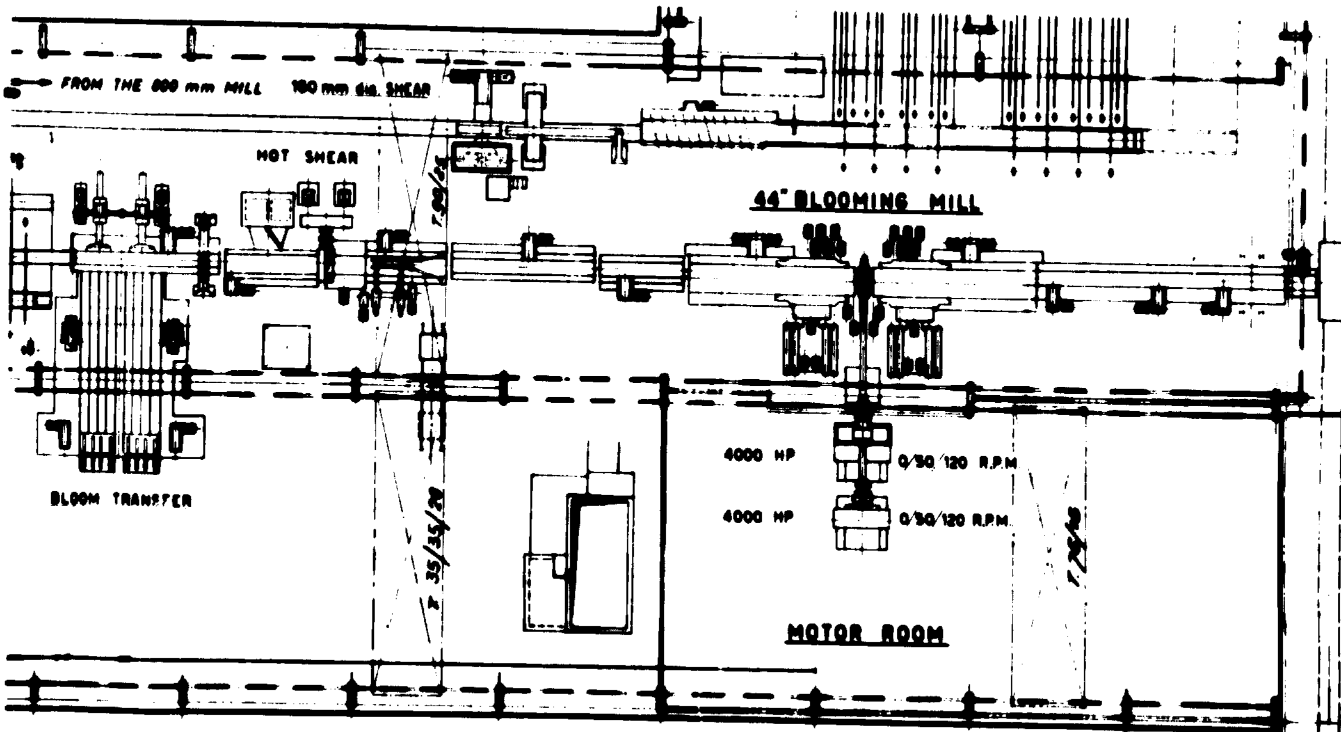

Figure 13 — The 44-in. blooming mill has a fast drive with moderate torque because it essentially produces blooms and billets.

Pit furnaces—There are eight one-way fired 125-ton soaking pit furnaces with refractory recuperators for the preheating of the combustion air. There are natural draught stacks, each one connected to four pits. The pit dimensions are 4500 x 6000 x 4000 mm (14.8 x 19.7 x 13.1 ft). They are fired either with electric furnace gase or fuel oil; maximum firing rate 23.8 x 10^6 Btu per hour per pit.

The normal control and regulation instruments (fuel-air ratio, furnace pressure, furnace temperature) are provided.

Heating time is comtemplated as follows: 4 to 5 hours for hot charge (2 to 3 hours track time) and 10 to 12 hours for cold charge.

There are two 15 metric ton (16.5 net ton) pit cranes for charging and discharging the pit furnaces. Foundations for two additional pits are under way.

Blooming mill—The blooming mill equipment, Figure 13, mainly consists of:

An ingot buggy side dumping the ingot into a receiving table.

An approach roller table, 23 m (75.5 ft) long, line shaft driven, and divided in three sections, table width 1320 mm (52 in.).

Two line shaft driven mill tables on the front and on the rear of the stand, about 13.85 m (45.5 ft) long [roller diameter 458 mm (15 in.), roller length 2700 mm (8.85 ft)].

Besides the two feed rollers the first six rollers on each side are individually driven (this arrangement avoids the mill tables working in the first passes of the ingots).

Stand:

Roll diameter . . . . 1100 mm (43.2 in.)
Body length . . . . 2800 mm (110 in.)
Lift . . . . 1320 mm (51.9 in.)
Counterweight balanced top roll

Manipulators: double manipulator with tilting fingers on both sides.

A delivery table 7.30 m (23.9 ft) long.

A shear approach table [about 25 m (82 ft) long].

Motor driven shear for cutting slabs 1060 x 152 mm (41.7 x 6.07 in.) and blooms 305 x 305 mm (12 x 12 in.) max.

A transfer for slabs and blooms 9 m (29.5 ft) wide.

Two slab and bloom pushers and pilers.

Drive:

Twin drive with two 4000-hp d-c motors, 700 volt, 0/50/120-rpm.

Motor-generator set:

One 9000-hp asyncronous motor, 13.8 kv, 60 cycles. 185,000 hp/sec² flywheel.

Two 3500-kw, 700 volt d-c generator.

Maximum working torque: 260 ton-meters (1,700,000 (lb-ft) (2.25 x normal torque).

Emergency torque: 315 ton-meters (2,060,000 lb-ft) (2.75 x normal torque).

Screwdown speed: 250 mm per sec (9.82 in. per sec).

Reversal time from +50 rpm to −50 rpm: 1.5 sec.

This blooming mill essentially produces blooms and billets; therefore a fast drive with a moderate torque has been chosen. However, it can normally produce slabs 1060 mm (41.8 in.) wide and 152 mm (6.09 in.) thick and exceptionally 1170 x 203-mm (46.1 x 8.0 in.) slabs.

Rolling time anticipated for forming a 200 x 200-mm (7.8 x 7.8 in.) billet from a 7.5 metric ton (8.25 net ton) ingot is approximately 80 sec in 17 passes. The average output of the blooming mill is conservatively estimated at 1,200,000 metric tons (1,320,000 net tons) per year [200 metric tons (220 net tons) per hour x 6000 hours], but this figure will certainly be exceeded in operation.

All the auxiliary drives are provided with d-c motors, mill type; screwdowns, mill roller table, manipulators and shear are driven at variable voltage; the other roller tables and services are driven at 230-volt constant voltage.

800-mm (31.4 in.) 2-high reversing mill—This is a 3-stand reversing mill with 800-mm (31.4 in.) diameter, 2200-mm (86.5 in.) body length rolls. Stand No. 1 has screwdown and manipulator on the entry side. Turning devices are installed on the front and on the rear of stands No. 2 and 3. A transfer connects the delivery end of the blooming mill roller table and the entry ends of stands No. 1 and 2 roller tables. This transfer can be extended in the future outside of the bay for feeding a continuous billet mill.

The main drive consists of two 6400-hp, 80/180-rpm d-c motors. These motors are fed by a motor-generator set with one 7500-hp, 13.8-kv, 60-cycle synchronous motor and four 2500-kw, 700-volt, d-c generators.

The drive motors are located one at the side of stand No. 1; the other at the side of stand No. 3.

The rolling mill can work with two stands driven by one motor and with the other stand driven by the other motor so as to roll at the first two stands at a certain speed and make the final passes on the third stand at higher speed.

Normally this mill rolls billets and blooms, as they are delivered by the blooming mill without reheating However, a 50 metric ton (55-net ton) per hour continuous reheating furnace allows also operation of the 800-mm (31.4 in.) mill independently from the blooming mill.

All drives subjected to many reversals (screwdowns, manipulators, roller tables on the front and on the rear of the stand) are fed by d-c motors, mill type, variable voltage. The other drives (approaching and delivery roller tables, transfer, etc.) are fed by a-c motors.

The rolling program of this mill is essentially the following:

For about 250,000 metric tons (275,000 net tons) per year it rolls 125 x 125-mm (4.91 x 4.91 in.) to 275 x 275-mm (10.8 x 10.8 in.) billets for tubes (a part of the tubes is rolled directly from ingots and blooms).

For about 200,000 metric tons (220,000 net tons) per year it rolls 80 x 80-mm (3.14 x 3.14 in.) billets for the rod and merchant mill and 160 x 160-mm (6.28 x 6.28 in.) billets for the medium section mill.

For about 70,000 metric tons (77,000 net tons) per year the mill rolls 100 lb per yard rails and heavy sections, angles from 120 to 200-mm (4.71 to 7.86 in.), channels from 140 to 300 mm (5.5 to 11.8 in.), "I"-beams from 180 to 300 mm (7.09 to 11.8 in.).

For each of these three types of products the rolling mill has an independent delivery arrangement with its own cutting and finishing facilities.

Tube billets are delivered on the rear of stand No. 2, billets for the 500-mm (19.6 in.) mill and the rod and merchant mill are delivered on the front of stand No. 3, rails and heavy sections are delivered on the rear of stand No. 3.

Finished rails will be 12 m (39.4 ft) long. They can be made in accordance with European standards. For American type rails, pits for the controlled cooling are provided.

300-mm (11.8 in.) rod and merchant mill—The mill mainly consists of:

a. One 45 (50 net ton) ton per hour heating furnace for 80 x 80-mm (3.14 x 3.14 in.) billets, 6 m (19.3 ft) of maximum length;
b. Six roughing stands whose motors are driven by a 1500-kw transformer-rectifier set:
   1. Stands No. 1 and 2: roll diameter 450 mm (17.6 in.) roll body length 900 mm (35.4 in.), 700-hp, 350/875-rpm, d-c drive motor.
   2. Stands No. 3 and 4: roll diameter 380 mm (14.9 in.), roll body length 900 mm (35.4 in.), 700-hp., 350/875-rpm, d-c drive motor.
   3. Stands No. 5 and 6: roll diameter 380 mm (14.9 in.), roll body length 900 mm (35.4 in.), 700-hp, 350/875-rpm, d-c drive motor.
c. Six intermediate stands, each driven by a 700-hp, 350/875-rpm, d-c drive motor. These motors are fed by a 3000-hp transformer-rectifier set:
   1. Stands No. 7 and 8: roll diameter 380 mm (14.9 in.) roll body length 900 mm (35.4 in.).
   2. Stands No. 9, 10, 11 and 12: roll diameter 300 mm (11.8 in.), roll body length 700 mm (27.5 in.).
d. Four finishing open stands, each driven by an 800-hp, 350/875-rpm, d-c motor, roll diameter 300 mm (11.8 in.), roll body length 600 mm (23.6 in.).
e. Six finishing tandem stands, roll diameter 250 mm (9.83 in.)., roll body length 500 mm (19.6 in.) driven by a 1500-hp, 300/650-rpm, d-c motor.

The motors of group (d) and group (e) are fed by one 3000-kw transformer-rectifier set.

The production of this rolling mill is mainly:
Wire rod of 5.38 mm (0.211 in.) diam.
Concrete reinforcing bars from 6 to 30-mm (0.23 to 1.10 in.) diam.
"T," channels and angles from 20 to 40 mm (0.78 to 1.58 in.).

Rounds from 10 to 30 mm (0.39 to 1.18 in.) and sections are finished at the four finishing open stands. The last of them is connected to the cooling bed by a roller table on which two flying shears are installed. Finishing equipment is installed such as straighteners, cold shear for cutting at length, and pilers.

Wire rod and rounds up to 8 mm (0.314 in.) are instead finished at the following six finishing tandem stands and are wound up in coils by four reels. The wire rod is delivered at 20 m per sec (3950 fpm) speed. A book conveyor transfers the coils to the storage.

500-mm (19.6 in.) 3-high mill—This is a conventional mill consisting of:

a. One 25-ton per hour heating furnace for 160 x 160-mm (6.3 x 6.3 in.) billets of 2.50 m (98.5 in.) length.
b. One 3-high roughing mill with 650-mm (25.5 in.) diam and 1800-mm (70.7 in.) length rolls, followed by a hot shear to cut sections up to

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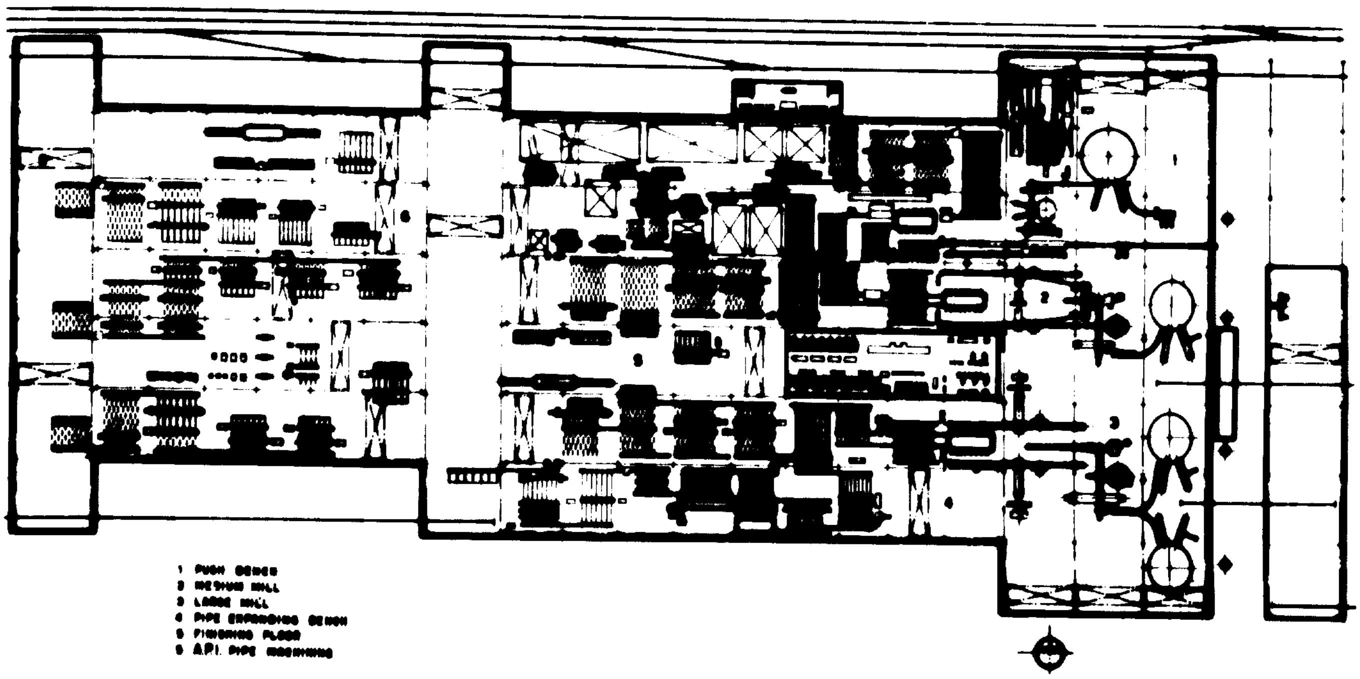


Figure 14 — The seamless pipe mill will be able to handle as much as 295,000 tons per year.

160 x 160 mm (6.3 x 6.3 in.). The mill is driven by a 1500-hp, 710-rpm, a-c motor.

e. Three 3-high finishing stands with 500-mm (19.6 in.) diam and 1600-mm (62.8 in.) length rolls for the first two stands and with 500-mm (19.6 in.) diam and 1250-mm (52.9 in.) length rolls for the third stand. These stands are driven through a reducing gear by a 2000-hp, 250/500-rpm d-c motor and are fed by a transformer-rectifier set. Mill speed can vary between 100 and 200 rpm.

On the delivery side of each stand there is a tilting table; on the delivery side of the third stand three hot saws are installed followed by three hot beds. Finishing equipment consists of two roller straighteners, a press and a cold shear.

The mill produces mainly angles from 50 to 100 mm (1.96 to 3.93 in.), channels from 65 to 120 mm (2.55 to 4.71 in.) and "I" beams from 80 to 160 mm (3.15 to 6.29 in.).

Type of sections—Nowadays rolled materials imported in Venezuela come from the U.S.A.; however, our proposal to adopt UNI standards has been accepted, pending the Coal and Steel Community unification.

Seamless steel pipe mill—It is planned to manufacture about as much as 295,000 metric tons (325,000 net tons) per year of seamless steel pipes and tubes from ½ to 24 in. diam through the following facilities, Figure 14:

a. One push bench for tubes from ½ to 5½ in. Estimated capacity 100,000 metric tons (110,000 net tons) per year.
b. One medium 2-stand pilger mill for tubes from 2⅜ to 7 in. Estimated capacity 60,000 tons per year.
c. One large 2-stand pilger mill for tubes from 6⅝ to 16 in. Estimated capacity 135,000 tons per year.
d. Hot tube expanding equipment to expand tubes made at the large pilger mill, up to 24 in. diam.

Push bench—This is fed with 127 to 178-mm (5 to 7 in.) billets. Hourly output 25 metric tons (27.5 net tons). Maximum number of pieces: 200 per hour.

The push bench consists of the following parts:

- One rotary hearth furnace for heating billets, rated at 25 metric tons (27.5 net tons) per hour, served by an automatic charging and discharging machine.
- One roller type sizing machine.
- One 400-ton horizontal piercing press to convert the sized billets into bottles with the inside of the bottom ogive shaped.
- One small rotary hearth furnace for intermediate reheating, served by an automatic charging and discharging machine, from which the bottles are transferred to the elongator.
- One elongator mill which also equalizes the wall thickness of the bottles. It is powered by a 1200-kw d-c motor. From this mill hollow blooms with solid bottom are obtained.
- One push bench for tubes up to 5½ in. diam. Maximum speed of the working stroke: 4.5 m per sec (14.7 ft per sec); constant return speed: 5 m per sec. (16.3 ft per sec). Complete set of mandrels from 66 to 133-m (2.66 to 5.22 in.) diam; maximum tube length: 12 m (39.4 ft).

The push bench is powered by two reversible, double wound motors, for a total power of 2500 kw fed by an adjustable voltage set driven by a synchronous motor.

The tubes obtained at the push bench are brought up again to hot working temperature in a walking beam furnace, the hearth of which is 14 x 3.6 (46 x 11.8 ft).

Starting from the discharge end of the furnace, the flow line divides into two separate branches designed to work alternatively according to the size of the tubes obtained from the push bench.

The first branch includes an 18-stand stretch reducing mill to produce tubes from 2 to ½ in., each stand consisting of two rolls. The reducing mill is driven by eight 120-hp d-c motors having a wide range of speed such as to allow a wide range of tube stretching. The motors are fed by a special converter set and have an automatic speed control. The second branch consists of a 7-stand sizing mill to size tubes from 5½ to 2 in., driven by a 200-kw variable speed d-c motor.

From the hot mills the hot rolled tubes are delivered to the cold finishing floor including straightening machines, cutting-off machines, automatic threading machines for API and standard pipes.

Medium mill—Rolls billets from 178 to 254 mm (5.84 to 8.37 in.), as well as 279-mm (9.17 in.) blooms. Output 25 metric tons (27.5 net tons) per hour. Maximum number of pieces 60 per hour.

The line starts with a rotary hearth furnace for heating billets, rated at 25 metric tons (27.5 net tons) per hour, served by two pinch type charging and discharging machines. The discharging is automatic.

The billets at rolling temperature are converted into bottles on an 800 metric ton (880 net ton) piercing press from which, after an intermediate reheating in a rotary hearth furnace, the bottles are fed to an elongator mill which also equalizes the wall thickness and opens completely their bottoms thus giving completely hollow blooms. The elongator mill is driven by a 1600-kw, d-c motor.

After leaving the elongator mill the hollows are delivered to the pilger mill stands, which are two and work in parallel alternately for manufacturing tubes from 7 to 2⅜ in.

The two pilger mill stands are driven by a single 80 to 175-rpm, 1500-kw, d-c motor placed in a central position. The hollow bloom is fed to the pilger mill by two feeders operated by 180-atmosphere hydraulic pressure.

The pipes obtained are brought up again to hot working temperature in a walking beam furnace with 15.5 x 3.8-m (0.861 x 0.149 in.) hearth and fed into a 9-stand sizing mill driven by a 200-kw, d-c motor. The sizing mill manufactures tubes from 7 to 2⅜ in.

From the hot working section the tubes are delivered to the cold finishing floor including one straightener machine, end machining equipment, hydraulic testing and final inspection. The finishing floor is specially equipped for pipes to be used in the oil industry.

Large mill—Rolls blooms from 279 to 330 mm (9.17 to 10.8 in.) and corrugated round ingots having 475 to 530 mm (15.6 to 20.8 in.) diam. Maximum output is 50 metric tons (55 net tons) per hour. Maximum number of pieces is 40 per hour.

The mill is equipped with two 25-metric ton (27.5 net ton) each rotary hearth furnaces served by charging and discharging machines. The blooms or ingots are pierced on a 1200-metric ton (1320 net ton) press. The operating cycle is then similar to that of the medium mill and the machines are the following:

- An elongator mill driven by a 1800-kw d-c motor.
- Two pilger mill stands working in parallel. Each stand is driven individually by a 35 to 90-rpm, 1600-kw, d-c motor. Both stands are provided with feeders operated by 180-atmosphere hydraulic pressure. The pilger mill produces tubes from 184 to 438 mm (7.23 to 17.2 in.) outside diameter.
- A walking beam furnace with 15.5 x 5-m (51 x 16.4 ft) hearth.
- A 5-stand sizing mill; three of these stands are driven by a 110-kw, d-c motor each. This mill manufactures tubes from 16 to 7 in.
- Cold finishing floor similar to that of the medium mill.

Hot tube expanding equipment—Starts from the hot rolled pipes produced in either pilger stand of the large mill. Maximum output 25 metric tons (27.5 net tons) per hour. Maximum number of pieces 12 per hour. A furnace is provided for heating one end of the pipe, which is then expanded and bell-shaped on a 450 to 700-metric ton (495 to 770 net tons) press. Then the end expanded pipes are heated throughout their length in a furnace having 15 x 6-m (49.2 x 19.7 ft) hearth.

The tubes are next conveyed to the hot expander draw bench, and the bell shaped end is spray-cooled and held firmly. By making proper bars—having expander plugs fitted on—to be drawn through the pipe, by the end of the operation the pipes can be expanded to diameters up to 24 in. outside diameter.

The expanding machine has a power of 100 metric tons (110 net tons) and is driven by a 600-kw, d-c motor fed by an adjustable voltage generator set.

This line also includes a cold finishing floor for tube end machining and hydrostatic testing facilities.

Wire drawing plant—The wire drawing plant, Figure 15, is fed by wire rod rolled at the semi-continuous wire rod mill. Its yearly production program is the following:

	Metric tons	Net tons
Black annealed wire	8,800	9,670
Galvanized wire	2,150	2,360
Barbed wire	14,850	16,300
Nails	1,200	1,320
Total	27,000	29,650

The plant is enclosed in a tubular structure building divided into several bays arranged in such a way as to allow a functional flow of the material in the course of processing.

The coiled rods storage and the pickling bath are located in the incoming material bay. From here the rod is handled to the draw benches (15 units).

After drawing, the wire that will only be annealed is sent to two annealing furnaces. The wire to be galvanised is sent to two 32-strand continuous hot dip galvanising lines with continuous lead bath annealing equipment. For barbed wire production there is a set of 32 machines. The nail machines (12 units) are kept separate owing to their noisiness.

Within the building there is ample room for storing the incoming coiled rods and the wire products. Provision has been taken for extending the building for the eventual enlargement of the plant.

Iron foundry—The integrated plant includes a pig iron foundry, Figure 16, for making ingot molds and stools as well as spun iron pipes.

The above are the main products. However, there are also facilities for small miscellaneous iron castings, which may be needed for maintenance and other uses, as well as facilities for small bronze castings.

As metallurgical coke is not available in Venezuela, cupolas cannot be operated; and therefore the foundry is fed with liquid charge which is processed and reheated in electric arc furnaces.

One ore reduction furnace is accordingly run for making foundry pig iron while the others make hot metal for the open hearth. As the production capacity of one 33,000-kva furnace is somewhat above the foundry needs, this pig iron excess is used in the open hearth charge either mixed with the hot metal from the other reduction furnaces or as cold pigs obtained at the pig casting machine. Also the rejected and scrapped ingot molds and stools are to be charged into the open hearths.

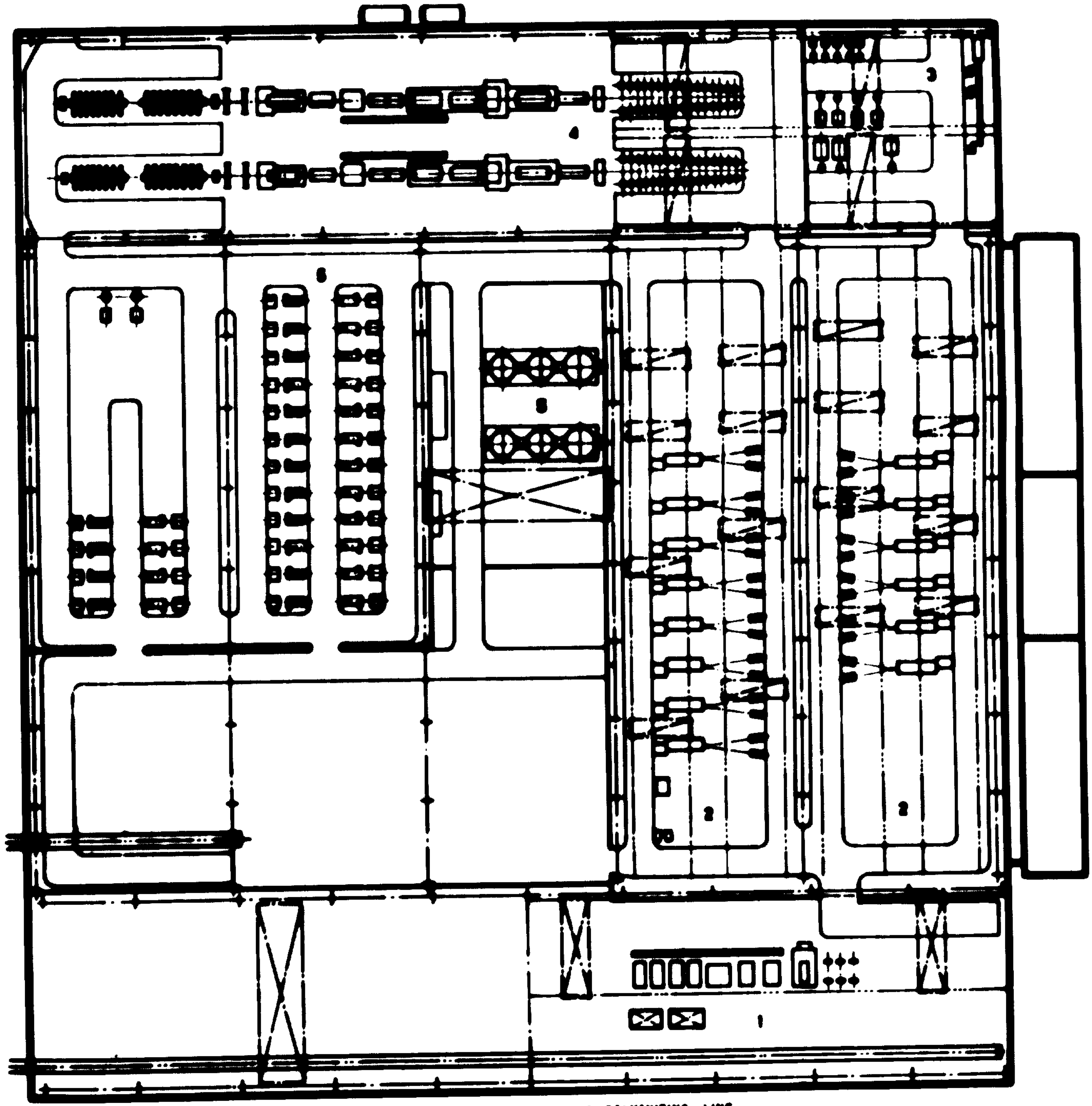
The foundry is enclosed in a building consisting of a transverse bay made up of structural steel framing and of several longitudinal bays in tubular steel framing. The total area is 26,000 sq m (280,000 sq ft) on a rectangle of 224 x 112 m (734 x 768 ft).

In the transverse bay there are the following facilities: molten pig iron arrival station, a 150-ton (165 net ton) mixer for the pig iron, two 10-ton electric arc furnaces and three 6-ton induction furnaces.

In one of the longitudinal bays, besides the centrifugal casting machines, the pipe finishing, testing and tar coating facilities are located. The iron pipe sizes produced will range from 50 to 150-mm (1.96 to 5.9 in.) diam, 2 m (6.55 ft) length, for civil engineering use (downspout, sewer and water drains), and from 50 to 400-mm (1.96 to 15.7 in.) diam and 3 to 4 m (9.83 to 13.1 ft) length for conduits.

In the other bays, the equipment is located for ingot

Figure 16 — Plan of wire drawing plant.



1 PICKLING
2 WIRE DRAWING MACHINES
3 NAIL MACHINES
4 GALVANIZING LINE
5 ANNEALING FURNACES
6 BARBED WIRE MACHINES

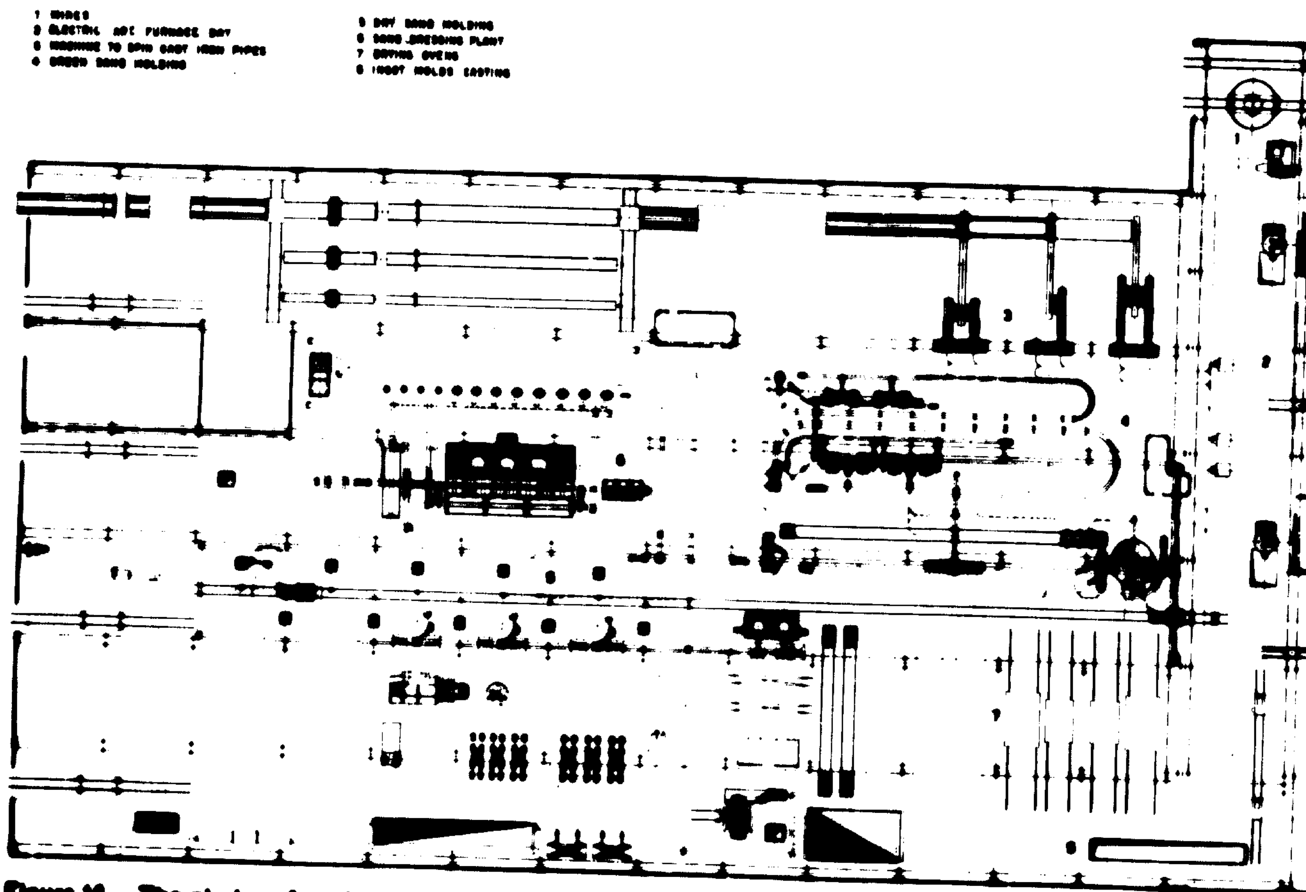


Figure 16 — The pig iron foundry makes ingot molds and stools as well as spun iron pipe.

mold and stool casting as well as for medium and small miscellaneous castings (core drying ovens, casting platform, etc.).

The foundry equipment is completed by a wholly mechanized sand dressing and handling plant.

BUILDING AND CIVIL ENGINEERING WORKS

Structures—roofs—siding—All the buildings are made of steel structures. Two leading ideas have been followed: for the light buildings (warehouses, mechanical shop, seamless pipe mill, wire drawing plant and foundry) tubular structures have been adopted; for the heavy buildings (reduction furnaces, open hearth, rolling mills) standard heavy structural framing has been adopted.

The roof deck is of aluminum sheets with glazing of transparent plastic sheets along the monitors.

The external cladding is aluminum sheeting with interposed transparent plastic sheet glazing. At the base there is a 2.20-m (7.1 ft) high wall of concrete blocks. Continuous openings all along the perimeter of each building provide for a good inside air circulation.

Owing to the plant location being in a tropical region, the aforesaid kind of highly reflecting roofing and cladding, better than any other material, insures comfortable living conditions inside the buildings.

Site conditions—foundation construction—drainage—To obtain a flat 2-km² (0.772 sq miles) area, over 6,000,000 cu m (7,850,000 cu yd) of soil have been moved. The site elevation of the plant is 45.40 m (149 ft); the amount of excavation above said elevation has more or less compensated the filling.

The soil has a top layer which was satisfactorily compact but immediately underneath, it was ma[...] very soft and friable. Its bearing capacity could [...] be assumed above 0.5 kg per cm² (7.1 psi). Theref[...] all the foundations required piles or wide reinfo[...] concrete slabs.

Up to September, 1958, during soil tests and exc[...]tions, no underground water layer has been stru[...] During the execution of the pier foundations in [...] Orinoco very solid rock has been reached at onl[...] to 5 m (13.1 to 16.4 ft) under the mud layer depos[...] on the river bottom.

The huge caisson enclosing the water intake [...] pumping station of the process water system is be[...] sunk within the solid alluvial banks of which the ri[...] bottom is made up in that location.

Provision has been made for the construction o[...] huge drainage and sewer system for disposal of [...] process waters (cooling and other uses in the plant)[...] well as the heavy rainfalls which during the rai[...] season reach considerable amounts, 60 to 65 mm (2[...] to 2.55 in.) in one hour. The main culvert is up to 2.5[...] (8.2 ft) diam.

SERVIC[...]

Also for the services, this discussion will indic[...] only the main characteristics.

Electrical distribution is shown in Figure 17.

Switch station—All the electricity for the Works [...] supplied by the Caroni hydroelectric power pla[...] through four overhead 115-kv lines to a switch stati[...] belonging to Electrificatiòn del Caronl. From th[...] station four lines are run direct to feed the electr[...] furnace receiving substation (R1), and two to anoth[...]

18

A 5-stand sizing mill; three of these stands are ...

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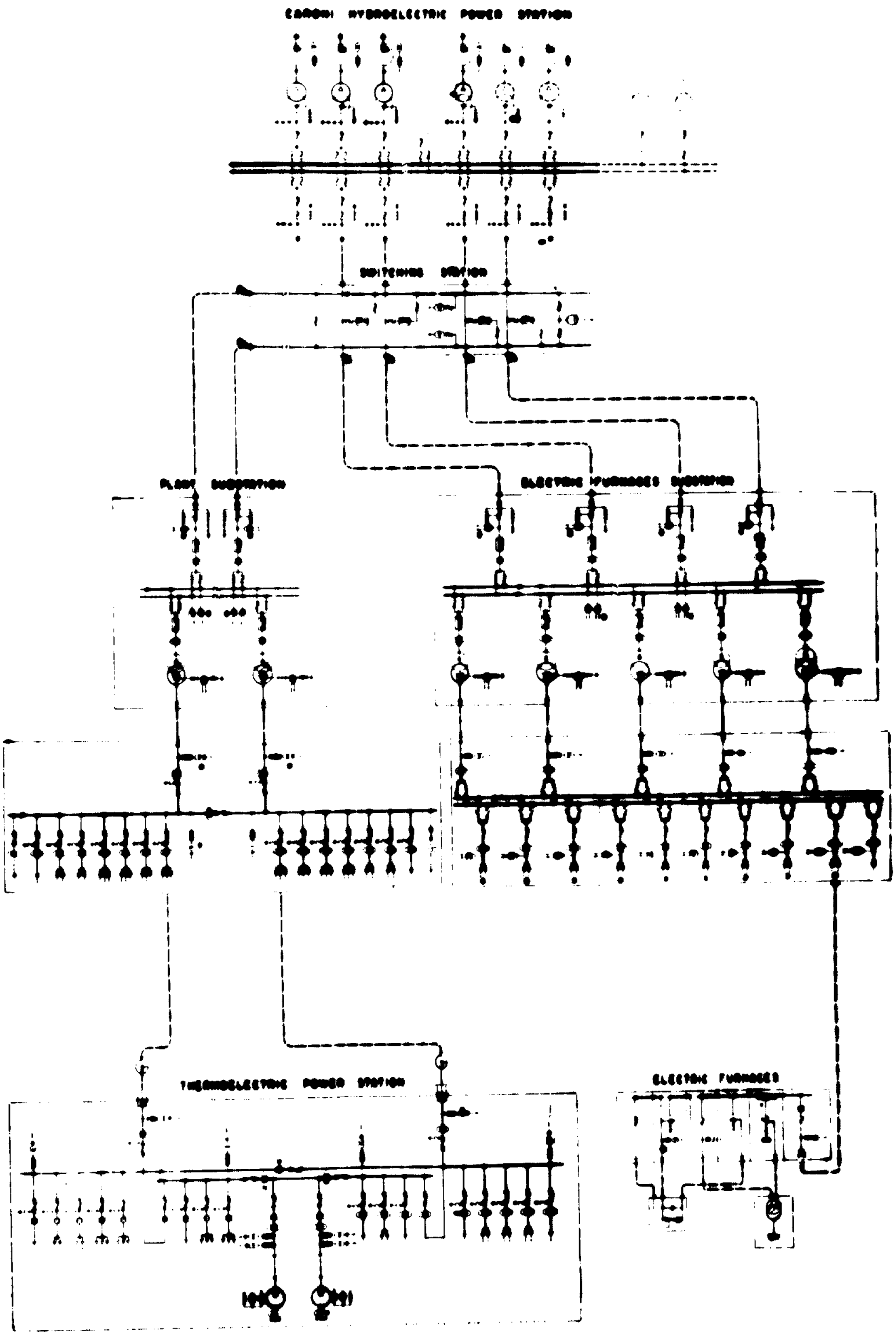

Figure 17 — Single line diagram of plant electrical distribution system.

substation (R2) for all the other needs of the works.

Electric furnace substation (R1)—This steps the incoming power down to 22-kv through five 55,000-kva transformers and a double bus bar system on the 11.5-kv side. Also on the 22-kv side there is a double bus bar system to which 11 lines are connected for feeding at 22-kv the nine electric smelting furnaces, the electrode paste plant and the electric furnaces of the foundry.

Works substation (R2)—This is equipped with two 40,000-kva transformers stepping the power down from 115 to 13.8 kv. It is fed by the two 115-kv lines coming from the switching station through a double bus bar system. On the 13.8-kv side, however, there is a single bus bar system with feeders to the various departments (seamless pipe mill, blooming mill, 800-mm (31.4 in.) mill, 500-mm (19.6 in.) mill, wire-rod mill and thermoelectric power plant). All these feeders are double and symmetrically located.

Thermoelectric power plant substation—As said above, a power plant equipped with two boiler-turbogenerator sets feeds the privileged services of the Works.

Excepting the rolling mills and the seamless pipe mill, which are fed directly by the R1 substation, the feeders to all the other departments and services are centralized in this substation.

Two 13.8-kv incoming lines from R2 substation feed a bus-bar (1); from this the feeders for the various departments and services depart as well as two feeders for a second bus bar (2) to which the two generator sets of the power plant are connected. From this second bus bar the lines feeding only the privileged services depart. Such services may be fed by bus bar (1) and bus bar (2). These two bars are generally not in parallel but may be put that way. All this distribution is at 13.8 kv. From here the department distribution is done through local substations which distribute at 4160-volt and 440 volt, 60 cycles.

Department substations—From the above substation switchboard double feeders depart for feeding the various department substations.

The plant distribution system has been divided into six zones each of them being fed by two feeders from which the department substations of the same zone are derived. The zones are the following:

Zone 1—Process water and pier.
Zone 2—Electric furnaces auxiliary services.
Zone 3—Open hearth, coke plant and coal yard.
Zone 4—Foundry auxiliaries, wire drawing, seamless tube mill auxiliaries, main office building.
Zone 5—Maintenance shop, five substations for rolling mill auxiliary services.
Zone 6—Ore stockyard and sintering.

The double feeders to the substations of zones 1, 2 and 3 are derived, one from bar (1) of the thermoelectric substation (fed by outside current) and the second from bar (2) of the same (fed by the turbogenerator).

The feeders to the substations of zones 4, 5 and 6, however, are derived by bar system (1) fed by outside current.

The 13,800/440-volt transformers of these substations have been standardized in two classes: 1500 kva and 1000 kva.

Summing up, the electrical distribution throughout the plant is done as follows:

Alternating-current system:

At 22 kv only for the electric furnaces (transformers of the furnaces).
At 13.8 kv for some high capacity drives and for the transformer substations.
At 4160 volt for the normal industrial uses.
At 440 volt for the low-voltage circuits.

The motors above 5000 hp [the motor-generator set with flywheel motor, the 800-mm (31.4 in.) mill motor-generator) set motor] are at 13.8 kv. Motors from 300 to 5000 hp are at 4160 volt. Motors under 300 hp are at 440 volt.

Direct-current system—For the main drives of the rolling mills, direct current is generated by proper sets or rectifiers. For some mill auxiliaries (blooming mill screwdown, manipulators, mill tables), where reversals are frequent, d-c variable voltage sets have been adopted. For other services (other mill auxiliaries, steel

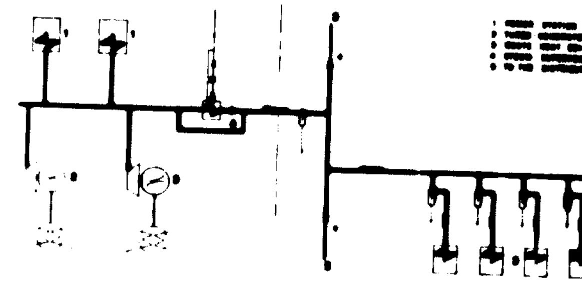

Figure 18 — Steam generator and distribution sche

shop cranes) constant 230-volt direct current i

Electric lighting—The plant lighting consists o systems:

a. Roadway lighting is done through lanterns mounted at about 11 m (36 ft) with an ap mate spacing of 30 m (98.5 ft). Lamps, each, are used within Zeiss bowls, and t luminating intensity is about 15 lux (1.5 candles).
b. Yards are illuminated by projectors mount platforms at the top of 20-m (65.7 ft) sel porting towers. The projectors can be ori and are fitted with 1000-w mercury lamps, illuminating intensity is about 15 lux.

Steam generation and distribution—This is show Figure 18.

Thermoelectric power plant—As said above, the p plant consists of two 30-ton per hour, 30-atmosp 400-C (742 F) boilers and two 3-phase, 7500-kva, kv, 60-cycle generators driven by 30-atmosphere, 3 (717 F) steam turbines.

This electrical generating plant has been planne view of insuring safe operation of the vital servic the works. In fact the power plant will be opera round-the-clock to generate—on a separate syste only that portion of power needed for feeding a of the privileged services (pumps, steel shop and e tric furnace d-c cranes, gas exhausters).

The expansion of the power plant, in case of enla ment of the works, will be done through the addi of other boiler-turboalternator sets.

The boilers will be fired with electric furnace and c oven gases available after Works demands have b satisfied and with fuel oil for the balance.

Open hearth waste heat boilers—The open hear are equipped with water tube waste heat boil These too have been designed for a working pressure 30 atmospheres; the super heated steam will be suppl at about 350 C (662 F). From each boiler an aver steam generation can be expected of six to seven tons hour. Altogether there will be about 24 to 28 tons hour of steam availability with four open heart operating and about 18 to 21 tons per hour when o of the open hearths is under repair.

As the Works' uses (fuel oil preheating and atomizin coke plant by-products, pickling bath heating a others) will require abut 15 tons per hour, there is surplus of steam generated by the waste heat boile available for other uses.

Steam distribution system—Provision has been ma

A 5-stand sizing mill; three of these

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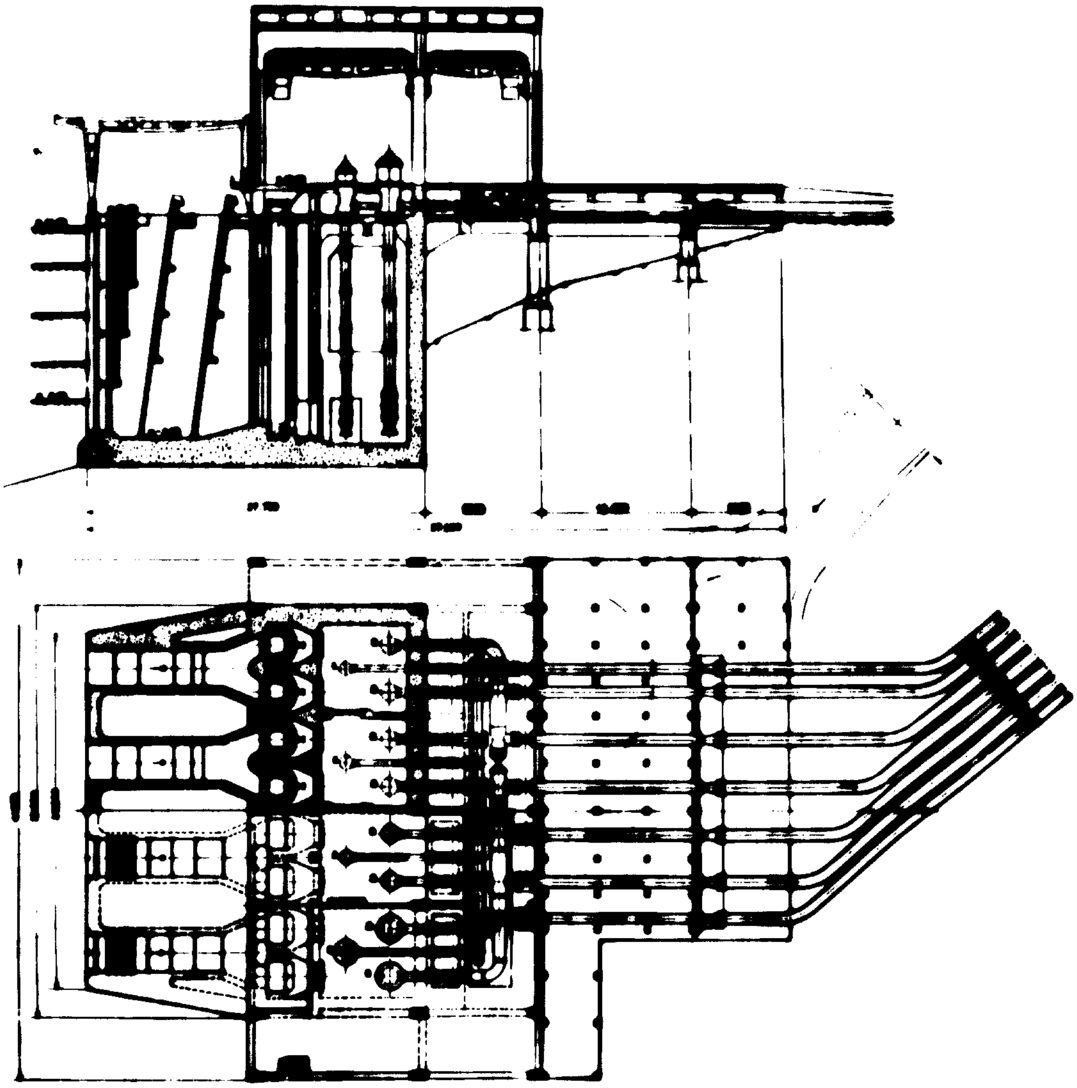


Figure 19 — This pump house supplies process and power house water.

for the installation of a steam main operating at 30 atmospheres linking the waste heat boilers with the power house. Every available amount of steam from the waste heat boilers will be used for driving the turbines of the power house; conversely, were all or part of the waste heat boilers not operating, the power plant will supply steam to the network. In this way a balanced system has been realised.

On the main many steam traps are fitted; at the entrance of the main into the power plant an independent superheater is installed for restoring the steam conditions for use in the turbines.

From the aforesaid main, through pressure throttling valves, the network is derived for the distribution to the Works' uses at 15 atmospheres.

Process water system—Shown in Figure 19 is the pump house.

The requirement of cooling water for the various departments and services is about 18,600 to 20,600 cu m per hour (81,800 to 90,700 gpm) of which 16,600 (73,000) are used in the main productive departments and 2000 (8800) to 4000 (17,600) in the condensers of the power house.

To meet this requirement a huge intake was erected, consisting of a large caisson 33 m (108 ft) long and 27.7 m (91 ft) wide sunk in the river bottom near the bank. This intake which is built for an ultimate capacity of above 45,000 cu m per hour (197,000 gpm) is divided into four longitudinal sections, each one provided with gates, grates and filters. The pumps, of the submerged type with long vertical drive shaft, are located within pits having a section of 7.2 x 7.35 m (23.6 x 24.1 ft) and a depth of above 18.5 m (60.8 ft).

The caisson bottom is 2.5 m (8.2 ft) under the lowest river level. The caisson top is at 15 m (49.3 ft) above. Altogether it is 17.5 m (57.5 ft) high, the river level difference from low to high water is about 13 m (42.7 ft).

In each pit there are fitted three pumps. Room has been left to add five more units. The process water (16,600 cu m per hour) (73,000 gpm) must be pumped at a pressure of 118 m (380 ft) [45-m (147 ft) static head + 25-m (82 ft) friction loss + 48-m (157 ft) pressure on Works floor].

The cooling water for the power station condensers (2000 to 4000 cu m per hour) (8,800 to 17,600 gpm) will be pumped at a pressure of 82 m (269 ft) [45 (147.5) + + 17(55.7) + 20 (65.6 ft) respectively].

In that way there are two separate systems of cooling water: one for the plant and one for the power station. For the first one, four 4700 cu meter per hour (20,700 gpm) pumps and one 2500 cu meter per hour (11,000 gpm) pump are provided, for the second three 2000 cu meter per hour (8800 gpm) units.

Distribution to the plant is done through three piping systems with 900 mm (35.3 in.) diam (in the future five) and one with 800 mm (31.4 in.) diam (in the future two)

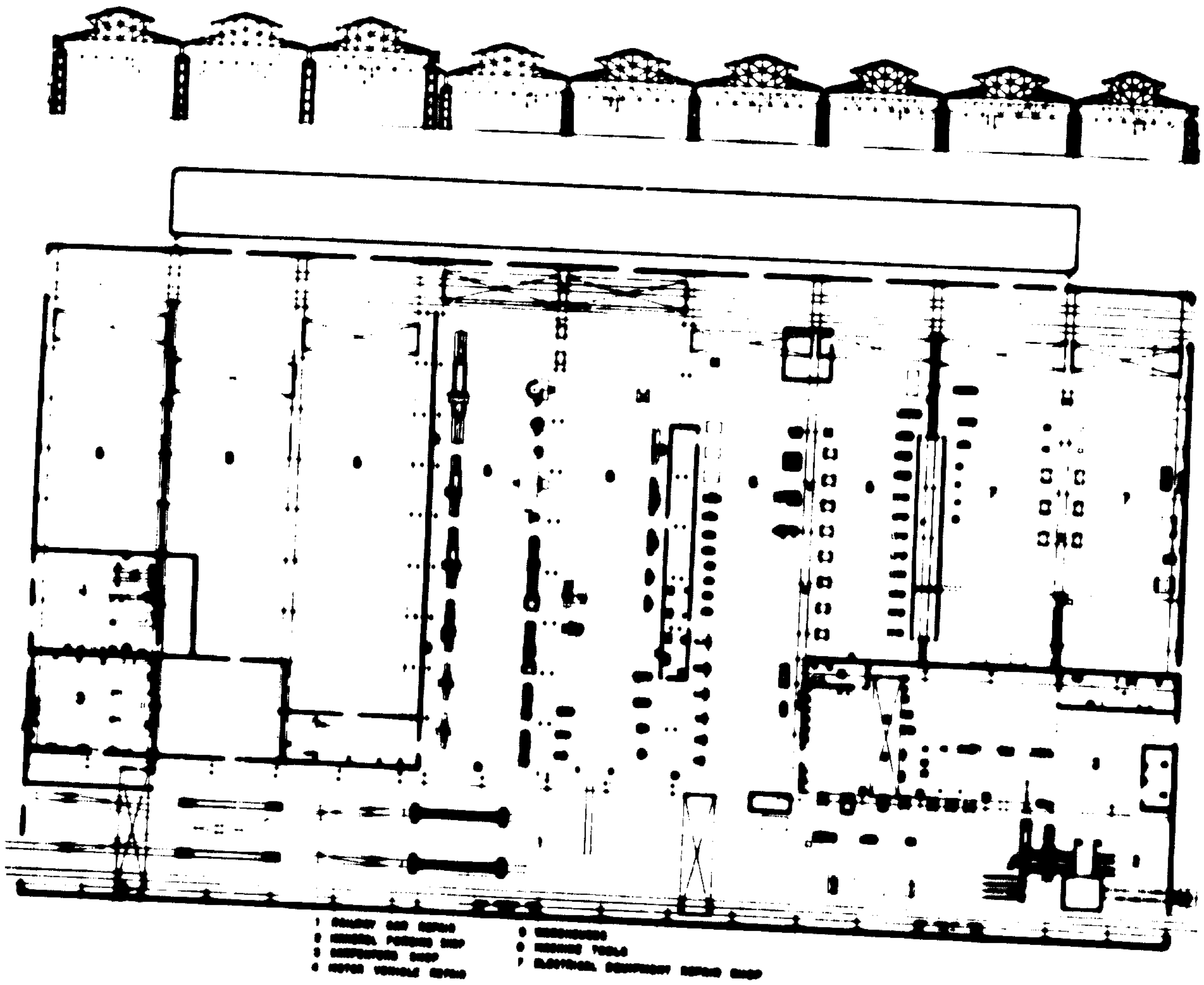


Figure 20 — Floor plan of the mechanical shop.

respectively, departing from the main headers sectionable in various sections. The main pipes are provided with suitable equipment to attenuate water hammer (bottles fitted with check valve, by-passes and air inlet valves). From the three aforesaid mains, water is delivered to a distribution station (valve house), from which it is supplied to the various departments through a loop system. By operating valves and by connecting adjacent loop systems it is possible to isolate any section of piping for repairing and other purposes without interrupting the service.

A 3500 cu meter (925,000 gal) piezometric water tower in reinforced concrete assures a constant pressure and water supply to the plant for about 12 min; this time is broadly sufficient to start other pumps or to switch any of them in either of the two electric systems.

In fact the operation is foreseen as follows: one part of the pumps is fed by external power, the other by the power house. These two electrical feeding systems are independent and do not work in parallel. Therefore, in case of a shutdown of one of the two systems, the other part of the pumps will not be discontinued and the piezometric reservoir will allow the operators to make the proper switching.

Gas distribution—The gas distribution throughout the plant is done through two separate systems: one for the reduction furnace gas and the other for the coke-oven gas.

The electric reduction furnace gas has a heating value of 2500 cal per Nm^3 (0.281 Btu per cu ft) and consists mostly of CO; its output is 450 to 650 Nm^3 per ton (1580 to 2290 cu ft) of pig iron. Each of the reduction furnaces is equipped with a booster and a scrubber so that the gas is delivered into the network washed and cleaned. It is distributed so as to be used mostly at soaking pits, continuous reheating furnaces of the rolling mills, sinter plant, coke ovens and finally at the power house in which all the excess resulting is burned. The main distribution pipe has 1600-mm (63 in.) diam.; it is connected to a 20,000-cu m (707,000 cu ft) gas holder.

The coke-oven gas has a heating value of 4,800 cal per Nm^3 (540 Btu per cu ft), and its output is about 350 Nm^3 (11,200 cu ft) per ton of coal. It is distributed to the coke-oven plant for heating the ovens and to the steel shop for firing the open hearth furnaces. The portion of gas for the steel shop is desulphurized. Possible excess resulting from above is used in the power house. The distribution main has 1200-mm (47 in.) diam, and it is connected with a 20,000 cu meter (707,000 cu ft) gas holder.

For both the mill reheating furnaces and the open hearth, together with the gas, some fuel oil or tar will also be use to carburize the flame and make it luminous. The seamless pipe mill furnaces are only fuel oil fired.

In arrangement of the two gas distribution pipe systems the possibility of adding a third main for blast furnace gas has been taken into account in case the pig iron output expansion be eventually realized through the installation of a blast furnace instead of more electric furnaces.

The three gas systems are kept separated, and the possible mixtures are made at the consumption centers.

Fuel-oil distribution system—Owing to the plant location, fuel oil supply is done through large tankers comingfrom the ocean. Therefore one big tank, having a capacity of 6000 cu m (1,580,000 gal) will be installed outside the plant site on the river bank and near a docking point for which it is contemplated to use a barge, properly adapted, which during the erection of the plant has been used as a provisional pier.

A pumping station and a pipeline will feed a 1000 cu meter (264,000 gal) tank installed centrally in the plant area. From this fuel oil will be distributed to the consumption centers.

Transportation—Raw materials, sinter and coke are all handled by belt conveyors from disembarcation to stocking and from reclaiming to consuming centers.

Hot metal, steel, semi-finished and finished products are moved from one department to another through railroad. The track gage is the standard one, i.e., 1435-mm (4 ft-8½ in.), 100-lb per yard rails and railway material comply with AREA specification. Wooden ties are spaced at 60 cm (23.6 in.) in the heavy traffic tracks (from the electric furnace to the open hearth and to the rolling mills as well as from the pier to the plant) and spaced at about 72 cm (28.4 in.) in the remainder of the trackage. The maximum grade in the track connection between the pier and the plant is 1.7 per cent. The minimum radius is 120 m (394 ft). The total length of the tracks is around 50 km (31 mile). The rolling stock will be moved by diesel-electric locomotives of the double bogie type and with a working weight of 65 and 80 metric tons (88 net tons), for a maximum speed of 30 km per hour (18.6 mphr).

A large roadway network allows for a considerable internal traffic by trucks complying with the present trend in modern plant transportation.

Maintenance shop—An over-all scheme has been developed for the maintenance department (Figure 20) so as to make it the basis for a centralized maintenance system, keeping in mind the special requirements which will be encountered in an integrated iron and steel plant and particularly for one located in a relatively new region situated at a considerable distance from sources of supply.

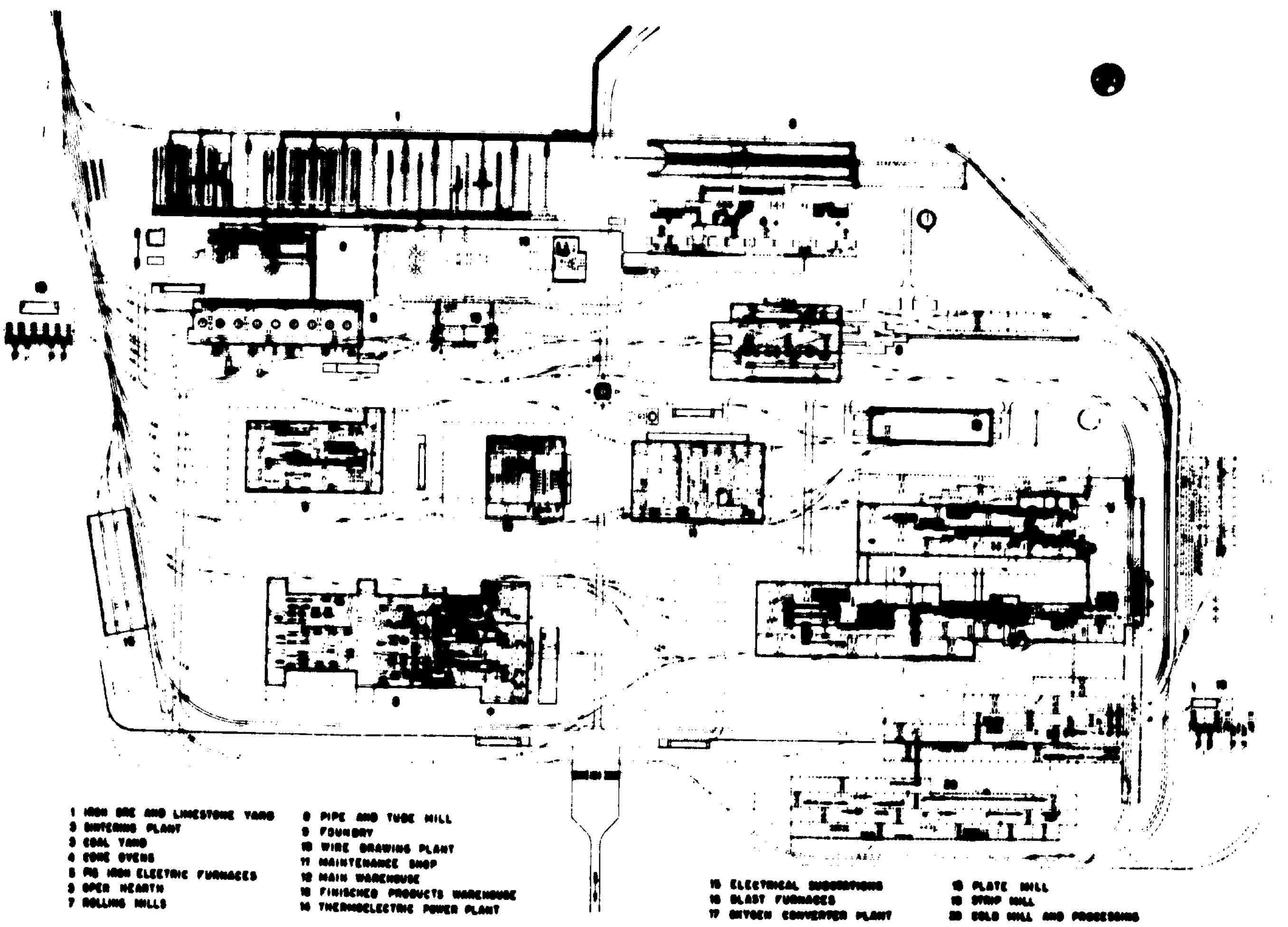
Besides the machine tools proper there is also a forge and blacksmith section, a section for manufacturing and repairing electrical equipment, a section for repairing rolling stock and motorcars, carpenters and cabinetmakers section, etc.

The maintenance building, in tubular steel structure, represents 29,000 sq meters (311,000 sq ft) (228 x 127 m) (749 x 416 ft) and is divided into 11 bays with 11 overhead traveling cranes.

OFFICES AND PERSONNEL SERVICES

Main office building—The main offices of the plant

Figure [illegible] — This plan shows some possible future expansions which might be made to attain an ingot capacity of 1,[illegible] tons per year.



will be housed in a large 8-story building in reinforced concrete located in an elevated position on the access road to the plant. In this building all the offices will be housed for plant management, general engineering, accounting, drafting rooms and research laboratory.

For local administration each plant department is provided with its own office block conveniently situated.

Personnel services. Four separate buildings are in the course of construction containing sanitary facilities and locker rooms. Each of them is sized for 800 persons and is located in a proper position near the relative departments.

PRELIMINARY STUDY ON POSSIBLE FUTURE PLANT EXPANSIONS

In this second plan, Figure 21, some possible future expansions are indicated to attain the ingot steel capacity of about 1,500,000 metric tons (1,650,000 net tons) per year. However, it is to be pointed out that for the time being it is only a matter of planning indicating eventual possibilities.

The increase in output of pig iron is contemplated with blast furnaces. Room has been left for two units. On the same alinement of the present coke ovens other batteries would be built to be fed with high grade coals suitable for making metallurgical coke. These batteries would be of the fully conventional type.

The coal yard would be prolonged accordingly. The ore yard would be doubled: an arrangement in a sense symmetrical to the present one has been contemplated. That way, there would result another complete group—storeyards, sinter plant, blast furnaces.

For the increase of steel production contemplated in the field of flat rolled products, the installation of an oxygen top-blown converter steel shop has been envisaged. Its location is indicated in the plan of Figure 21. Room has also been left for additional open hearth furnaces.

As of today there is no final program concerning the future expansion of the rolling mills. We have studied a possible expansion plan which specially keeps the door open to any possible manufacture of a wider range of steel products.

In the plan of Figure 21, the installation is indicated of a 360-mm (14.1 in.) merchant mill, which, as far as the product range is concerned, would fit well between the two existent 500-mm (19.6 in.) and 300-mm (11.8 in.) mills. A continuous billet mill is contemplated for feeding the three aforesaid mills and eventually selling billets to others.

We have also indicated the possibility of installing a 4-high reversing stand followed by a tandem continuous mill for rolling heavy plates and coils.

This semi-continuous unit could be fed by slabs prerolled from slab ingots at the same reversing stand and from slabs rolled at the present blooming mill. Some heavy plates could also be rolled directly from slab ingots.

The hot rolled strip may be partly hot finished and, for the remainder, cold finished. An underground transfer could bring the hot strip coils to a cold rolling and finishing department of proper capacity.

As already stated, all of this is just a matter of general outline giving various potential solutions.

OVER-ALL STATUS OF ENGINEERING AND OF CONSTRUCTION WORK

In the Milano offices of our company the general engineering was almost finished, in September, 1958. The numerous detailed studies were underway. All of the most significant orders were placed.

A Works management controls the erection and setting up of the plant at the field.

The layout of the plant was established in the meetings held in Caracas in October, 1956, and January, 1957, by the Venezuelan authorities, Rumseyer and Miller and Innocenti.

The works in the field were actually started in March, 1957.

On April 20, 1958, the first seamless tubes have been rolled at the large mill. The buildings for the warehouses, wire drawing plant, iron foundry, maintenance shop and seamless pipe mill have been completed.

As of September, 1958, more than 3000 men were working in the field. The pier was built to a length of 80 m (262 ft). The erection of the electric reduction furnaces was started. The foundation of the open hearth shop was underway. The erection of the rolling mills building was also started. General services and facilities installation was underway.

All the works will be in the main finished within 1960, and during the following three to four months all the departments will be ready to operate.

ACKNOWLEDGMENT

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