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PARTICIPATION OF DEVELOPING COUNTRIES IN THE WORLD IRON ORE MARKET 1/

by

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S U M M A R Y

The paper examines the evolution of iron ore and steel production in both the world and the developing countries, and also studies the correlation between them.

The representative curves for the production statistics used in the paper were substituted by straight lines derived by the method of least squares. No shifting was applied to these straight lines to take account of special situations or trends. They can therefore be interpreted as curves of natural growth of the 1970s.

The study comprises an appraisal of existing and likely increases in production, so that the mining and iron and steel industries in the developing countries can continue to make a significant contribution to their respective economies.

Based on this appraisal and in order to achieve the purpose of the paper, the author considers the suitability of setting up agreements between producing and consuming countries, aiming at a plan for the merging of their common interests.

In general terms, developing countries producing iron ore offer more favourable conditions for beneficiation and pelletising of iron ore than consumer steel works, located close to densely populated areas, in view of the problems of environmental pollution. This favours the increased industrialisation of the iron ore, which in turn provides the opportunity for an increase in the foreign exchange earnings of the exporter country.

This paper is an attempt to analyze the means that would be required by the iron ore mining and steel industries to further the economy of developing countries.*

The author manifests the thesis that the aforesaid development could be appreciably increased, provided it is possible to establish cooperation between "producers" and "consumers". This cooperation could rest on a system of associated interests between the aforesaid suppliers and consumers, covering in an adequate way the supply of these products and the necessary financing to meet the plan to be established for this cooperation.

The analysis presented rests on the possible trends of the developments of the iron ore and steel production so that these products may, effectively, contribute toward the economy of the developing countries. Within this line of thinking, some aspects concerning iron ore, prereduction and steelmaking are looked into in the following lines.

In the period of 1960/71, the production of crude steel shown in Graph 1 can be satisfactorily substituted by a straight line, the angular tangent of which is 25.0%.

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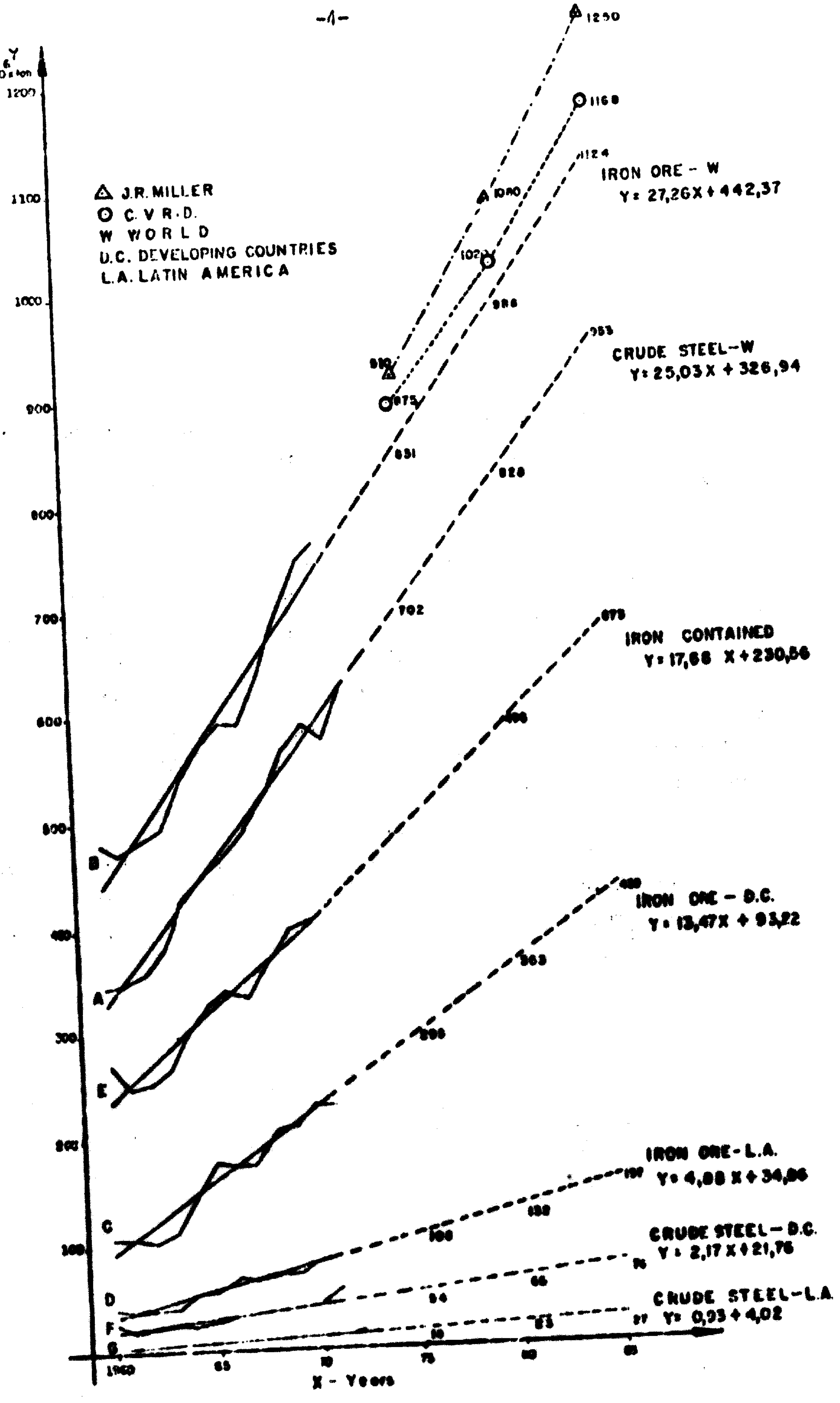
* The ideas set forth in this paper reflect the thoughts of the author, under his exclusive personal responsibility.


Y
10⁶ x ton
J.R. MILLER
C.V.R.D.
W WORLD
D.C. DEVELOPING COUNTRIES
L.A. LATIN AMERICA
IRON ORE - W
Y = 27,26X + 442,37
CRUDE STEEL-W
Y = 25,03X + 326,94
IRON CONTAINED
Y = 17,68 X + 230,56
IRON ORE - D.C.
Y = 13,47X + 93,22
IRON ORE-L.A.
Y = 4,88 X + 34,86
CRUDE STEEL - D.C.
Y = 2,17 X + 21,76
CRUDE STEEL-L.A.
Y = 0,93 + 4,02
X - Years

Graph 1

During this same period world iron ore production (line B) can be represented by a straight line with an angular tangent of 27.26. It will be noted that in the aforesaid period these lines are almost parallel. As of 1971 and up to 1985, the directional forecasts of these curves differ considerably from the straight lines referred to here and to a greater degree. Thus, for a value of 828 million tons of steel, which the straight line indicates as the production for 1980, forecasts by Jack Miller and others position it around 910 million tons. For the same year of 1980, our line indicates a production of 988 million tons of ore when other forecasts place these values between 1,020 and 1,080 millions of tons. For the year of 1985, these discrepancies are even more pronounced. The author believes that the horizon beyond 1980 is too unprecise for numerical attributions and will be happy enough if the analysis which he proposes to realize is valid, at least qualitatively, up to that year. If, in Graph 1, we look at curves C and D, we will see that the angular tangent of the straight line representing iron ore production of the developing countries is 13.47 and the identical line representing Latin America is 4.88, which signifies that the world production increases twice as fast as that for the developing countries and five times faster than that for Latin America.

About 70 countries exploit iron ore of a metallic content varying between 22 and 68%. This wide range requires upgrading with varying degrees of sophistication, in order to meet the ever increasing and rigid specifications imposed by the steel industry.

The intensity in the exploration of iron ore and its beneficiation is, obviously, extremely variable from country to country. Thus, among approximately 70 countries which are dedicated to this industry, about 55 of them could

be rated as developing countries, and, therefore, among those which, in a general way, dispose of less technological, economic and financial resources, and often political, to be able to take advantage of this mineral wealth.

To exemplify, we will consider the years 1960 and 1971. In 1960, the world iron ore production was 467.8 million tons, and that of the developing countries was 109.5. In 1971, these values were 757.5 and 256.8, respectively. It derives, therefore, from this period, that a zone where the participation of the developing countries, as compared to world production, oscillates between 22.2 and 30.6%. Thus, half the producers supplied only 1/3.

Table I contains the data concerning the period mentioned. Of the 35 developing countries only about 35% produce, by themselves, more than 5 million tons per annum, selecting the year of 1971 to estimate this rate.

In this picture, the position of Latin America offers the following participation indexes in the world production - in 1960, 8.6% and in 1971, 11.9% -, considering that among the 7 countries in question, 5 produce, each one of them, well over 5 million tons per annum. Analyzing Graph 1,it will be noted that it is highly probable that the divergence of the straight lines B and C will persist. Should this situation continue this raw material will not appear in any significant figures in the export statistics of several countries. In an attempt to improve this situation, one could conceive that the creation of stable conditions for production, and,consequently, confidence in the future, would be decisive. The author believes that this scheme may be achieved provided that the angular tangent of line C trends to equal line B.

TABLE I

WORLD IRON ORE AND STEEL PRODUCTIONS

(In millions of metric tons)

Years	Iron Ore (World)	Iron Ore (Developing Countries)	Iron Ore (Latin America)	Iron Ore Developing Countries Total	Crude Steel (World)	Crude Steel (Dev.Countries)	Crude Steel (Latin America)
1960	487,0	109,5	47,3	22,2	346,0	23,0	4,7
1961	476,6	109,1	39,4	22,9	351,2	22,0	5,3
1962	487,3	106,9	40,0	21,9	360,1	24,0	5,9
1963	499,2	113,7	41,2	19,0	386,6	28,5	7,1
1964	543,7	142,6	55,2	26,2	434,0	28,1	8,0
1965	577,5	170,7	58,4	31,1	454,0	29,4	8,2
1966	593,5	177,4	70,3	30,0	472,0	33,0	9,1
1967	583,9	177,1	68,7	30,0	496,0	36,1	9,7
1968	643,9	200,3	72,2	30,4	520,0	39,0	11,0
1969	702,1	214,3	75,6	30,5	571,0	41,4	11,9
1970	748,5	231,4	85,6	30,9	575,0	44,7	13,1
1971	757,5	236,8	80,4	30,6	580,0	48,8	13,9
1975	875 (a) 910 (b) 851 (c)				742 735 702		
1980	1.070 (a) 1.080 (b) 988 (c)				915 917 828		
1985	1.160 (a) 1.270 (b) 1.124 (c)				1.037 1.025 993		

SOURCES:

ECE. Economic Commission for Europe. The Steel Market in 1968, New York, 1969

ECE. Economic Commission for Europe. The Steel Market in 1971, New York, 1972

UN. Statistical Yearbook, New York, 1970

ILAFA. Anuário Estadístico, 1967, Santiago, 1967

(a) UNIDO

(b) MILLER, J.R. The increasing production and use of directly-reduced iron [illegible] aspects. Bucharest, ECE. Economic Commission for Europe, 1972

(c) [illegible]

The accomplishment of such a scheme would require an adjustment, whether in production or in its increments, between the developed areas and those in the process of development. One of the means for an attempt to achieve, even though partially, such an objective would possibly be the establishment of agreements between companies or even countries which would permit adequate associations of interests with reciprocal guarantees of markets and financial assistance. As no doubt many companies may not wish or may not be in a position to participate in a plan of this nature, the necessary measures for its execution would have to be taken by a relatively restricted number of companies. The association of interests of an international nature which already exist between producers and consumers of iron ore may possibly contribute with its experience toward the studies herein suggested. If the idea presented is accepted, and admitting that the aforesaid parallelism is reached in the period of 1971/80, the increase in production of the developing countries, associated to the developed ones, should attain, in 1980, the value of:

988 - (502 + 242) = 244 million tons, representing an increment of 27×10^6 t/year (Graph 2). Thus, in 1980 the production would be 244 + 242 = 486 million tons, which represents double the 1971 production. This calculation includes the vegetative growth forecast by the straight line CH: $Y_{CH} = 15.47\ X + 95.22$ plus the gradual increase arising from the aforesaid parallelism, which in 1980 should have the value of

$$Y_{CG} = 27.26\ X + 242$$
$$-Y_{CH} = -15.47\ X - 242$$

Δy 1980 = $15.76\ X$ which for X = 9 results in 124×10^6 t.

In the event of the developing countries achieving the capacity of maintaining the present growth rate, the thesis raised would be extensive only to the covering of the difference $\Delta Y = 13.76 \times 10^6 \times X$ t. On the contrary the association would be measured by other values.

The increase in production mentioned, of 244 million tons up to 1980, will probably be due to the development of new mines, the expansion of existing ones, besides the installation of new beneficiation plants and the improvement of those in operation.

The economic success of a mining operation is intimately connected to the degree of utilization of the various types of ore which comprise a mine. Thus, the ores which produce a high percentage of fines will have to be treated to offer at least four products: lump, sized ores, sinter feed and pellet feed. The processing of these is relatively simple when complex gangue and harmful mineral impurities are present. In the latter case, the processing can become complicated and, obviously, make the operation less economic.

The handling and transport of the lump, sized ores, sinter feed and concentrates does not present any particular problem. However, the consumers of sintering fines are reluctant to accept the superfine fraction, which compels the mines to classify their ore in such a way as to remove from it the corresponding fraction of pellet feed and to bind it into pellets. When the ore is destined for pellet production, this problem is simplified; in fact important technological advances have been achieved, constituting the "MARCONAFLO PROCESS".

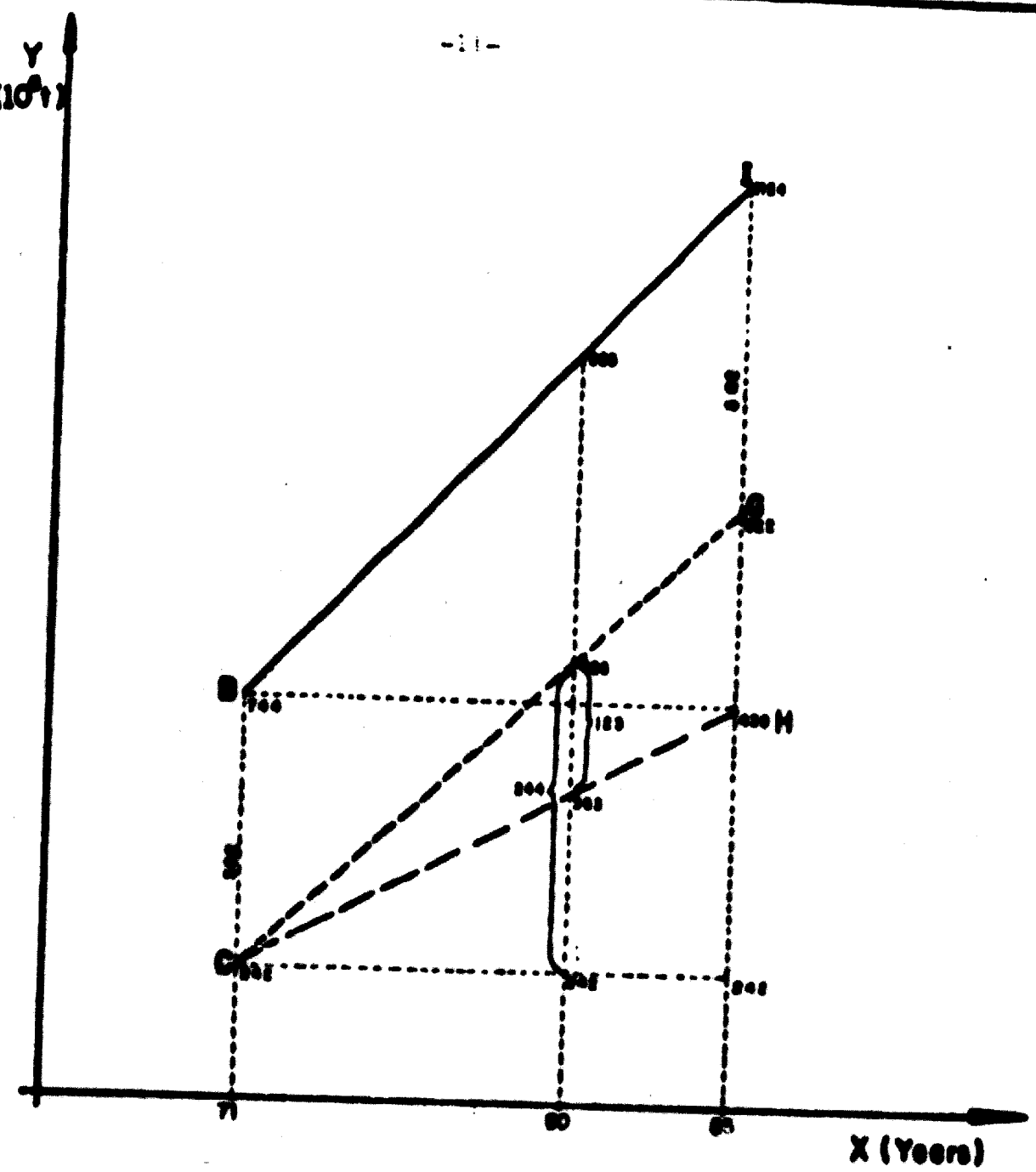
The steelmakers however are insatiable in their

demands, which forces the ore producers to adopt processes of ever increasing sophistication. Thus, a series of features such as granulometric composition, the geometry of the particles, reducibility, swelling, crepitation, basicity index, etc., have to be met, often requiring a series of complex operations - grinding, classifying and blending. Besides this, sometimes a range of ores, so carefully prepared, does not satisfy some consumers in the light of the ultimate metallurgical processes adopted. Thus, some ores which possess excellent properties for agglomeration by sintering or pelletizing do not produce satisfactory results in fluidized-bed equipment, be it due to the time for reduction, or due to the geometry of the particles.

These considerations indicate that the iron ore mining industry is demanding an ever-increasing scale of production to be maintained economic. Large-scale operations signify heavy investments, advanced technology, etc. In other words, they require the presence of a series of parameters which many developing countries do not yet possess in the necessary measure. In the following lines we present, tentatively, some figures to weigh the principal parameters involved, in order to show the order of magnitude of the investments required to increase by 244 x 10^6 t the overall production of the developing countries, in the period of about 9 years.

To begin with we will assume that:

a) the increase in production considered will be met by 50% in new mines;
b) the other half will result from the expansion of existing mines;
c) only 70% of this ore will be beneficiated (excluding agglomeration and prereduction);



$$\Delta Y_{71/80} = \frac{[988-(502+242)]\times 10^6}{9} = \frac{244\times 10^6}{9} = 27\times 10^6\ t/y$$

FORECASTS FOR:

World Iron Ore Production - BI

Developing Countries

Iron Ore Production - CH

Graph 2

d) the average distance of the railroads will be of 200 km for new railroads and 200 km for remodelling;

e) as for the ports, some will be newly built and others expanded.

The necessary financial resources will, therefore, be:

	US$ x 10^6
New mines - equipped	20.00 x 0.5 x 244 = 2,440
Expansion of mines	10.00 x 0.5 x 244 = 1,220
Beneficiatio	4.00 x 0.7 x 244 = 680
Railroads - equipped	3.00 x 244 = 732
Ports	5.00 x 244 = 1,220
Engineering and Administration Financial expenses Contingencies	7.00 x 244 = 1,708
	8,000

This results in an average investment of the order of magnitude of US$55/t.year. This value would be a measure of the effort to be engaged by the developing countries so that the tangents of the lines B and C become equal. As stated before, this paper defends the idea of an association between developed and developing countries, admitting the hypothesis of the parallelism of lines B and C being achieved. The differences between the straight lines CG and CH (Graph 2) are translated by the expression $\Delta y = 15.7 \times 10^6 \times X$ t. Admitting the value of US$55/t.year for the investment required, we will immediately arrive at a simple expression which will measure the value of the investments to be effected: $\Delta V = 15.7 \times 10^6 \times 55.0 \times X$ US$. This equality would possibly establish conditions of equilibrium and, therefore,

of security, over a long period, equally for the producers as for the consumers.

The investments which we have just considered are aimed at the extraction and preparation of iron ore so as to meet the normal specifications required by the consumers. The perfectioning of the steelmaking processes, as well as the development of new processes, has created a range of specialized products that meet the requirements of the steel mills. These are agglomerates and prereduced materials. The first group includes sinter and pellets. Although at present sinter cannot be transported over great distances, even so it does not fail to present growing requirements in respect of the properties of the pertinent ores. It is therefore a product to be produced alongside of the consumer works.

As for pellets, an exportable product, the question offers greater flexibility, since it may be produced both by the mining company and by the consumer. Since pellets are a partially enriched product they fetch more attractive prices than the natural ores, thus increasing through their exports the earnings in foreign exchange. This valuation, in FOB terms, oscilates around 1.6, indeed an attractive relation. Among the parameters involved in the installation of a pelletizing plant, one may single out the following:

- the need for large areas of land to stockpile the various types of fines;
- equipment for the handling and blending of these fines;
- a guaranteed supply, on a permanent nature and at adequate prices, of electric power, fuel oil or gas, water and binders.

One could add that in order to minimize fragmentation and the accumulation of fines from this material, the institution of a system, conveniently projected and operated, for loading at the plant, transport, unloading at the port and loading on board ship, is highly recommended. It would be fit to remember that the stockpiling of this product out in the open may entail some problems, to the extent of the basicity index increasing as a result of an increase in the free lime content in the binder and the possibility of its hydrating. The examination of the foregoing statement should be, however, made in an industrial character, so as to offer data to be utilized in the future projects.

As for the acid pellets, they do not present any problem, and as such should enjoy an ever increasing participation in the exports of iron ores.

In a general way, the developing countries producing iron ore have favourable conditions to offer the parameters indicated above, which is not always true in the case of the consumer steel works, located close to densely populated areas, considering, particularly, the problems of pollution. These reasons, therefore, favour the economy of industrializing the iron ore, whilst, offering the opportunity for increasing the revenue in foreign exchange for the exporter country.

The trend in the dimensioning of modern plants conditions production at about 3 to 4 million tons of pellets per annum and per unit. The respective investment is in the region of US$17 per ton/year, including therein a minimum item required to meet the social aspects of the venture. In the event of a plant being constructed close to the mine this value may be reduced to US$15, since the social charges

mentioned were already considered in the investment for the mining complex.

The second product group to which we refer consists of prereduced iron ores, which, in order to be used in large quantities and easily handled, should be granular sized or formed into pellets or briquettes. On a restricted scale sponge iron has been produced for a long time, either by the Wiberg or by the Höganas processes. Its cost, however, restricts the use of it to considerably specialized areas. On a truly industrial scale, currently applied in steelmaking, it is produced, as we all know, by HyL. Other processes are in the course of being investigated, experimented and in early stages of operation on an industrial scale. Some are continuous and others are not. Some perform the reduction in shaft furnaces, others in rotating kilns, yet others in fluidized bedding. There is also talk of trials which make use of grates. Each one of these processes has its own peculiarities which are linked to the physical and chemical properties of the ores, to the reduction agents available, to the nature and properties of the products, to the values of the investment, to the production costs and to the markets. You can see that the approach to this theme is extremely complex, particularly so in areas which are struggling for their development.

The author feels that this subject may be divided into two groups, both based on the market as the determining factor. In the first group one could place the plants which are destined to meet the requirements of the industrial areas of their own neighborhood. It is taken for granted that these areas are relatively abundant in electric furnaces and other consumers of scrap. The prereduced materials produced here would, therefore, have the main object of supplying the home market.

The second group would be aimed mainly for the markets abroad, which could be subdivided in two classes: the first one would consume material with a high degree of reduction (granular sized, pellets and briquettes), destined therefore as a complement when in fact it may act partially as a substitute for scrap. The second class would consist of partially prereduced material, destined for blast furnaces. The degree of reduction of this product could be determined in such a way as to require for its production less sophisticated installations, thus resulting in investments and production costs compatible with its nature. Should the trials under way with this type of product achieve success, and everything seems to point that way, a new and promising field will be opened, which may substitute to a considerable extent, the sized ores. The developing countries that will dedicate themselves to the fabrication of this product will thus have a chance of increasing their inflow of foreign currency as against what they are presently receiving for the exports of natural ores and agglomerates. If we would admit the hypothesis that each ton of pig iron would consume 50 kg of iron originating from partially prereduced material, the market prospects in a not too distant future would be of the order of 25×10^6 ton/year. The utilization of this material, in the last analysis, will be conditioned by the inequality:

$$\text{Cost } Fe_{PR} < \text{Value of pig iron production increment} + \text{value of the coke-rate savings}$$

With regard to the values of the investments and production costs in respect of the modern processes, with the exception of the HyL, there are no reliable data yet. Some estimates comprising various types of works do exist, but comparison becomes very difficult.

As an example we repeat below some data:

A) Investments

a) M.M. Fine, in "An appraisal of the production and utilization of metallized iron ore" (1971), estimates the investment in respect of mining, concentration, pelletizing and prereduction for 1.5×10^6 t/year of iron at US$80/t.year;

b) Gerhard Reuter, of Lurgi, in the "Influence of various types of raw materials on the costs for production of sponge iron applying the SL/RN Process" (1972), analyses various hypotheses. We have selected one which is closer to the foregoing one:
Production of 1.2×10^6 t/year of prereduced material, starting from a pelletizing plant and employing two rotating reduction kilns. The corresponding investment is in the order of US$98/t.year.

The estimate by Lurgi only considers the capital costs of the plant equipment inside battery limits, whilst Mr. Fine considers an integrated system.

B) Production Costs

a) M.M. Fine, in the aforesaid report, estimates as US$25.85 the ton of prereduced iron;

b) Lurgi, in the report mentioned above, estimates the value of one ton of prereduced iron between DM 125.8 and DM 157.84, i.e., between US$ 58.70 and US$ 49.50;

c) J.R. Miller, in "The impact of directly reduced iron ore in the iron and steel industry on coke consumptions" (1972), submits the following production costs:

i) Their own figures: US$29.70 to 32.10
ii) HyL - Puebla (1972): US$34.20
iii) Other sources: US$29.40 to 30.50

As you see, each case must be examined in a very particular way. In respect of the production costs, the data considered and others given in the pertinent literature indicate a range of values between US$25 and 50 per ton of prereduced material.

This picture, however, does not signify that the developing countries should not venture, with prudent enthusiasm, into this technology. These processes are still in the course of development. Much research is still to be done, aimed not only at perfecting the quality of the product, but perhaps mainly to find means to reduce the investments and respective production costs.

One could mention the field of reducing agents as an example of a subject to be thoroughly investigated. Normally a prereduction plant comprises of two large units: the chemical and the metallurgical. The chemical unit transforms the natural reduction agent into an adequate reducing agent for the process. The metallurgical unit is responsible for the transformation of the iron oxides into prereduced material. The author believes there is still much to be studied in respect of the chemical unit, particularly by the countries that do not possess an abundant quantity of good-quality reducing agents in its territory. The simplification

of these units will lead to the lowering of the investment values, thus improving the economic condition of the respective ventures. Research in this area may refer to the following investigations:

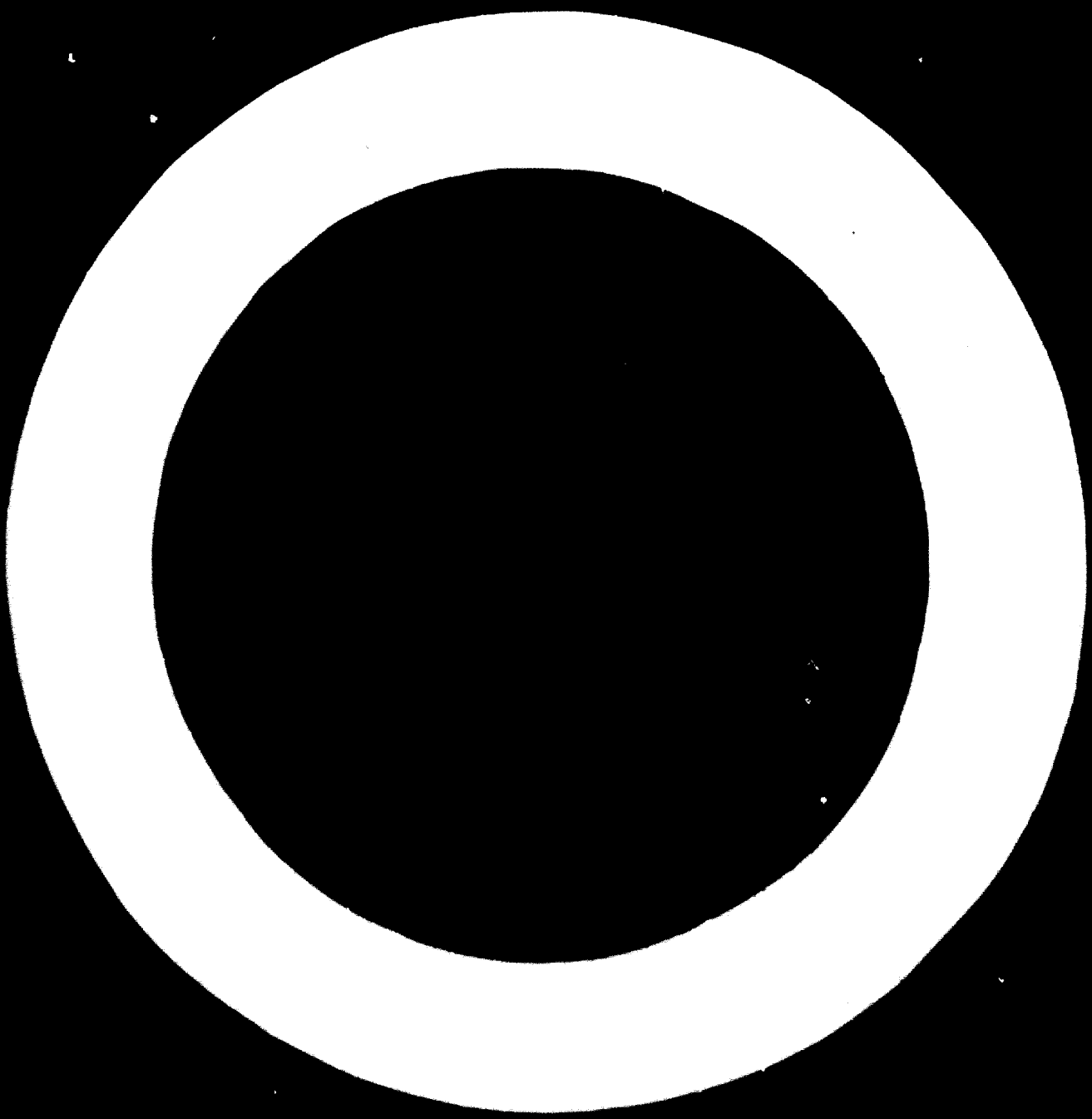
a) the utilization of natural gas without reforming;
b) the possibility of employing low-cost hydrocarbons;
c) the possibility of utilizing low-grade coal, whether through its beneficiation, or through gasification;
d) the possibility of utilizing surplus gases from the blast furnaces and coking plants in the steel mills.

Considering this is a practically new subject and this field relatively virgin, the developing countries, with the financial support or association with developed countries, may win considerable achievement in favour of their respective economies.

Having examined some basic aspects related to the industrialization of iron ore, I propose to offer some comments in respect of the steel industry in the area of the developing countries.

Reverting to Table I we can see that between 1960 and 1971 the participation of the developing countries in the world iron-ore production expanded from 22% to 51%, i.e., from 109 x 10^6 to 257 x 10^6t. From the figures in this table, one may conclude that about 27% of the iron ore produced by these countries were consumed at home and that 73% were exported.

When you further consider the steel sector, you will verify that the developing countries increased their production, in estimated numbers, of 20 x 10^6t in 1960 to 49 x 10^6t in 1971, which against world production represents, almost



constantly, a figure of aproximately only 8%. Of this modest production, possibly 4% are exported and 96% consumed in the home market.

We can thus see that in the steel sector the phenomenon consumption-exports is inverted as compared to iron ore. In the latter case consumption is very high as against exports; in the former, the opposite is the case.

Nevertheless from the point of view of an economic increment both events are of importance, the iron ore earning foreign exchange and the steel producing internal wealth, particularly due to the multiplicative effects resulting from the expansion of the metal engineering industries.

Graph 1 shows the trends of the world steel productions and that of the developing countries.

The straight line A - world steel production - has the angular tangent value of 25.05.

The straight line F - steel production in developing countries - has for its own angular tangent the value of 2.17.

The straight line G - steel production in Latin America - indicates for its tangent the value of 0.95.

We can thus see that the world increment for steel production is 11.5 times greater than that for the developing countries (in the case of iron ore it is only twice as large). In respect of Latin America this relation is 25 for steel and 5 for the iron ore.

The author believes that the scheme for the association of interests, as previously proposed, is also valid in the area of steel production as a factor for the economic development of the countries in question.

In its application however one must consider that the steel industry, demanding heavy investments, will require from the developing countries very particular solutions for its installation. The value of these investments, which are appreciably influenced by the scale of production, in some way, conditions the possibilities of these countries. Many of them try to overcome this difficulty through the utilization of three classes of enterprises: a) enterprises controlled by the respective governments, b) mixed capital enterprises, c) private capital enterprises.

This solution grants the developing countries the possibility of mobilizing financial resources, both internal as well as external, with a reasonable flexibility, a flexibility which increases with the degree of planning that the interested countries happen to organize.

The parameter "scale of production" very often presents difficulties in the determination of its value; these difficulties result from the non-coincidence between the level of consumption of the steel to be produced and the unit value of the investment for this same level. Hence the importance of setting up, provided that they are economically viable, integrated and semi-integrated mills of a smaller size, as well as, eventually, of mini-mills.

For the developing countries, however, provided it is economically healthy, any type of steel mill is of importance, not only by the consequent enrichment within its

area of influence but also by means of its contribution towards the raising of the social welfare in all its aspects.

An estimate, even though very vague, and very conservative, of the investments which these countries would have to carry out in the period 1971/1980 in order to maintain constant the present growth of their production at 2.17×10^6 t/year (Graph 1, line F), and considering the unit value of US$400 t/year, results in the global value of $2.17 \times 10^6 \times 10 \times US\$400 = US\$8.7 \times 10^9$. This amount applied in the course of a decade and in several countries would produce instalments of which the order of magnitude would probably be acceptable to the interested parties. Nevertheless, the development of the economy of the countries considered cannot conform with the mere vegetative growth of its steel industry. Every effort should be made to increase their increment and it is in the execution of a plan of such a nature that the author believes that the suggested scheme may find its most important application.

With the foregoing comments the author attempted to show that the possibilities for incrementing the economy of the developing countries in the mining and steelmaking areas exist and are great. One of the possibilities suggested in this paper would consist in conjugating the industrial and commercial interests between the entities that deal in these matters in the international market. There is nothing new in the suggestion in itself as there are already numerous examples of "joint ventures". What may possibly be new is the idea that such associations be significantly developed, in accordance with a programme based on the spirit of compensations, and in adequate quantities and values, between enterprises belonging both to developed as well as to developing countries.

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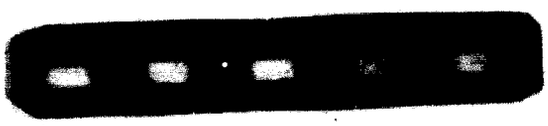

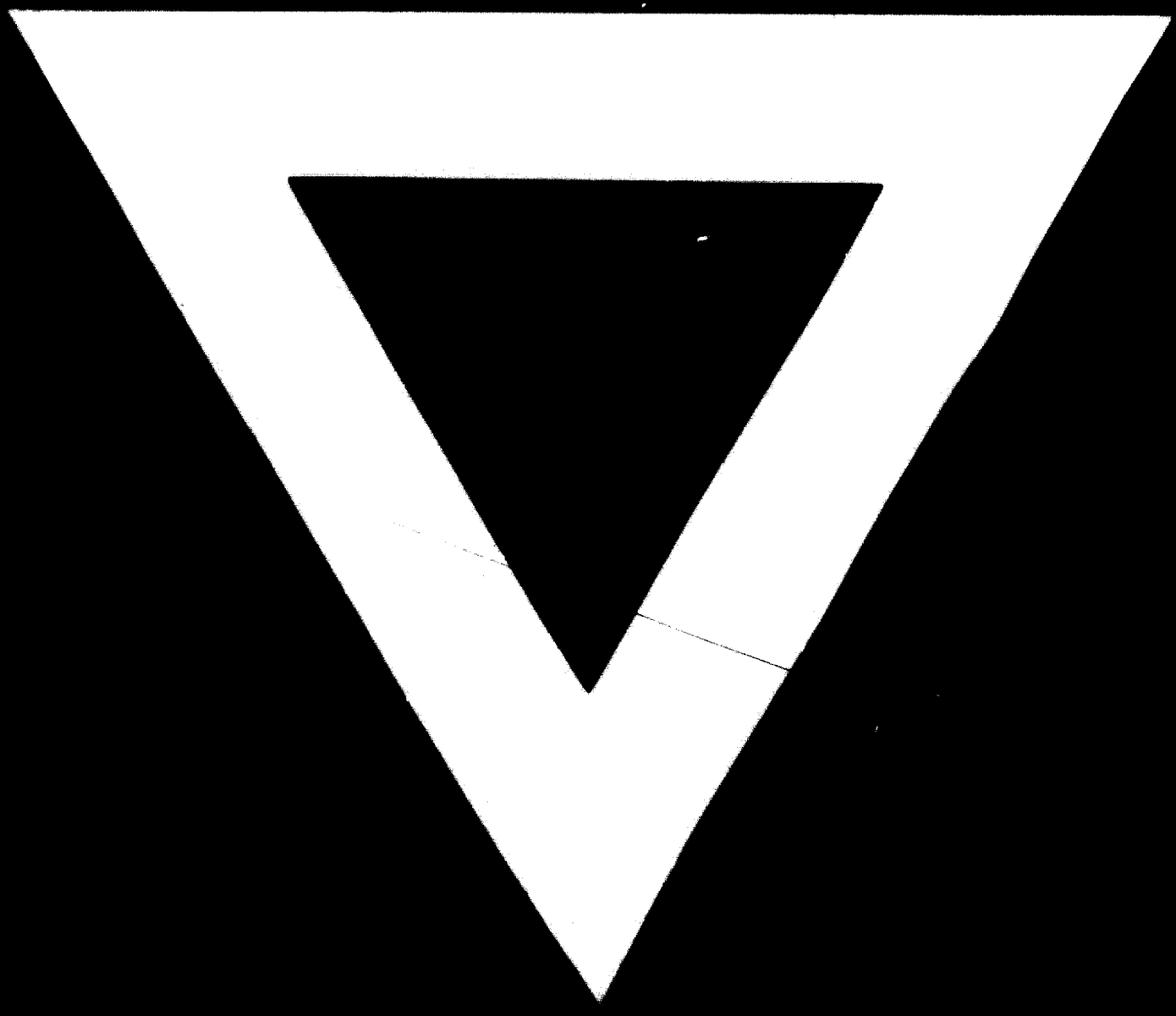

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