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POSSIBLE PROGRAMME OF ACTION IN THE IRON AND STEEL SECTOR FOR DEVELOPING COUNTRIES THROUGH THE MINI-PLANT CONCEPT*

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INTRODUCTION

The concept of mini-mills in iron and steel making was the object of several international meetings (some of them are quoted in the bibliography of this paper), including the Consultations of UNIDO about the iron and steel industry. In a more precise approach, at the Third Consultation on the Iron and Steel Industry held in Caracas, Venezuela (13 to 17 September 1982), it was recommended that, specially, the newcomers to this industry should seriously study and envisage this approach to their development. Such an approach, indeed, could help them to develop faster their iron and steel industry and deliver the steel products needed for the expansion of their economies. Furthermore, such an approach could put them in a better position not only to master the iron and steel technology but also, to make the linkages with other sectors of activity.

In such a context, UNIDO decided to further study this concept of mini-mills and the Section for Economic Co-operation among Developing Countries started such a programme in organizing an expert group meeting in Vienna, from 2 to 4 December 1985. The present study will serve as a background paper for this meeting.

At this point it must be remembered that the large integrated iron and steel plants, usually based on the blast furnace-oxygen converter scheme, are no more expanding in the world; this is absolutely true in industrialized countries but, even in developing countries, their growth is quite limited.

A proof of it is found in the evolution of capacity or production of oxygen steel in the world (Table 1 and Figure 1).

The most important, however, is to explain this evolution. We think it is linked with the five following points:

1) Such large plants, producing several million tonnes per year, require a large increase in the demand of steel products and this is no more the case in industrial countries; even in developing countries, the expansion of the demand is, in general, not sufficient

in a given area, to justify such a large plant (see Figure 2). We may add that there is an additional problem which we shall discuss later (see page 3) that even a large plant cannot produce all types of steel products and this again complicates the problem.

2) These large integrated iron and steel plants are very costly, from the capital costs point of view and require huge financing sources.

3) This is further complicated by the fact that these large integrated iron and steel plants require large and costly infrastructures both from the point of view of supply (mines, energy, refractories, etc.), and transport and population (cities, railway, port, etc.).

4) More generally, these plants and also their infrastructure, require a large number of trained people which is raising, especially in developing countries, a number of difficult problems of selection, education and training.

5) Finally, such large plants are quite complex and this is reflected in the difficulties of starting and operating such plants as it can be seen in many cases around the world. It must be noted that even in industrialized countries, this problem is not easy to solve. It is, thus, more complicated in developing countries where we find, here again, the aspects of education, management and training.

As a consequence, we can see all around the world, an evolution from these large integrated iron and steel plants towards new types of plants which can be characterized by:

- the orientation towards one single type of steel product (specialized mono-products plants);
- the trend to design, build and operate smaller plants, the "mini-steel plants" and this is especially true for light long products such as reinforcing bars for concrete.

To cover this subject, we shall review, in this background paper:

- first, the evolution of such concepts in industrialized countries;
- then, their possible application in developing countries,

before coming:

- in a third part, to possible guidelines for an expansion of the iron and steel industry in developing areas based at least partly on mini-steel plants;
- and, in the last part, to the conclusions and recommendations.

I. THE MINI-STEEL PLANT CONCEPT IN INDUSTRIALIZED COUNTRIES

This first chapter will be divided in six parts respectively devoted to:

- the historical aspects, i.e., the evolution of this concept in the industrial countries
- the geographical aspects, i.e., the evolution of the various industrialized countries
- the technological aspects
- the economical aspects
- the human problems
- the prospects for future evolution and new schemes and processes.

I.1. Evolution of the Iron and Steel Plants in Industrialized Countries (Figure 3)

The large integrated iron and steel plants specialize in flat products, sometimes in heavy products (plates, large beams) and this is logical if we remember the capacities of the various types of rolling mills (see Figure 4). It is, indeed, very difficult to tie, either by conventional casting or by continuous casting, the production of large tonnages and the normal feed of a mill for bars or merchant iron.

- Mini-steel plants, on the other hand (see Figure 5) tend to specialize in light and long products.

- Finally, in industrialized countries, specially when consumption of steel is not much increasing or, sometimes, even stagnate (or decrease...) there is plenty of scrap available as it can be explained in Tables II and III and the consequence in Table IV.

I.2. Situation of the Main Industrialized Countries Regarding Mini-Steel Plants

After looking to this evolution, along the time, in the preceding pages, we have to see how this trend appears in the space, i.e., in the various industrialized countries.

To do it, we shall cover specially (see Table V):

- USA
- Canada
- Western Europe
- Japan
- and Eastern Europe

USA

In recent papers, J.R. Miller (7) gave a list of mini-mills in the USA. It is reproduced in Appendix I and we see what are their structure and their products. However, a number of difficulties can arise when we compare, as we do in Appendix I, various estimates of the mini-mills' capacity in a given country like USA. This capacity can, in fact, be situated between:

- The total electric steel-making capacity (which, in the case of USA, corresponds to production between 20 and 30 Mt in the recent years), which includes:
  - special steel production not often very easy to separate from the production of the "mini-mills";
  - steel produced in large electric melting shops of the "big steel companies" and which is, again, not very easy to incorporate in one category or another.

  This is why, in Table V, we shall find, not only for USA but also for other areas, a range of capacity instead of a single value.

Canada

The situation is, more or less, similar to the one of the USA, and there, with about 9 plants, it covers about 10% of the total iron and steel capacity (see Appendix II).

Western Europe

We are giving in Appendix III an approximate list of mini-steel plants in this area and the case of Italy must be emphasized. Here:

- the production of electric steel is becoming higher than oxygen steel;
- the large integrated plant (public sector, Nuova ITALSIDER) is concentrated on flat products;
- the mini-mills are producing 20% of the total outp·:.

Eastern Europe

This is an area where the advantages of mini-mills were discovered quite late.

In a recent speech, the Minister of Iron and Steel of the USSR acknowledged that is must now be developed.

The first one seems BYELORUSSKIY METALLURGICHESKIY ZAVOD at Zhlobin: it is a 720,000 t/year plant (see Table VI).

Japan

Here again, both electric arc steel-making and mini-mills capacity are developing (see Appendix IV).

I.: Technological Aspects

If we try to look behind what is the metallurgical scheme of a mini-steel plant in an industrialized country, we find (see Figures 5 and 6):

- it is based on scrap as raw material;
- it produces mainly light long products (bars, wire rod, small beams or merchant iron);
- it uses electrical arc furnace;
- steel is cast, continuously in billet, although it can also be cast in small ingot ("pencil ingot");
- billets are rolled in one, sometimes two mills.

I.4. Economical Aspects

The classical mini-steel plant we have described, i.e., this one presented, in a simplified form in Figure 6 can be characterized by the average following figures (Table VII):

- for investment costs, something around USS 250 (1985) per annual tonne of steel. This is a very good figure if we compare it (see Table VIII) to the values for large integrated iron and steel plants, always in industrialized countries;
- for production costs, something around the figures given in Table IX where we can see the relative weight of:
  - (a) scrap which is the most important item
  - (b) electrical energy which is important specially from the double point of view of:
    - reliability which is generally quite good in industrialized countries in quantity and quality (i.e., network sufficient to absorb perturbations such as the flicker effect)
  - (c) electrodes which are, also, a very important item
  - (d) manpower costs which are not too large in that such plants can be operated with high efficiency. A figure often quoted is 1,000 t of steel/year and man, which corresponds to slightly less than 2 manpower hour/t of steel
  - (e) various fabrication costs such as additions (lime, ferro-alloys, etc.), and maintenance costs
  - (f) amortization.

I.5. Human Problems

What we have said shows the relative small problems raised, on the human side, by the expansion of mini-mills. It is small:

- as well for the number of people which need far smaller facilities for housing, transportation or training, for example, as for the large integrated iron and steel plants;

- as for the fact it is dispersed in several small plants with, say 250 to 1,000 people, instead of the 5,000, 10,000 or more needed in one place for a large plant;
- and finally, as for the impact on environment which is, usually, not very important.

I.6. Prospects for the Future

From the "classical" mini-steel plant we have described (see Figures 5 and 6), several possible evolutions (or revolutions...) could be anticipated for the future. We can separate them in the four following categories:

1. The evolution of the classical mini-steel plant which is, most certainly, along the various lines mentioned in Figure 8, i.e., towards a more continuous, more efficient mill. At the mini-mill meeting of March 1984 (5), several proposals were made in this respect and it is interesting to note they were made both in the direction of a larger mini-steel plant (i.e., to have a single line of 500,000 t/year) as well as to design smaller mini (or micro?) steel plants in the range of 100,000 t/year.
2. A possible evolution, in a given area, of a simple mono-product plant, on one line, towards a more diversified production (Figure 9). This is a classical evolution of many plants to add a new furnace, a new caster and a new mill...
3. Another evolution to move in the flat products field. If indeed, we look to the simplified structure of steel consumption in the world (see Figure 10), when mini-mill production exceeds, say 30% of the total production, they have covered most of the long product market. This is the case of Italy and the trend in USA, Japan and

Western Europe. To go further, mini-mills must enter the field of "flat products". As it is well-known, a definite move is taking place in this direction with:

- production of plates from electric furnace steel-making
- design of new casters to produce thin slabs
- adaptation of existing mills (steckel or semi-continuous) or design of new mills (planetary).

4. A revolution where the whole scheme is changed. As it is indicated in Figure 11, it is possible to design new types of mini-steel plants based on iron ore, hot metal production (specially by the new smelting reduction processes which are described in Figures 11 and 11b) and oxygen steel-making. Although this is not yet at the industrial level, experiments in that direction have to be followed seriously for future projects.

II. THE MINI-STEEL PLANT CONCEPT IN DEVELOPING COUNTRIES

This second chapter will be divided into the three following points:

- evolution, both from historical and economical points of view, compared to the industrial countries;
- situation of the various countries and, specially, of Africa (geographical point of view);
- main technical, economic and human issues.

II.1. History and Economic Context of Expansion of Mini-Steel Plants in Developing Areas

In fact, mini-steel plants started to be built in developing areas about the same time as in industrialized countries but this development, and more generally, the development of the iron and steel industry, was in a different context which is summarized by Figure 12 (which we can compare to Figure 4):

(a) In many areas, the sizes of the markets were not sufficiently large to build large integrated steel plants and furthermore, (see Figure 10), the flat products market was not sufficient to build a modern strip mill.

In this way, either integrated steel plants could not develop very much or, even, they were not started at all! This gave more chances to mini-steel plants or, even, micro-mills! Table X shows, in this respect, what population is needed, at a given consumption in kg/capita of a given product, to build such a market.

(b) On the other hand, availability of scrap is quite different in a developing area and in an industrial country (see Table XI, to be compared to Tables II and III) and this is raising a first problem, a first issue, which as we can see later, can be solved:

- either by scrap imports
- or by direct reduction, i.e., local production of D.R.I. (directly reduced iron) imports

- and, of course, by improving scrap collection.

(c) Another issue is raised by the supply of electrical energy: many developing areas suffer from a lack of electrical energy and the introduction of an electric arc furnace into such a network could be either impossible or lead to difficult disturbance.

This is why a number of possibilities have and should be explored, such as:

- using a special power plant for feeding the arc furnace,
- use of different electric furnaces such as the D.C. electric arc furnace,
- or, even considering other steel-making processes such as open-hearth furnaces or new methods such as E.O.F. process.

(d) At last, there are the usual problems of the developing areas, problems we must mention again:

- the availability of trained manpower;
- the problems of maintenance, spare parts and various supplies;
- the general problem of infrastructure where electrical energy is just one aspect.

II.2. Expansion of Mini-Mills in the Various Developing Areas

This expansion, as we have already indicated, is very different according to the areas and Table XII indicates, more or less like Table IV for the industrialized countries the situation. Details are given, here again, in the Appendices.

Latin America (see Appendix V)

This is the developing area where we find the highest percentages of mini-mills and several countries have a pattern quite similar to what we have found in Southern countries of Western Europe such as Italy or Spain.

Furthermore, a number of countries such as Mexico, Argentina or Venezuela are relying on direct reduction to feed their electric arc furnaces.

The paper of Millin (see reference (3)) shows (Figures 13 and 14) a completely different pattern of sizes between mini-mills of:

- USA and Japan (Figure 13)
- Latin America (and also SEAISI countries, see later) (Figure 14).

Asia (See Appendix VI)

There, the situation is quite different from one country to another. From the paper of Millin already quoted (see reference (3)), we see that the pattern of sizes of mini-mills from South East Asia is rather similar to the one of Latin America (Figure 14). For India, the many mini-steel plants existing are very often of small size and could be better qualified micro-steel plants with production around 10,000 t/year.

On the other hand, Singapore and South Korea have mini-steel plants which can be compared to those of USA and Japan.

Middle East

A number of data are in Appendix VII and they show quite clearly the difficulty of defining what are the mini-steel plants (we shall come back to this question in the third part of this study). We find, there, indeed:

- First, "true mini-steel plants", as were IRMCO in Iran or LEBANON STEEL MILL in Lebanon.
- Then, more diversified small plants which produce, as an example, pipes and tube like GECOSTEEL in Syria.
- Lastly, "large mini-steel plants", based on natural gas-direct reduction as in Iraq, in Qatar, in Saudi Arabia and in Iran where we are getting out of the classical field of the mini-mill with plants of capacity of 2 or 3 million tonnes per year, or more.

Africa

We have given more details on this continent in Appendix VIII, and it quite interesting to note that, once more, we find:

- re-rollers, i.e., plants buying billets to roll them, usually in bars;
- "true mini-steel plants", based on electric arc furnaces with some special cases where they are based on open-hearth furnaces;
- as in the Middle East, "large mini-steel plants" (around 0.8 Mt/year in El Dekhila and 1 Mt/year in Warri) based on direct reduction;
- one mini-steel plant based on blast furnace and oxygen convectors in Tunisia.

II.3. Main Technical, Economical and Human Issues for Mini-Mills in Developing Areas

From this survey, we can see that these mini-mills, in developing areas are characterized by the six following points:

1) from the raw materials side, there is often a lack of scrap which leads either to direct reduction or other metallurgical schemes;
2) from the energy side, there is often a lack of reliable electrical supply which, again, can lead to other metallurgical schemes;
3) so, regarding metallurgical schemes and processes, we have a larger choice than in industrialized countries where, generally speaking, the combination scrap and electric arc furnace, maybe with some D.R.I. imports, is sufficient. Table XIII gives an approach to these problems with the two main inputs:
   - iron-bearing raw materials, i.e., scrap or iron ore
   - energy, i.e., electrical energy, oil or gas, coal... or sun and biomass.

4) Those three first points lead us to the most important one which is the market (present and future) as well in size (tonnes/year) as quality (types of products, grades, possible prices, etc...). This is, if we can say so, still more important for developing areas than for the industrialized countries.
We must remind, there, that the "mini-mill philosophy" will be to be as near as possible as a mono-product line, depending, of course, on the prospective market, some compromise has to be made to adjust to a diversified product mix.

5) The need of trained manpower, from operating crew to maintenance people and managing staff, will be essential and more difficult to solve in a developing area.

6) Finally, the problems of infrastructure will be very important in a developing area.

III. GLOBAL AND DETAILED ANALYSIS OF THE PROBLEMS RAISED BY CREATION AND EXPANSION OF THE STEEL INDUSTRY OF DEVELOPING COUNTRIES ALONG THE MINI-MILL ROUTE

We have seen how the mini-mill concept has been used generally with success in industrialized countries as well as in developing countries for the expansion of the iron and steel industry. However, this concept cannot be used without problems, and we shall try to define them by giving a number of points to be discussed and some recommendations concerning the creation and expansion of mini-steel plants in developing countries. We shall list them under the three following headings:

- The definition of the mini-steel plants, to have a clear idea of this concept;
- The problems raised by application of this concept to developing countries, especially in Africa;
- Finally, a larger survey of the whole problem raised by the creation of a mini-steel plant in a developing region.

III.1. The Definition of the Mini-Steel Plants

From what we have seen in the two preceding parts of this paper, the concept of mini-steel plants can be defined from three points of view:

- production capacity
- type of steel products
- metallurgical scheme.

Capacity

As opposed to the large integrated plants of several million tonnes of steel per year, the mini-steel plants have a steel production capacity which is usually, in industrialized countries, between 100,000 and 1 million tonnes per year. However, especially in developing countries, it is necessary to include smaller units and we can distinguish, as indicated in Table 14, the following:

- an area which has never been very well studied of very small plants which can be built in villages or in the country and can justify further studies to see if it is possible to establish a very small iron or steel plant to satisfy the basic needs of a small area;

- A micro-steel plant which will be defined by capacity between 100 tonnes per day which means about 30,000 tonnes per year, up to 100,000 tonnes per year.
- Finally, a mini-steel plant with capacity ten times higher, which means between 100,000 and 1 million tonnes of steel per year.

Types of Steel Products

We have seen in the historical background of the development of mini-steel plants that they have usually started by production of bars, especially reinforcing bars for concrete, and later, they developed to produce other long and light products such as merchant iron, wire rods, etc. We must emphasize that those products are the real field of the mini-steel plants. Other types of steel products could, of course, be produced by mini-steel plants, but much care must be exercised when a project is undertaken in such fields. This arises from two completely different points of view:

- The capacity of the various types of rolling mills, (see again Figure 4), are not always very well adapted to the concept of mini-steel plants, especially of the various steel plant capacities which have been given in Table XIV. This is especially one of the problems we find when we want to apply the mini-steel plant concept to flat products; for such products, the capacity of the strip mill is generally around one million tonnes per year, or preferably, more. There are a number of research and development studies around the world to find new technologies, but it is not yet proven that an economical rolling mill can be built in the range of 100,000 tonnes per year, up to 300,000 tonnes per year for flat products.

- The production of each grade of steel for each type of steel product can raise quite a number of different problems. This is a very complex subject as we have to consider in each case the following:

- o the economical grade which is needed
- o the metallurgical possibility of each metallurgical scheme
- o the type of raw material where we can see as an example, that in an electric arc furnace, we can use various types of scrap or directly reduced iron.

Metallurgical Scheme

Here again we have seen an evolution of the mini-steel plant in the industrialized countries as well as in developing regions. Especially for a new project to be undertaken in developing countries, we have to be quite clear about the various schemes which can be envisaged. In that way, we can distinguish:

- o the rolling mill which is the base of each mini-steel plant and can be built alone as a first part of the development of such a plant
- o the possibility of integrating this mill at the level of a primary metal (scrap, directly reduced iron, etc.), or even at the level of iron ore, as is indicated in Table XV.

Among all these schemes, we find completely different situations:

- o For the classic semi-integrated mini-steel plants, (i.e., those which are based on a primary metal), the most usual scheme is based on electric arc furnace (our reference 01), but in some special circumstances, it could be possible to use open-hearth furnaces (our reference 02); new processes could appear or are even in the development stage, but no important commercial development has yet been made in such fields.
- o For the integrated mini-steel plant, (i.e., based on iron ore), there are two different possibilities:
  - -- We can use the preceding semi-integrated solution and use direct

reduction instead of scrap (our reference 11, or in some cases, 12);

— we can use the blast furnace and especially the charcoal blast furnace (our reference 22).

Here again, new processes are appearing (our reference 24), but they are not yet at the industrial scale.

III.2. The Problems Raised by Application of this Concept to Developing Countries, Especially in Africa

If we are coming back to the various aspects of the application of this concept to developing countries, we must recall that these regions are characterized, especially in the less advanced countries, by:

- A very low level of steel consumption which could, however, increase in the future as a function of the development of this region (see Figure 10);
- Natural resources including iron ore, scrap or energy (coal, oil, gas, electric energy) which are completely different from one country to another;
- Without coming for the time being to all the problems which arise from the development of such a region (which will be the subject of the next chapter) there is a lack of trained persons, again quite different from one region to another. This point is very important when we remember the complexity of the iron and steel industry and specially the different complexities of the various schemes and processes.

In this context, the possibility of applying the mini-steel plant concept to developing regions has to be included in the following three aspects regarding the mini-steel plant itself; the problem raised by the infrastructure will be the subject of the following point (our reference III.3):

1. The market (see Table 16) is the most important point and it is a very different one as we have to consider it from two different points of view:

- the actual state of the market by product and by type of steel (quantity and quality)
- and, what is far more difficult to appreciate, the evaluation of this market by product in the medium and long-term prospects.

This market survey is essential as it will define the type of product which will be selected for the production of the proposed mini-steel plant, the type of rolling mill which will be needed and finally, the level of production capacity which will be required.

2. The metallurgical scheme (see Table XVII) which will be selected:

- on the one hand, from the conclusion of the market survey (conclusion of Table XVI)
- on the other hand, from the various possibilities which are given in Table IV and which depend on the natural resources.

3. The human aspects which are linked with the complexity of the metallurgical scheme and with the detailed structure of the projected mini-steel plant. In this field, we could come back to the conclusion of another UNIDO study which emphasizes:

- on one side, the importance of four parameters which are linked to any function in a steel plant:
  - (a) The know-how (KH), which is the level of knowledge which is necessary for a given function;
  - (b) The behaviour (B), which means the way in which the person is doing the work which is needed in a complex system of relations in a steel plant;
  - (c) The extent of power (P), which means the freedom associated with each function to operate;

(d) The responsibility (R) which can be direct (vertical links), or indirect (horizontal links) in the organization scheme of the enterprise.

In this way, we can characterize each function by giving a value to each of these four parameters.

- On the other side, when we consider a given unit operation (in our example, it will be the continuous casting operation which is an essential link between steel making and rolling mill), we find twenty key functions, and for each of them, (see Table XVIII), there is a delicate equilibrium between the four parameters (see Figure 16).

III.3. Survey of the Whole Problem Raised by the Creation of a Mini-Steel Plant in a Developing Region

In this final part of this paper, we shall examine in what context such a project can and must be developed. Six points of view seem to us to be especially important to consider, and they are:

- the market, again
- technology
- infrastructure
- training
- possibilities of regional co-operation
- raw material and various product requirements.

1. The market

This subject seems to be again emphasized in the sense that in a given developing region, it is absolutely necessary to examine the links between the production anticipated for the proposed steel plant on one side and the need, now and in the future, of the region. This examination should specially concentrate itself on the links with other industries and other activities (agriculture, trade, etc.), either existing or envisaged for the future. In this respect, it seems that very often, a project of a mini-steel plant is undertaken in a developing region, considering exactly the same production and the same utilization of those products as in industrialized countries. In those countries, it must be recalled that there is a long tradition and quite a specialization in the use of steel products and it is based on the fact that there are many different producers competing for a modest market, which is not the case, generally speaking, in a developing region.

In other words, it would seem very useful in a developing region to consider two new approaches of the market along the following lines:

- First, we can consider a mini-steel plant based on a single steel product; it could be for example, a bar for reinforcing concrete. In such a case, it could be useful to develop a number of non-classical uses of such products. We have been seeing in various countries that by welding such bars, it is possible to make beams for telephone or electric distribution lines. Quite a lot of thinking can be made along these lines.
- On the other hand, it could be possible to list for a given area the basic needs in various materials and from those needs "centred on the local needs", it could be possible to find the best type of steel plant which could produce most of those materials. It could be again bars, but a number of narrow flat products could be added and they could be quite useful for a number of implements used in agriculture. Generally speaking, it appears absolutely necessary to have one integrated approach of the market when we are doing a project of such a mini-steel plant which means that we have to remember all the linkages with other activities or other projects which are made in the given area.

2. Technology

As it is for the market, the technological aspects have to be seen simultaneously from two different points of view:

- The general aspects - we could say the international aspects - are based on the technological evaluation of the iron and steel industry in the whole world. As we have seen previously, such trends are used both in industrialized and in developing countries.
- The specific aspects, which means those which are related to the political, economic context of a given area; in this respect, we find there is a real lack of adapted technology for a number of techno-economic contexts; a number of problems which are especially interesting for developing countries are very often not an object of research in industrialized countries as they have not much interest in such countries. As an example, we could mention the capitalization of electric arc steel making based on directly reduced iron ore: continuous charging is now quite classis but the continuous operation of the furnace including continuous tapping could be quite interesting.

  In this respect, a very important remark has to be made: this is the difficulty for such projects in developing countries to find the best route between:

  - processes which are quite classical and which avoid most of the risk of the new processes, but on the other hand could become obsolete especially if the plant is very slow to design, start and operate.
  - New processes which could be more adapted to the local resources and more efficient, but there we find the risk of using new technology which has not yet been used in many plants.

3. Infrastructure

As we have mentioned several times in this report, this is a place where the developing countries have many difficulties. Especially for large integrated iron and steel plants, large infrastructures are needed, but even for a mini-steel plant, the weight of infrastructure should not be under-estimated. To obtain some ideas about the importance of infrastructure, we are providing in Table XIX the cost of various configurations of a reference plant to support the cost of equipment and the cost of what we call internal infrastructure which means supply works, buildings and erection.

Outside of this infrastructure which is absolutely necessary in every case, we have to add what we call external infrastructure which can be divided into three categories:

- Infrastructure of the first order is related to what is needed to operate the plant and which is generally speaking included inside the plant limits. It means (see Table XXI) the main offices, the laboratories, maintenance facilities and general transport and handling systems. Of course, all that equipment is absolutely needed either in industrialized countries or in developing regions but it is quite evident that much simplification and considerable savings can be made in the industrialized regions for example in workshops and warehouses due to the proximity of other industrial plants. On the other hand, in a developing country, many things have to be made on the spot and many more spare parts have to be kept in the warehouse.
- Infrastructure of the second order (see Table XXII) is related to facilities which are outside of the mini-steel plant limits. As a typical example, we could mention using facilities for the people and their families working in the plant; another example is the energy supply as the mini-steel plant has to be connected to various

systems such as the electricity network, water network, sometimes natural gas pipelines or any kind of supply of fuel oil, coal, etc. Again, in an industrialized country, much of this infrastructure is already existent: villages or cities have already been built and connection to the existing networks are very easily established.

- Infrastructure of the third order (see Table XXIII) concerns again infrastructure outside of the limits of the plant which is normally not needed in industrialized countries as they have supplies which are provided by other companies existing before the creation of the mini-steel plant. Again, in a developing country, we find the opposite situation, where they have to be created at the same time as the steel plant.

As a summary (see Table XXIV), the cost of the mini-steel plant could be increased in various and sometimes very large proportion due to the cost of infrastructure and such a burden should be remembered while making a project of such a plant and especially when it is compared to the investment cost of a similar plant in an industrialized country.

4. Human problems in training

This essential point which we have already covered in paragraph III.2 must be approached from three different points of view:

- First, the general education programme of the country including all the possibilities of regional co-operation which will be mentioned later (see point 5(c)). As an example, it is probably possible to have a single school or university for engineers and technicians in the field of metallurgy for a large area.
- Then the specific training for all the fields which are needed, not only for iron and steel making, but also for what is needed especially in maintenance, infrastructure, etc. In this respect, it must be

reminded that most of the training programmes are not specific to the steel industry but could be used for the general industrial training of the people in the considered area.

- The specific formation for the steel industry which, in a mini-steel plant means only the training of a very limited number of people and has probably to be made either in an industrialized country, or, when possible, on a regional basis through the regional co-operation programme.

5. Regional co-operation

This aspect is evident but we have to stress the importance of it under the following three headings:

(a) Co-operation regarding the steel product which includes the possibilities of specialization of the production and the various mini-mills in a given area; this is co-operation in the down-stream field.

(b) Co-operation for the raw material, energy and various products which means the co-operation in the up-stream field.

(c) Co-operation for management, training and all the various human aspects associated with a mini-mill project.

Each of these points has a very large effect and they become quite evident when several projects or existing plants are not very far away which gives far more possibility for regional co-operation. As an example, we can mention the following:

(a) For the products, it is always possible for several mini-mills in a given area to have a different range of product and specialize each plant on a narrower number of steel products. Even for reinforcing bars, there can be much interest to reduce the number of diameters of bar which are rolled in a given plant. In many industrialized countries, as an example, the mini-mill can be very much specialized in type and dimension of the product and this specialization has a lot of advantages for the for the operations themselves, maintenance and stocks of finished products.

(b) For each material, either the main raw material such as iron ores or scrap, or any additives such as fluxes or various products needed for production of steel, co-operation is also very important. We could, as an example, have in a given area a production of iron ore in one country, maybe associated with direct reduction or production of pig iron and deliver these primary metals to the mini-steel plant of a whole area to supplement the scrap supply.

(c) Regarding technical co-operation, it is clear that exchange of experience and know-how between managers, engineers and technicians doing more or less the same job in various plants of the same area can be very important, either for normal operation or especially when some incidents or accidents are happening in a given plant.

One way which can be envisaged to develop such regional co-operation could be the promotion and development of multinational production enterprises and enterprise-to-enterprise co-operation among developing countries. Multinational production enterprises as pursued in UNIDO's programme and in accordance with the General Assembly Mandate on Economic Co-operation among Developing Countries (ECDC) are confined to equity arrangements among two or more developing countries or their nationals to increase their industrial manufacturing output and/or encouraging national resource development through a process of mutual and concerted actions for creation, expansion and/or better utilization of their production potentials as well as fostering their intra-trade flows and their bargaining position in the world market with a view to attaining reciprocal benefits from economies of scale, specialization and resources complementarities. In this connexion, multinational production enterprises of developing countries (MPEDCs) are a specific component of a much broader concept of enterprise-to-enterprise co-operation arrangements (ETEC) among developing countries.

For the benefit of the developing countries and in order to set up the parameters of its characterization of MPEDCs versus the conventional approach of transnational/multinational enterprise, several other criteria should be fulfilled, such as:

1. Equal treatment of all investors in terms of distribution of the benefits, exercise of control, access of technology and other relevant resources of the company;
2. Contribution to the achievement of specified national goals and needs;
3. Promotion of investors technological build-up and strengthening their bargaining power vis-à-vis the outside world;
4. Contribution to better use of available local resources and setting up conditions for the economies of scale and specialization;
5. Facilitating other forms of ECDC among the countries concerned.

The first phase of this programme, to which the mandate of the General Assembly attaches great importance, is being completed by defining this phenomenon in developing countries and its potential for a better utilization of the existing resources. The second phase will take into account the sectoral experiences and will attempt to draw up guidelines in general for its establishment and specific principles to be followed on a sectoral basis.

In the case of mini-mills, we can come back to the three points which have already been mentioned and which are related to the creation or the development of such mini-mills, especially in Africa:

(a) Multinational production enterprises to produce primary metals (pig iron or directly reduced iron)

This production could be based on the best site which means:

- Probably along the coast to facilitate transportation and distribution of this primary metal to mini-mills based on melting of this product, usually in electric arc furnaces.
- Near the iron ore deposits which are most interesting from the metallurgical point of view (i.e., very rich in iron or easy to concentrate in the case of direct reduction), as well as from the economic point of view.
- Near energy resources such as natural gas or forests or plantation areas where charcoal could be produced; we must also mention the possibility of using cheap hydro-electric power.

In the case of Western and Central Africa, we can see that some mini-mills have problems to find the scrap supply which is needed for the operation (this is the case of SOSIDER in Zaïre, but probably also of several other mini-mills). At the same time, we can see that: The WARRI direct reduction plant in Nigeria is not operating at full capacity.

- Other direct reduction units could be built in those areas, especially in Cameroon.
- Raw material suitable for direct reduction (fine concentrates or pellet fines) could also be produced in the same area, again in Cameroon, as an example.

(b) <u>Multinational production enterprises to distribute some steel products</u>

Such a multinational production enterprise will not be very easy to establish as they will be taken between:

- The interest to lower transportation costs and create production units as near as possible to the market in a given area.
- The interest to optimize and specialize the production of each unit in different products, the type of product as well as for the dimensions.

(c) Multinational production enterprises to produce or to deliver a number of fluxes, products or even spare parts which are absolutely essential for the normal operation of a mini-mill.

There are many products which can be included in this category as every mini-mill requires quite a number of various products such as:

- Fluxes: lime, dolomite, etc.
- ferro-alloys
- bricks and refractory products
- electrodes
- mill rolls
- various spare parts.

It must be noted that a number of mini-mills mention the problem they find in this field and the many difficulties they have to import such products and raw materials.

6. Requirements for various products

Just to emphasize what we have mentioned, we want to draw the attention to all the various products which are needed to operate an iron and steel plant either a large or a small one like a mini-mill. It is difficult to make a complete list of all the products which are needed, but even if they are not very important in quantity or in price, the lack of any of them can have very severe consequences on the operation. As examples, Tables XXV, XXVI, XXVII provide some idea of the number of such projects which are needed in a steel plant.

This aspect which is not very critical in an industrialized country where it is usually very easy to order them with a quick delivery, becomes quite a critical factor in developing areas where it takes much time to place an order and the products to be delivered. The official regulations and the problem of foreign currency to pay even a very small amount of such products can add to further delays. The study of IISI on electric arc furnaces provides some very interesting classification of the various refractories which are needed for steel-making and it illustrates the point we have mentioned about such products. Here again, multinational production enterprises can be very useful in this field.

IV. CONCLUSIONS AND RECOMMENDATIONS

This background paper has firstly given the use and the success of the mini-plant concept in industrialized countries where they represent a production of around 50 to 70 Mt/year and, due to their efficiency, they continue to grow in spite of the difficult general economic situation.

In the developing countries, this concept has also been used with success and the total capacity there is between 13 and 30 Mt/year but it is a far more heterogeneous group than in the industrialized countries with respect to:

- unit capacity
- routes and processes
- their steel products

as well as for:

- operations and maintenance problems
- efficiency
- and, of course, the specific problems raised by designing, building and operating such plants in developing areas.

In such an expert group meeting, the first question to be raised concerns agreement or disagreement of the participants on the principle of such a study and such a meeting, i.e., the validity of this approach of the iron and steel development through the mini-mill concept for the creation of new plants as well as for improving and expanding existing mini-steel plants in the developing countries.

If an agreement is reached on this approach, we can recommend its application on the various levels:

- national
- regional
- and international.

To prepare discussions on such recommendations, we are giving some of them as examples:

1. Create links by associations or institutes (such as ILAFA, AISU, SEAISI on the regional level, or ATS in France) between people doing similar jobs in mini-mills of the same region. This could concern:

- technical and metallurgical functions (engineers and technicians)
- management
- maintenance, etc.

This could promote exchange of information, of visits, of practical experience in a real network of communication between the enterprises.

2. Create multinational production enterprises between developing countries or between enterprises of developing countries to centralize and optimize some operations and avoid too much division between countries and enterprises. We find, there, the desire of many international organizations such as the World Bank to avoid ambitious projects and, also, duplication of small costly projects.

3. Give assistance, on a regional or international level, to the operation of existing mini-mills, not only by the preceding recommendations (1 and 2), but by individual technical assistance missions.

4. Give the same kind of assistance for study and design of new mini-mills in the best context such as it was summarized in the third part of this paper, and especially taking advantage of past history, i.e., successes as well as failures of mini-steel plants built, say, in the last twenty years.

TABLE I

DEVELOPMENT OF OXYGEN AND ELECTRIC STEELMAKING AROUND THE WORLD

(Production based on IISI statistics)

		from the collected statistics IISI		
year	world total steel	total steel	oxygen steel	electric steel
1960	346	327	12.2	35.1
1965	454	447	81.5	54.4
1970	595	578	237	85
1971	583	563	245	85
1972	630	590	281	92
1973	698	654	329	106
1974	703	659	340 (51.6%)	111 (16.9%)
1975	643	595	311 (52.3%)	100 (16.9%)
1976	675	629	338 (53.7%)	112 (17.8%)
1977	675	621	336 (54.2%)	116 (18.6%)
1978	717	656	357 (54.5%)	133 (20,2%)
1979	746	681	381 (55,81%)	142 (20.81%)
1980	716	648	359 (55.31%)	143 (22.38%)
1981	708	641	358 (55.86%)	144 (22.44%)
1982	645	576	317 (55.03%)	134 (23.21%)
1983	663	591	(55.2%)	(23.7%)
1984	710	633.3	(56%)	(24.6%)

TABLE II

EVOLUTION of SCRAP ORIGIN in INDUSTRIALIZED COUNTRIES

a) Basic assumption				
Case	Case the past (say 1970)	"Now" (say 1985 or better 1990)		
Evolution of the steel industry	Expansion	Stagnation		
Casting	Ingot	Continuous		
Trade of steel products	No trade outside the country	No trade outside the country	Exporting country	Importing country
Crude steel production	140	108	108	108
Finished steel production	100	100	100	100
Consumption	100	100	70	130
Consumption 15 years ago	50	100	70	130
b) Scrap availability				
Circulating scrap (home scrap from steel plant)	40	8	88	88
Process scrap	(15%) 15	(10%) 10	(10%) 7	(10%) 13
Obsolete scrap	21.25	43.5	30.45	56.55
(50% of finished products used 15 years ago)	(50% x 85%) of 50	(50% x 87%) of 100	(50% x 87%) of 70	(50% x 87%) of 130
TOTAL	76.25	61.50	45.45	77.55

TABLE III

SCRAP NATURE in INDUSTRIALIZED COUNTRIES

From the assumptions and calculations of table II, we can see that the nature of scrap available in industrialized countries is, completely changing :

Case	"in the past" (say 1970)	"now" (say 1985 or better 1990)		
Evolution of the steel industry	Expansion	Stagnation		
Casting	ingot	Continuous		
Trade of steel products	no trade outside the country	no trade outside the country	Exporting country	Importing country
Nature and proportion of scrap	(see figure below)			

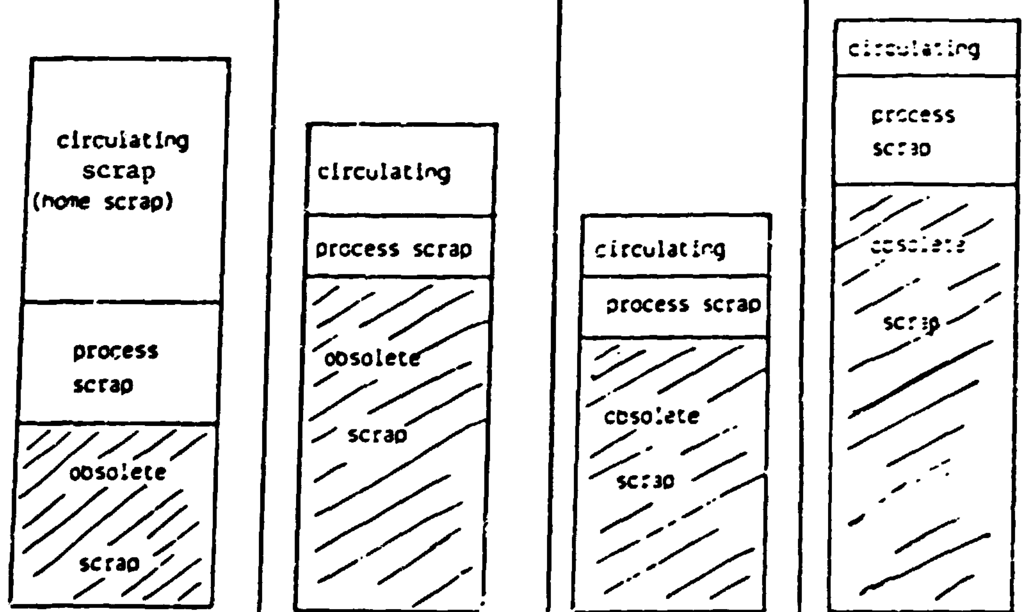


TABLE IV

ORDER OF MAGNITUDE OF CCSIS IN US DOLLARS

FOR 1 METRIC TON OF HOT ROLLED PRODUCTS

Case	Maxi plant 4 000 000 t/year Blast furnace Oxygen Steelmaking Continuous casting (slabs) Hot strip mill	Mini plant 400 000 t/year Scrap Electric Steelmaking Continuous casting (billets) bar/wire rod mill
1) fabrication costs		
Ore/scrap	35	85
Energy	50	20
Manpower	30	20
Various others fabri-cations cost (additives etc...) and maintenance	45	35
TOTAL	160	160
2) Amortization and financial costs		
Base $/annual ton 10%	(1.000) 100	(250) 25
3) TOTAL	260	185

ESTIMATE OF MINIMILL

CAPACITY IN INDUSTRIALIZED COUNTRIES

area	approximate total capacity Mt/year	approximate minimill cpacity Mt/year	%
U.S.A.	120	14.7/24	12%/20%
CANADA	20	2/2.5	10%/12.5%
WESTERN EUROPE (Italy)	150 (25)	18.35/20 (5,1)	12% (20%)
EASTERN EUROPE	200	1 ?	0,5%
JAPAN	120	11.8/24	10%/20%
TOTAL	610	48/71	8%/12%

source { J.R. MILLER
and various publications such as the Metal Bulletin.

TABLE VI

THE MINIMILL OF ZHLOBIN IN U.S.S.R.

décision : February 1981

start up : october 1984

capacity (liquid steel : 720 000 t/year

i.e.	billets for sale	: 200 000 t/year
	wire rod	: 150 000 t/year
	bars and light sections	: 350 000 t/year

total cost 550 M US $

2 Electric arc furnaces 100 t 75 MVA

2 continuous casting 6 lines of billets 125 mm

1 walking beam furnace 170 t/h

1 rolling mill for bars and light sections

1 rolling mill for wire rod

TABLE VII

EFFICIENCY of MINI-STEEL-PLANTS for REINFORCING BARS

- Typical Investment Costs

  250 $/annual ton of the steel

- Typical manpower needs

  1 man for 1000 t/year

  i.e. 1.8 hour/t of steel

  (for 1800 hours/man and year)

- Typical energy requirements

  0.1 to 0.3 Gcal fuel oil or similar/t of steel

  + 700 kWh/t of steel (arc furnace + continuous casting + rolling mill + services)

INVESTMENT COSTS FOR VARIOUS IRON AND STEEL PLANTS

(industrialized areas)

scheme	Electric Arc Furnace					Blast furnace and Oxygen Steelmaking	
	scrap	scrap	D.R.	scrap	D.R.		
mill	bar mill	bar mill		semi continuous hot strip mill		semi continuous hot strip mill	continuous hot strip mill
capacity Mt/year	0.2	0.5		1.0		1.0	4.0
unit cost M US $ agglomeration							
pellets	-	-	-	-	(100)	-	-
sinter	-	-	-	-	-	100	250
Ironmaking							
coke ovens	-	-	-	-	-	100	400
blast furnace	-	-	-	-	-	150	400
Direct Reduction	-	-	90	-	150	-	-
steelmaking and continuous casting	20	50	50	150	150	150	450
mill	20	50	50	350	350	350	1000
Infrastructure (yards, services ...)	10	25	40	100	150	300	1100
TOTAL	**50**	**125**	**230**	**600**	**800**	**1150**	**3600**
US$/t of steel per year	250	250	460	600	800	1150	900

EXEMPLE OF PRODUCTION COSTS FOR STEEL IN ELECTRIC ARC FURNACE

(see also table IV)

for 1 t of continuously cast billets

scrap	60 to 100 $
electrical energy { 500 kWh between 10 and 50 $ for 1000 kWh	5 to 25 $
electrodes { 3 to 6 kg at 3 to 6 $/kg	around 15 $
manpower { 1/2 h at 1 to 10 $/h	around 5 $
various supplies, additions, maintenances	around 10 $
TOTAL without amortization	95 to 155 $

SPECIFIC NEEDS OF A GIVEN AREA DEPENDING ON THE POPULATION

and ON THE LEVEL OF DEVELOPMENT ABOUT BARS

(kg crude steel/capita and year)

Population M \ kg crude steel/cap/yr	10	50	100	
			a	b
1	3 000	15 000	20 000	16 000
5	15 000	75 000	100 000	80 000
10	30 000	150 000	200 000	160 000
50	150 000	750 000	1 000 000	800 000
100	300 000	1 500 000	2 000 000	1 600 000

small bar mill (micro-mill)

mini plant

different types of plants are possible in this zone

TABLE XI

SCRAP ORIGIN IN DEVELOPING COUNTRIES

(depending of case, steel consumption is multiplied by 2 or by 10 in 15 years)

case :	small country with consumption concentrated on bars and merchant irons — continuous casting —	large country with consumption of all types of Steel Products — continuous casting —
plant	one plant for light lung steel products	several plants and mills for various products
production :		
crude steel	108	108
finished products	100	100
consumption :		
now	150 *	100
15 year before	15*** or 75**	10*** or 50**

Note
* to take account of products imported
** has been multiplied by 2 in 15 year
*** has been multiplied by 10 in 15 year

POSSIBILITIES OF SCRAP COLLECT

home scrap from the Steel plant	8	8
Prompt scrap (13 % ?)	20	13
obsolete scrap	5.1 or 25.5 (40% of 85% of 15*** or 75**)	4.25 or 21.25 (50% of 85% of 10*** or 50**)
TOTAL	33.1 or 53.5	25.25 or 42.25

ESTIMATE OF MINIMILL

CAPACITY IN DEVELOPING COUNTRIES

area	approximate total capacity Mt/year	approximate minimill capacity Mt/year	%
AFRICA	15	1.1	14%
MIDDLE EAST		1.04	
ASIA (Japan excluded) (S. Korea) (India)	75	6.0 * (1.8) (1.1)	8%
LATIN AMERICA (Brazil) (Mexico) (Argentine)	30	5.4 (2.3) (1.4) (0.7)	18%
TOTAL	120	13.5	11%

source : See tables of appendices.

* Recent values from China could add about 15 Mt/year.

TABLE XIII

VARIOUS METALLURGICAL ROUTE FOR MINIMILLS

DEPENDING OF ENERGY AND RAW MATERIALS

iron bearing raw mat / energy supply	SCRAP	IRON ORE	
electrical energy	Electric arc furnace	+ direct reduction	
natural gas or oil	Open hearth ?	direct reduction	---
coal	gas producer ? or power plant	direct reduction	blast furnace ? or new smelting reduction process
sun → biomass → charcoal		charcoal direct reduction	charcoal blast furnace

TABLE XIV

VARIOUS CAPACITY RANGES

OF MINI-STEEL PLANTS

Capacity Range t/day	t/year	Remarks
10 i.e.,	3 000	Not much research and development in this capacity range
1 to 30	300 to 10 000	
100 i.e., MICRO-PLANT	30 000	Capacity range of a number of plants, specially in developing countries
30 to 300	10 000 to 100 000	
1 000 i.e., MINI-PLANT	300 000	Classical capacity range of mini-mills, specially in industrialized countries
300 to 3 000	100 000 to 1 000 000	

TABLE XIV bis

SITUATION OF THE AFRICAN MINI-STEEL PLANTS

IN THE VARIOUS CAPACITY RANGES

(Re-rolling plants, Table XV ter, are not included)

Micro-steel plants 10 000 / 100 000 t/year	14/36 000 t/year	SAFA	Mauritania
	20 000 t/year	LMI	Libya
	20 000 t/year	SNS	Togo
	24 000 t/year	SMEA	Uganda
	30 000 t/year	KUSCO	Kenya
	30 000 t/year	TEMA	Ghana
	34 000 t/year	NIGERSTEEL	Nigeria
	36 000 t/year	CISCO	Nigeria
	50 000 t/year	ASSAAA	Nigeria
	50 000 t/year	Siderurgica Nacional	Angola
	63 000 t/year	SIDER-ORAN	Algeria
	80 000 t/year	Delta Steel Mill	Egypt
Mini-steel plants over 100 000 t/year	150 000 t/year	Sosider	Zaïre
	150 000 t/year	Copper Works	Egypt
	150 000 t/year	El-Fouladh	Tunisia
	200 000 t/year	National Metal	Egypt
	800 000 t/year	Alexandria National Steel	Egypt
	1 000 000 t/year	Warri	Nigeria

TABLE XV

THE VARIOUS SCHEMES OF MINI-STEEL PLANTS

			0) Re-rolling plant (no steel-making facility)
	Melting of a primary metal	Electric arc furnace	01) Classical case of mini-steel plants
		Open-hearth furnace	02) Solution used in special cases
		Other types of furnaces	03) Solutions to be envisaged in the future
Production of a primary metal	Reduction of iron ore in solid state (Direct Reduction D.R.)		brings to: 11) DR + electric furnace 12) DR + open-hearth 13) new process
	Reduction of iron ore in liquid state (combined reduction and fusion)	Coke blast furnace (BF)	21) Classical solution for large integrated plants; difficult for small plants
		Charcoal blast furnace	22) Solution used in some countries
		Electric pig iron furnace	23) Solution used in specific cases
		New processes	24) At the research and development stage

TABLE XV bis

SITUATION OF THE AFRICAN MINI-STEEL PLANTS ACCORDING TO THEIR METALLURGICAL SCHEMES

	Melting of a primary metal	01) With electric arc furnace	14/36 000 t/year	SAFA	Mauritania
			20 000 t/year	LMI	Libya
			20 000 t/year	SNS	Togo
			24 000 t/year	SMEA	Uganda
			30 000 t/year	KUSCO	Kenya
			30 000 t/year	TEMA	Ghana
			34 000 t/year	NIGERSTEEL	Nigeria
			36 000 t/year	CISCO	Nigeria
			50 000 t/year	ASSAAA	Nigeria
			50 000 t/year	Siderurgica Nacional	Angola
			80 000 t/year	Delta	Egypt
			150 000 t/year	Sosider	Zaïre
		01) and 02) together	150 000 t/year	Copper Works	Egypt
		02) with open-hearth furnace	63 000 t/year	SIDER-ORAN	Algeria
			200 000 t/year	National Metal	Egypt
Production of a primary metal	Direct Reduction (DR)	11) DR + electric arc furnace	1 000 000 t/year	Warri	Nigeria
	Blast furnace (BF)	21) BF + oxygen converter	150 000 t/year	El-Fouladh	Tunisia

TABLE XV ter

RE-ROLLING PLANTS IN AFRICA

Re-rolling of billets to produce bars, etc.	KATSINA	Nigeria	210 000 t/year
	JOS	Nigeria	210 000 t/year
	OSHOGBO	Nigeria	210 000 t/year
	SOLADO	Cameroon	40 000 t/year
	IMCI	Ivory Coast	20 000 t/year
	SOMETAL	Morocco	40 000 t/year
Re-rolling of hot-rolled coils to produce cold rolled and coated coils or sheets	MALAKU (with galvanizing line)	Zaïre	150 000 t/year

TABLE XVI

PROJECT OF A MINI-STEEL PLANT

APPROACH FROM THE MARKET

INPUT		TIME →	
Estimate of total present market		Present market	Future market (in 10 years?)
Present total consumption t/year per product	Percentage of market needs covered by the projected plant		
-----	-----	-----	-----
50 000 t/yr of re-bars from 8 to 20 mm	60% →	30 000 t/year	Depending hypothesis: 30 000 t/year 45 000 t/year 60 000 t/year
-----	-----	-----	-----

TABLE XVII

PROJECT OF A MINI-STEEL PLANT

APPROACH FROM THE NATURAL RESOURCES

INPUT	TIME	
Capacity and type of production (quantity and quality) envisaged	Present choice (see Table VI)	Possible choice in the future (in 10 years?)
45 000 t/year of rebars or from 8 to 20 mm or 50 000 t/year of steel (billets)	01 Electric arc furnace with scrap	Probably not too many other choices? (03)
→	11 Idem with direct reduction	
	22 Production of pig iron with charcoal blast furnace and production of steel in oxygen converters	New processes? (24)

TABLE XVIII

PROJECT OF A MINI-STEEL PLANT

APPROACH FROM THE HUMAN RESOURCES

List and codes of key functions

DEPARTEMENT		LIBELLE DE LA FONCTION	CODE FICHE
APPROVISIONNEMENT (non postés)		Chef acheteur de rechanges	1
		Chef acheteur de matières premières	2
		Gestionnaire Magasins/parcs et dédouanement	3
		Responsable de réapprovisionnement des stocks	4
ENGINEERING		Responsable de la documentation technique des installations	5
ENTRETIEN SECTORIEL	postés	Magasinier de poste coulée continue	6
		Machiniste pomperie coulée continue	7
		Contremaître de poste d'entretien sectoriel coulée continue	8
	non postés	Chef magasinier/visiteur coulée continue	9
		Chef préparateur d'entretien coulée continue	10
		Contremaître Chef d'entretien sectoriel coulée continue	11
PRODUCTION COULEE CONTINUE (Postés)		Responsable de l'atelier des réfractaires de coulée continue	12
		Préparateur de distributeurs (tundish) à la coulée continue	13
		Contremaître Chef de parc à billettes de coulée continue	14
		Surveillant des utilités et auxiliaires coulée continue	15
		Agent de mise en nuance à la coulée continue	16
		Couleur à la coulée continue	17
		Contremaître Chef de machine coulée continue	18
		Opérateur en cabine coulée continue	19
		Contremaître Chef de poste coulée continue	20

TABLE XIX

INVESTMENT COSTS FOR THE VARIOUS CONFIGURATIONS

OF THE REFERENCE PLANT IN MILLIONS US DOLLARS (1985)

	Cost of equipment M$	Cost of internal infrastructure Civil. erection, building work M$	Total Cost M$
Simple bar rolling mill 100 000 t/year	25	15	40
Combination mill for bars, wire rod and medium profiles 400 000 t/year	60	40	100
Same as above semi integrated with EAF and billet CC 400 000 t/year	+ 45 = 105	+ 55 = 95	200
Same as above inte-grated with natural gas D.R. Plant 400 000 t/year	+ 50 = 155	+ 50 = 145	300

TABLE XX

INVESTMENT COSTS FOR THE VARIOUS CONFIGURATIONS

OF THE REFERENCE PLANT IN MILLIONS US DOLLARS (1985)

	Cost equipment and internal infrastructure	
	Total cost M$	Cost in $ per annual Ton
Rolling millalone : 100 000 t/year 400 000 t/year	 40 100	 400 250
Rolling mill semi-integrated with EAF and billet CC (420 000 t/year billet) (400 000 t/year product)	200	500
Same as above integrated with gas D.R.	300	750

TABLE XXI

COST OF THE INFRASTRUCTURE OF THE FIRST ORDER

(everything is related to a 400 000 t of product/year plant)

Item	order of magnitude of cost M$
Main offices	10
Laboratories	3 to 5
Maintenance facilities :	
Workshops	10
Warehouses	5
General transport and handling systems	5
TOTAL	33 to 35

TABLE XXII

COST OF SOME INFRASTRUCTURES OF THE SECOND ORDER

(everything is related to a 400 000 t of product/year plant)

item	order of magnitude of cost M$
housing for families of 1380 people + associated facilities	30 M$
energy supply we mean only, here, the connections to existing systems of : Natural gas Fuel oil Coal Electrical energy Water etc ...	))).... 40 to 60 M$)))

TABLE XXIII

ORDER OF MAGNITUDE OF THE COST OF SOME INFRASTRUCTURES OF THE THIRD ORDER

(everything is related to a 400 000 t of product/year plant)

item	basis	total cost M$
Iron Mine (600 000t/year of high grade lumps or pellets)	from 15 to 75 $/t	10 to 50 M$ * even more if long railroad or pipe line have to be built
gas field (for 150 M㎥/year)	difficult to give average datas	
Power station (for 400 GWh/year) and 140 MW	from 500$ to 1 000$ per MW	70 to 140 M$
water intake (for 3 M㎥/year)		1 to 5 M$ even more if it is far away ...
Port	difficult to give average datas	

* some 25 to 35 M$ could be added if pelletizing plant is needed

TABLE XXIV

VARIOUS COSTS OF IRON AND STEEL PLANT WITH INFRASTRUCTURE

(total cost in million US dollars (1985))

	Total cost of plant			Extra infrastructure	
	Equipment	internal infrastructure	1st order	2nd order	3rd order
Rolling mill 100 000t/y	15 to 25	+ 10 to 15 25 to 40	+ 5 to 10 30 to 50	+ 2 to 10 up to 60	?
semi integrated classical minimill 200 000t/y	55	+ 40 = 95	+ 5 = 50	---	---
semi integrated diversified miniplant 400 000t/y	105	+ 95 = 200	= 30 = 230	+ 10 to 50 up to 280	?
integrated steelplant with D.R. 400 000t/y	155	+ 145 = 300	+ 40 = 340	+ 70 to 100 410 to 440	+ ?
Classical integrated Iron and Steel plant 2 Mt/year	total 2 500 to 3 000			→	can reach 4 000 to 6 000
Classical integrated Iron and Steel plant 4 Mt/year	total 4 000 to 5 000			→	can reach 6 000 to 8 000

TABLE XXV

ORDER OF MAGNITUDE OF SOME RAW MATERIALS, ADDITIVES AND VARIOUS PRODUCTS NEEDED TO PRODUCE ONE TON OF STEEL IN THE ELECTRIC ARC FURNACE

	kg/t steel
Scrap	around 1 100
Fluxes: lime dolomite, etc.	20 to 100
Electrodes	4 to 10
Ferro-alloys: ferro-manganese ferro-silicium Re-carburizing agent (anthracite, coke, ...)	A few kg
Refractories (see details in tables XXVIII and XXIX and Figure 21)	-
Mechanical parts	-
Electrical parts	-

TABLE XXVI

LIST OF SOME MATERIALS AND PRODUCTS

NEEDED TO CAST ONE TON OF STEEL

Powder in casting moulds

Oil

Ingot moulds

Mechanical parts

Electrical parts

Etc...

TABLE XXVII

LIST OF SOME MATERIALS AND PRODUCTS NEEDED TO ROLL ONE TON OF STEEL

Oil

Grease, etc.

Rolls

Guides

Rollers

Mechanical parts

Electrical parts

Etc...

TABLE XXVIII

CLASSIFICATION OF REFRACTORIES FOR STEEL-MAKING

SPECIALLY FOR ELECTRIC ARC FURNACE AND LADLES

REFRACTORY TYPE	1. Magnesite (MgO)
	2. Magnesite - chrome ($MgO - Cr_2O_3$)
	3. Magnesite - carbon (MgO - C)
	4. Magnesite - dolomite ($CaCO_3 - MgCO_3$) MgO
	5. Dolomite ($CaCO_3 - MgCO_3$)
	6. Lime (fused/sintered) CaO
BONDING	1. Burned brick - conventional
	2. Burned brick - direct bonded
	3. Burned brick - sintered
	4. Burned brick - resin bonded - regular grain
	5. Burned brick - resin bonded - fused grain
	6. Fused cast
	7. Chemically bonded (inorganic)
	8. Chemically bonded (organic)
	9. Impregnated (inorganic)
	10. Impregnated (organic)
RAW MATERIALS	1. Natural magnesite
	2. Synthetic magnesite
	3. Fused magnesite
	4. Chrome ore
	5. Simultaneous sinter ores - (Magnesite - Chromite)
	6. Dolomite
	7. Lime
	8. Flake graphite
	9. Conventional graphite
	10. Carbon (lamp black, etc.)

TABLE XXIX

MAIN REFRACTORIES USED IN ELECTRIC ARC FURNACES

	Standard refractory material	New or experimental material
Hearth	MgO high purity, dolomite; Dolomite-MgO ramming	MgO high purity bricks Special CaO ramming
Slagline	As above, plus: $MgO \cdot Cr_2O_3$ rebonded fused grain	MgO-C bricks (C = 6 - 35%) $MgO-Cr_2O_3$
Lower sidewall	MgO high purity impregnated	Special direct bonded bricks $MgO-Cr_2O_3$ chemical bonded/water cooled panels
Upper sidewall	$MgO-Cr_2O_3$ burned or chemical bonded dolomite	Water cooled panels
Hot spots	Fused cast $MgO-Cr_2O_3$ High purity MgO	MgO-C bricks (C = 6 - 35%) Water cooled panels
Taphole	Monolithics, bricks, checks or sleeves	Fused cast $MgO-Cr_2O_3$ block
Tapping spout	Basic monolithics 94% MgO 86% MgO bricks	Blocks made from refractory oxides such as ZrO_2, SiO_2, Al_2O_3, MgO associated with SiC and C
Roof	70-86% Al_2O_3 bricks, partial or complete $MgO-Cr_2O$	Water cooled membrane or panels
Delta section	High Al_2O_3 bricks and monolithics, 70-86% (ramming or castable) $MgO-Cr_2O_3$ materials	Castables 96-97% Al_2O_3 or basic material MgO-C bricks

FIGURE 1

THE WORLD STEEL-MAKING PROCESSES IN THE 80s

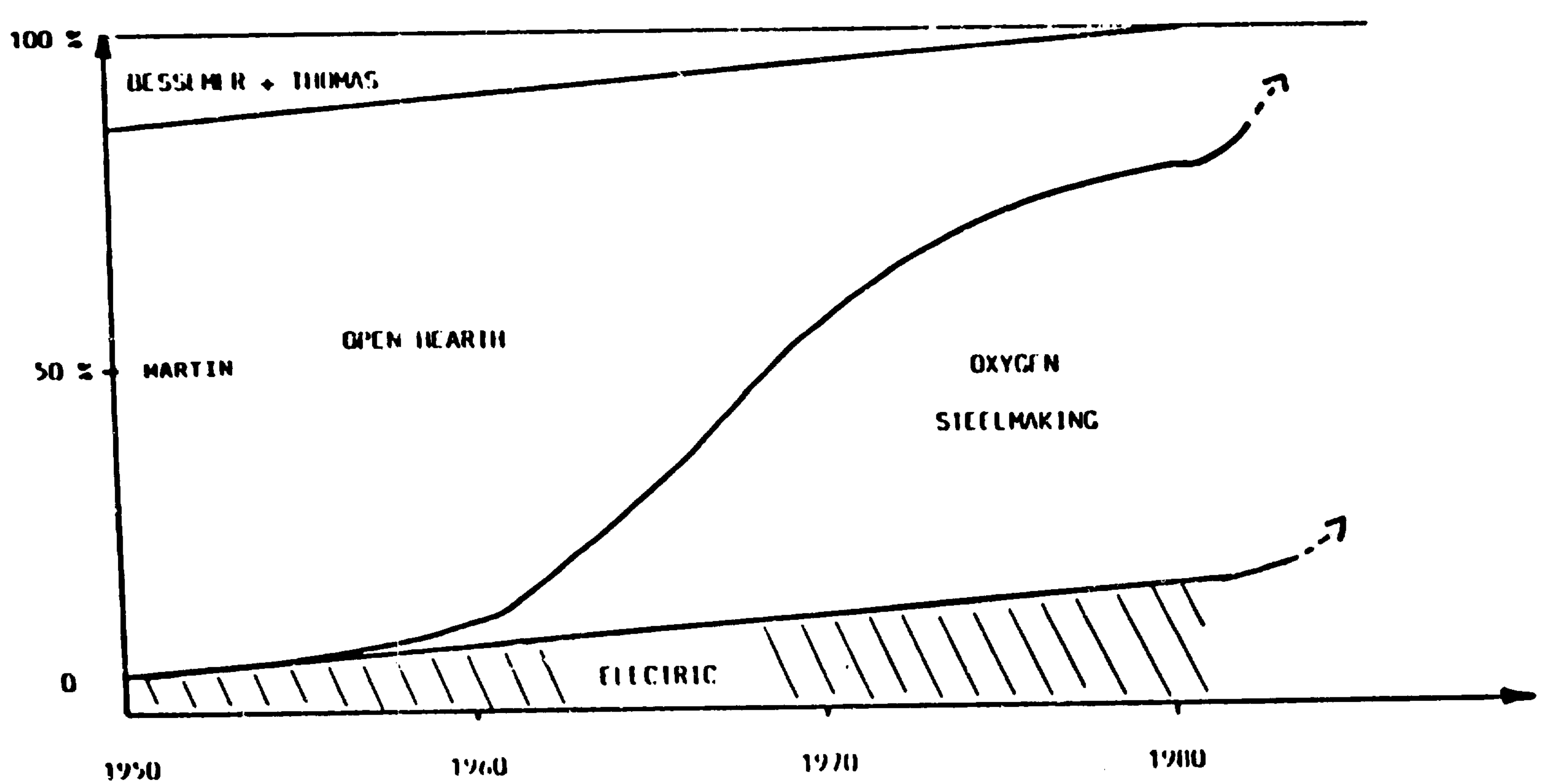
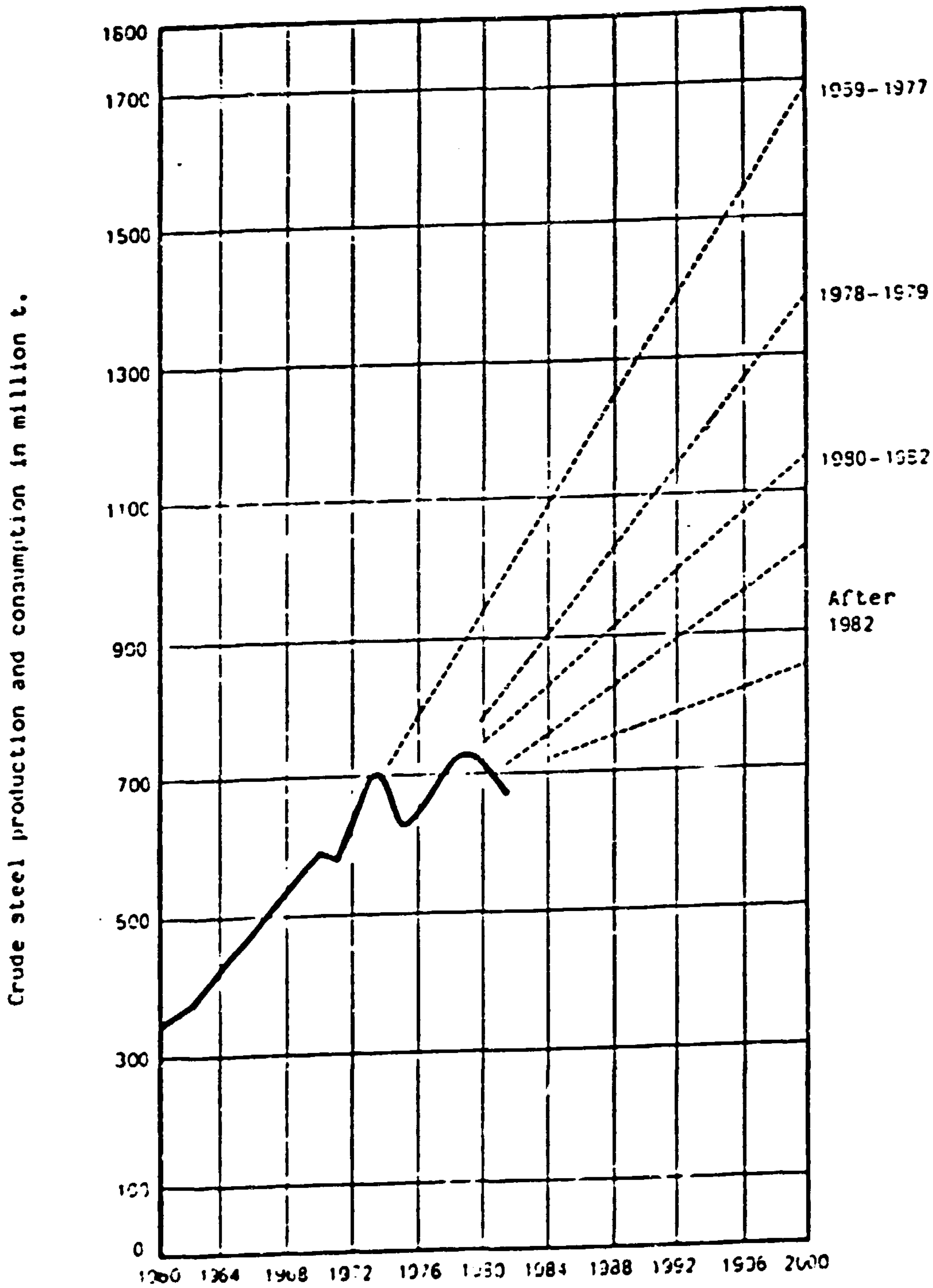


FIGURE 2

TREND LINES OF FORECASTS OF WORLD STEEL PRODUCTION AND CONSUMPTION

FOR THE PERIOD 1975-2000 IN RELATION TO TIME OF FORECASTING



From UN ECE Study (6)

FIGURE 2 b

WORLD STEEL CONSUMPTION

(Mt of crude steel)

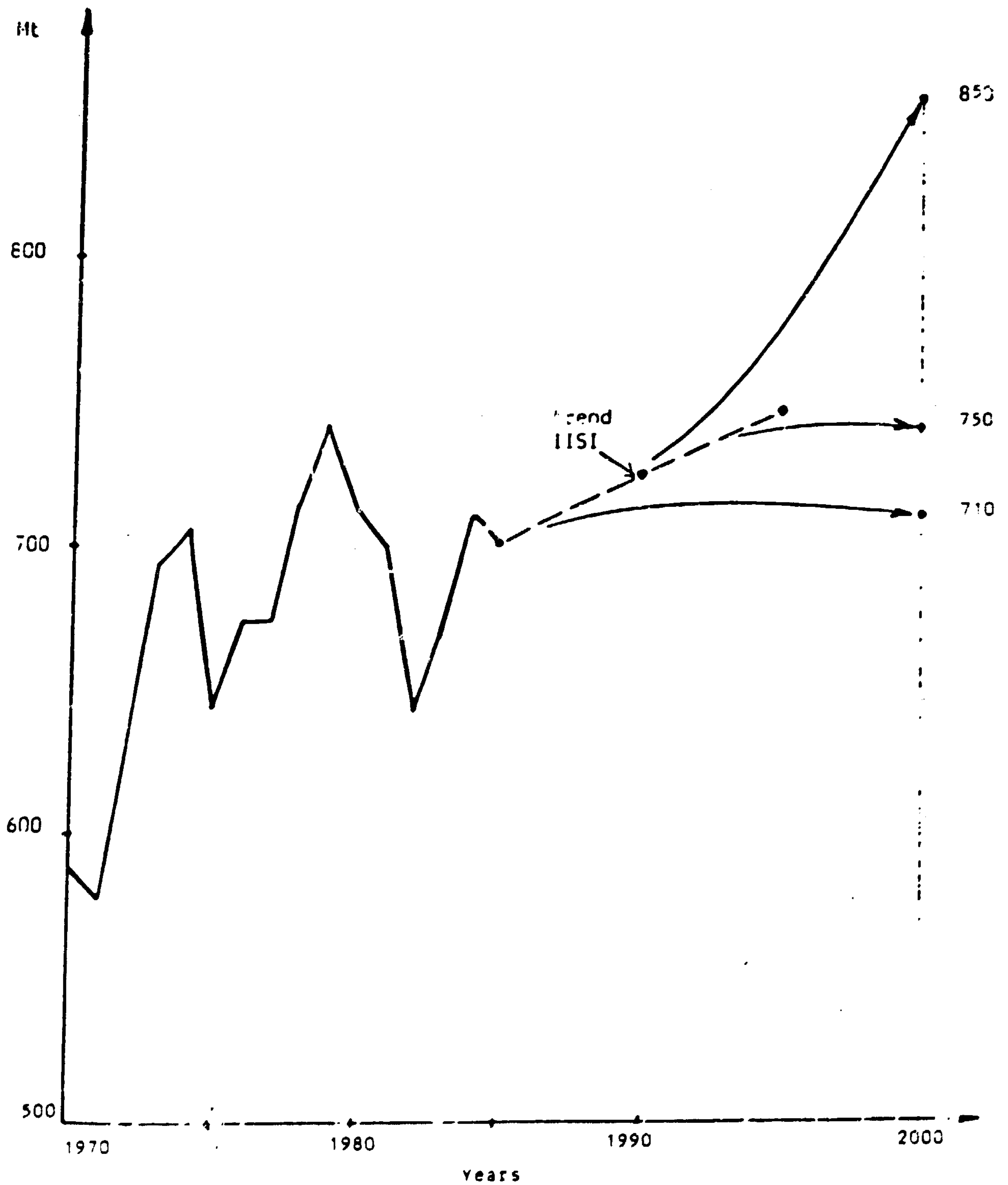


FIGURE 2C

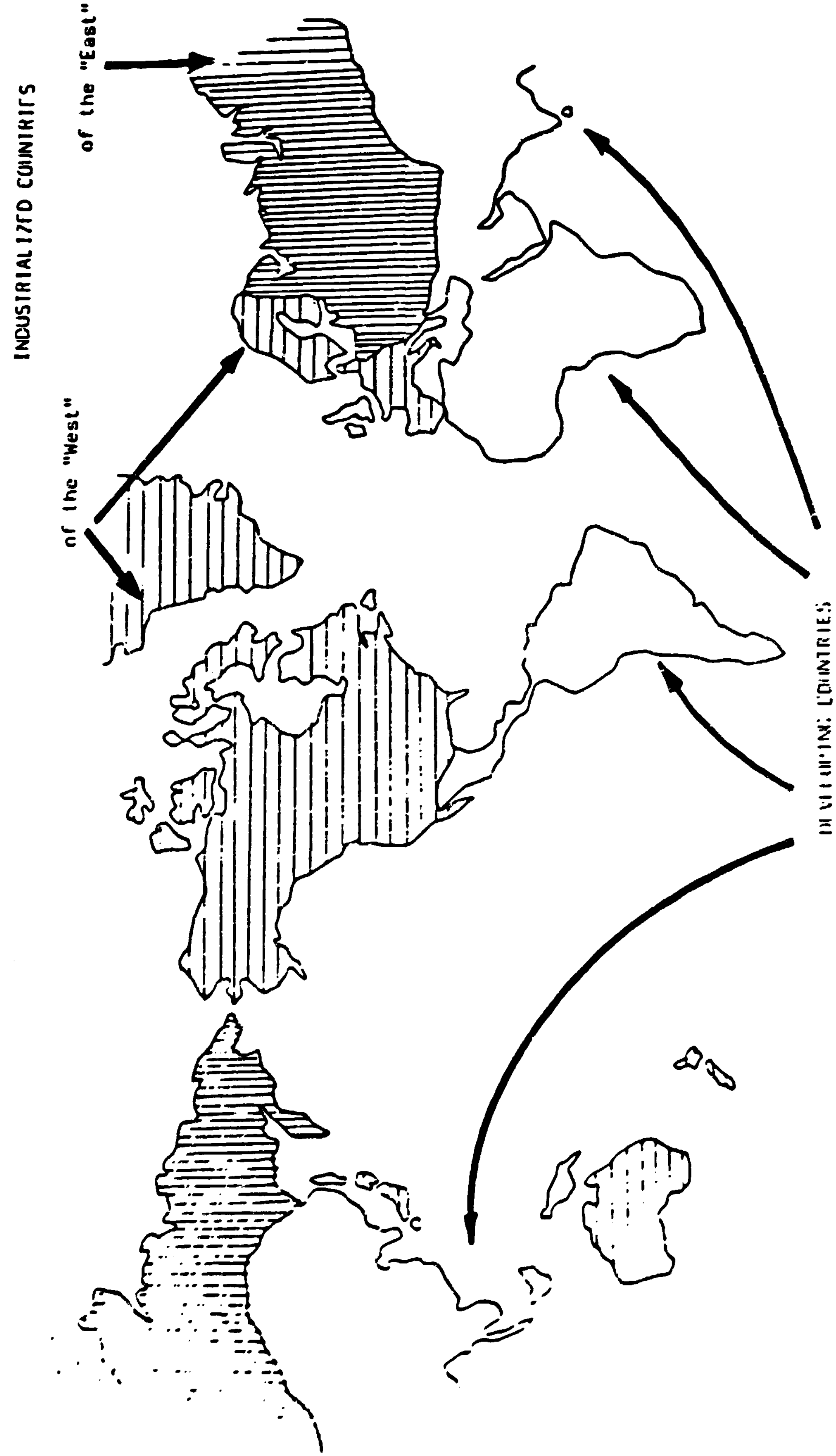

INDUSTRIALIZED COUNTRIES
of the "East"
of the "West"
DEVELOPING COUNTRIES

FIGURE 2d

REGIONAL STEEL CONSUMPTION

(Mt of crude steel)

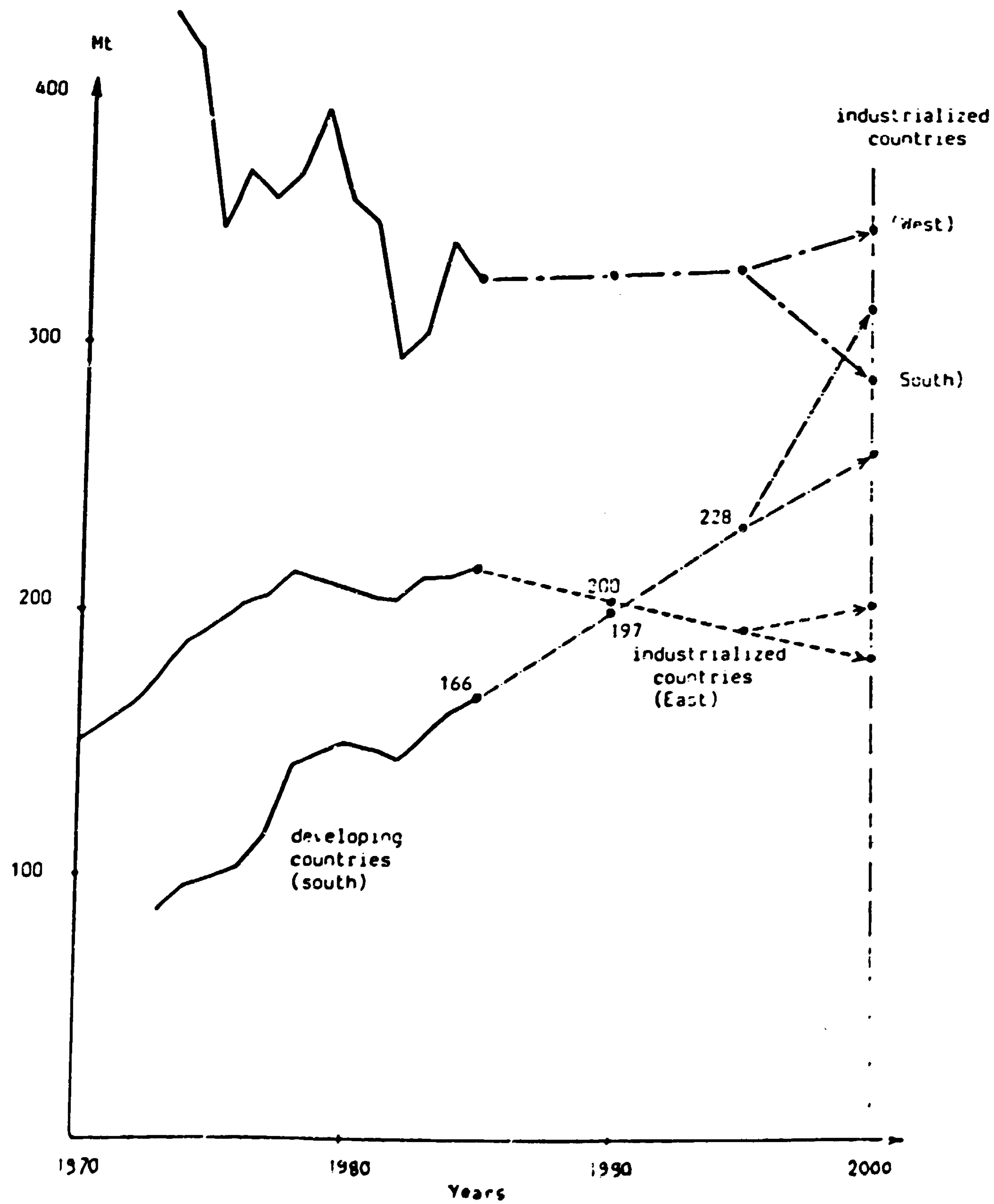


FIGURE 3

THE TWO TYPES OF IRON AND STEEL PLANTS

IN INDUSTRIALIZED AREA

Processes and routs / capacity t steel/year	"Classical" with Blast Furnace and Oxygen Converter	with Electrical Arc Furnace based on scrap	with Electrical Arc Furnace and Direct Reduction
Less than 100 000	Such plants are disappearing	Evolution of the mini steel plants for long products	(Difficult too small)
100 000 to 1 000 000			Difficult for economical reasons
1 000 000 to 5 000 000	Evolution of the large flat products integrated plant		Difficult (too large)
More than 5 000 000			

FIGURE 4

AVERAGE CAPACITY OF MAIN ROLLING MILLS

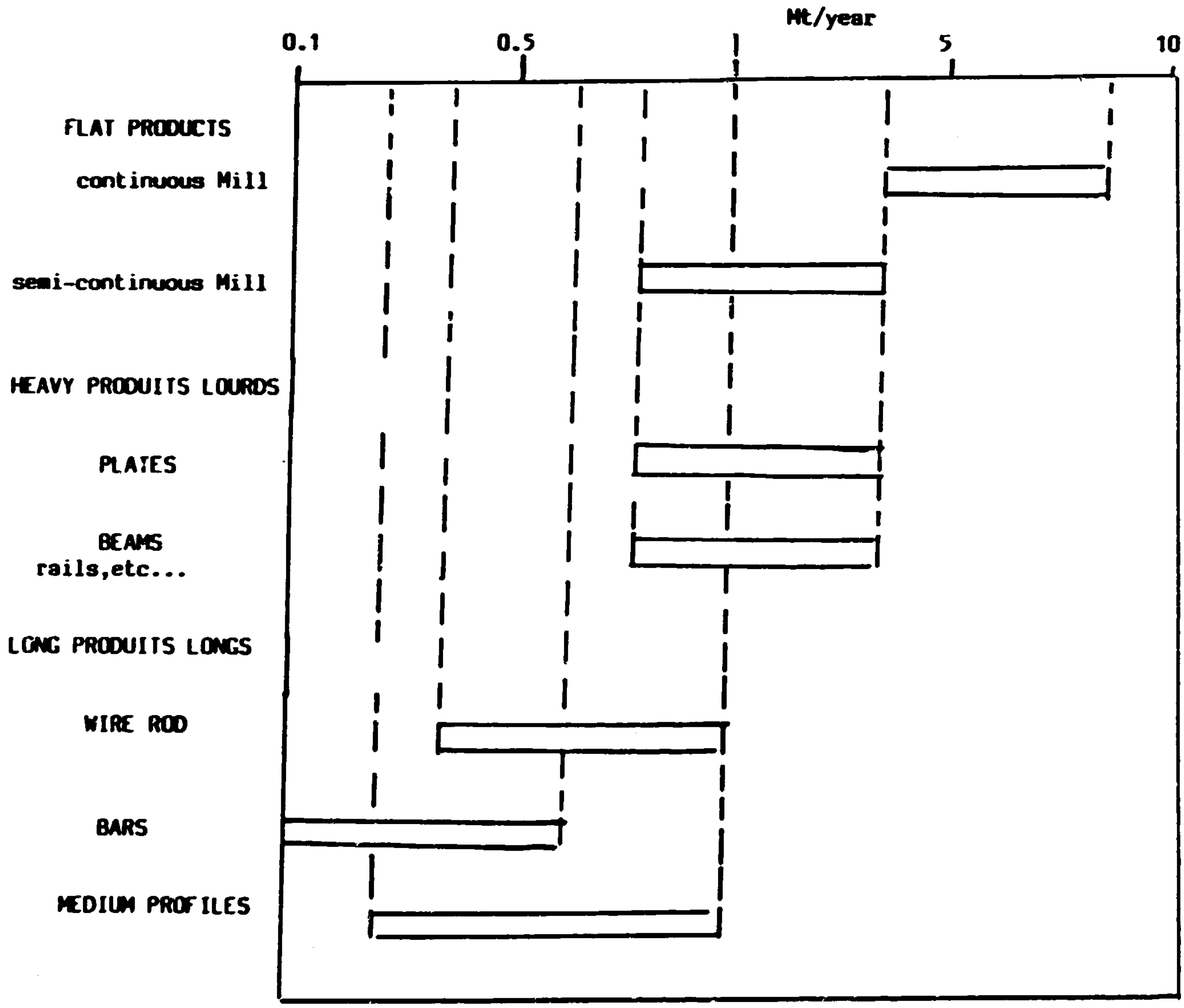


FIGURE 5

TREND TO DIVIDE THE IRON AND STEEL INDUSTRY IN INDUSTRIALIZED COUNTRIES IN TWO DIFFERENT TYPES OF PLANTS

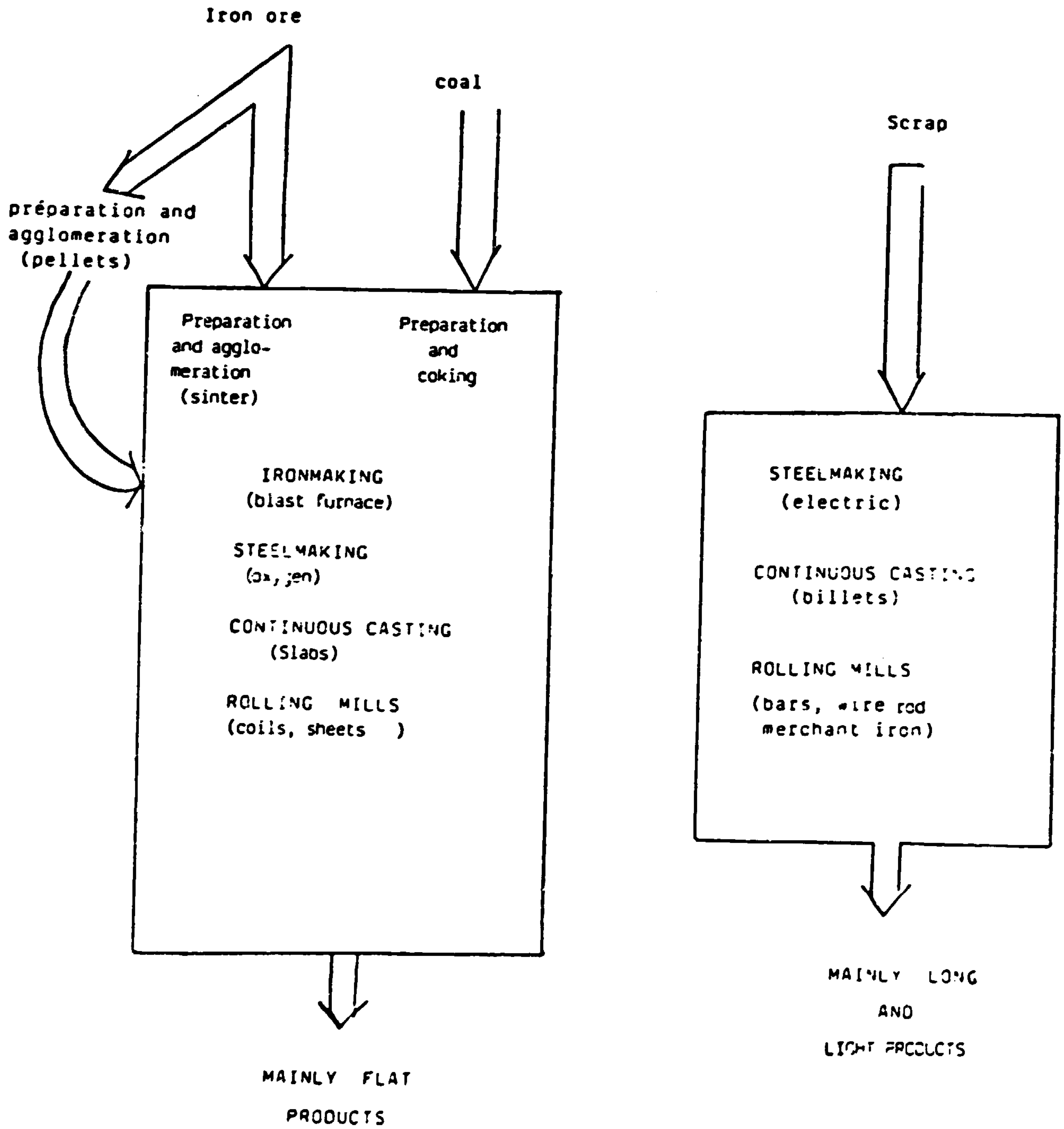
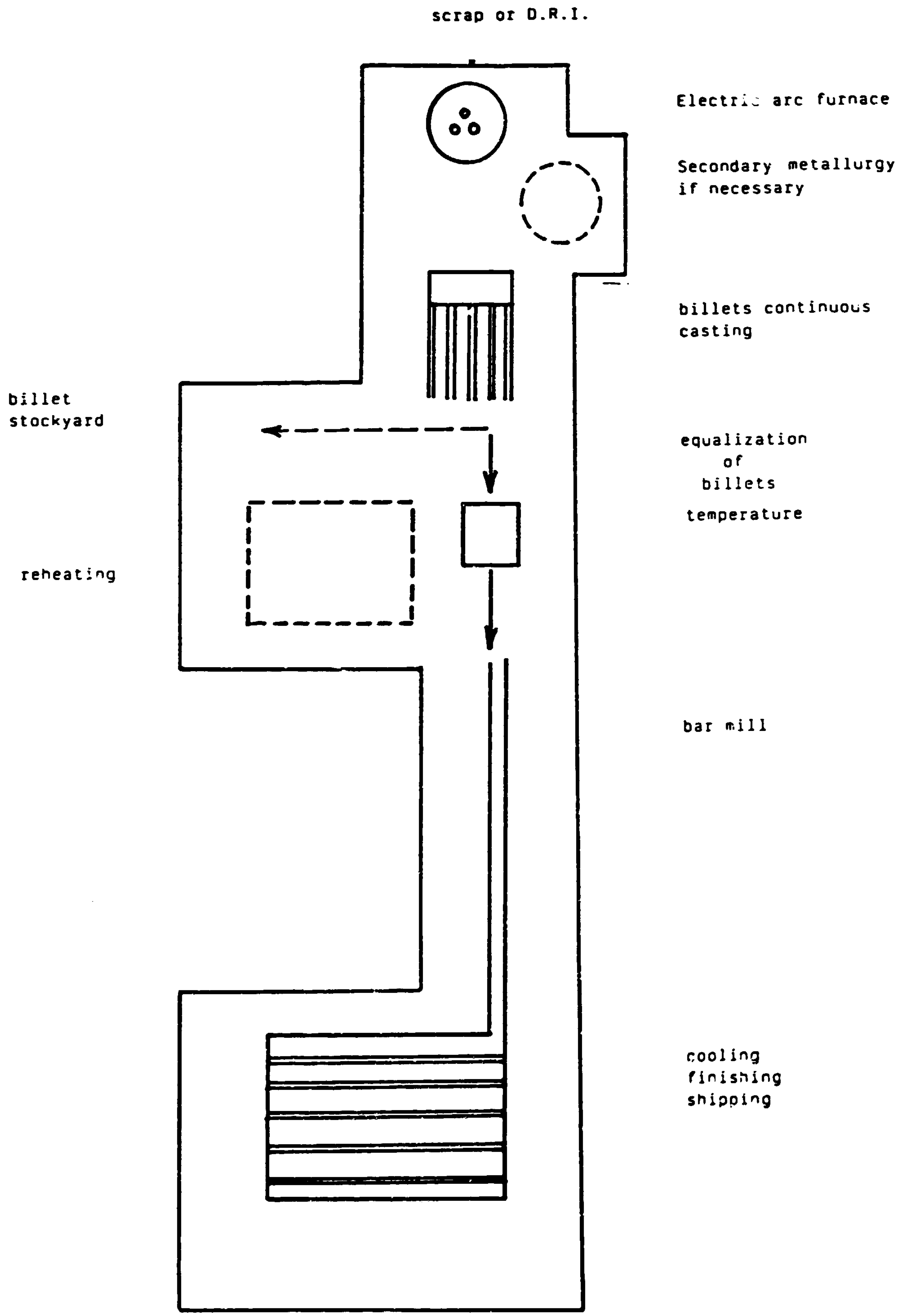


FIGURE 6

THE TYPICAL MINI-STEEL PLANT



ORDER OF MAGNITUDE OF COST OF 1000 kWh

AROUND THE WORLD (in US $ 1985)

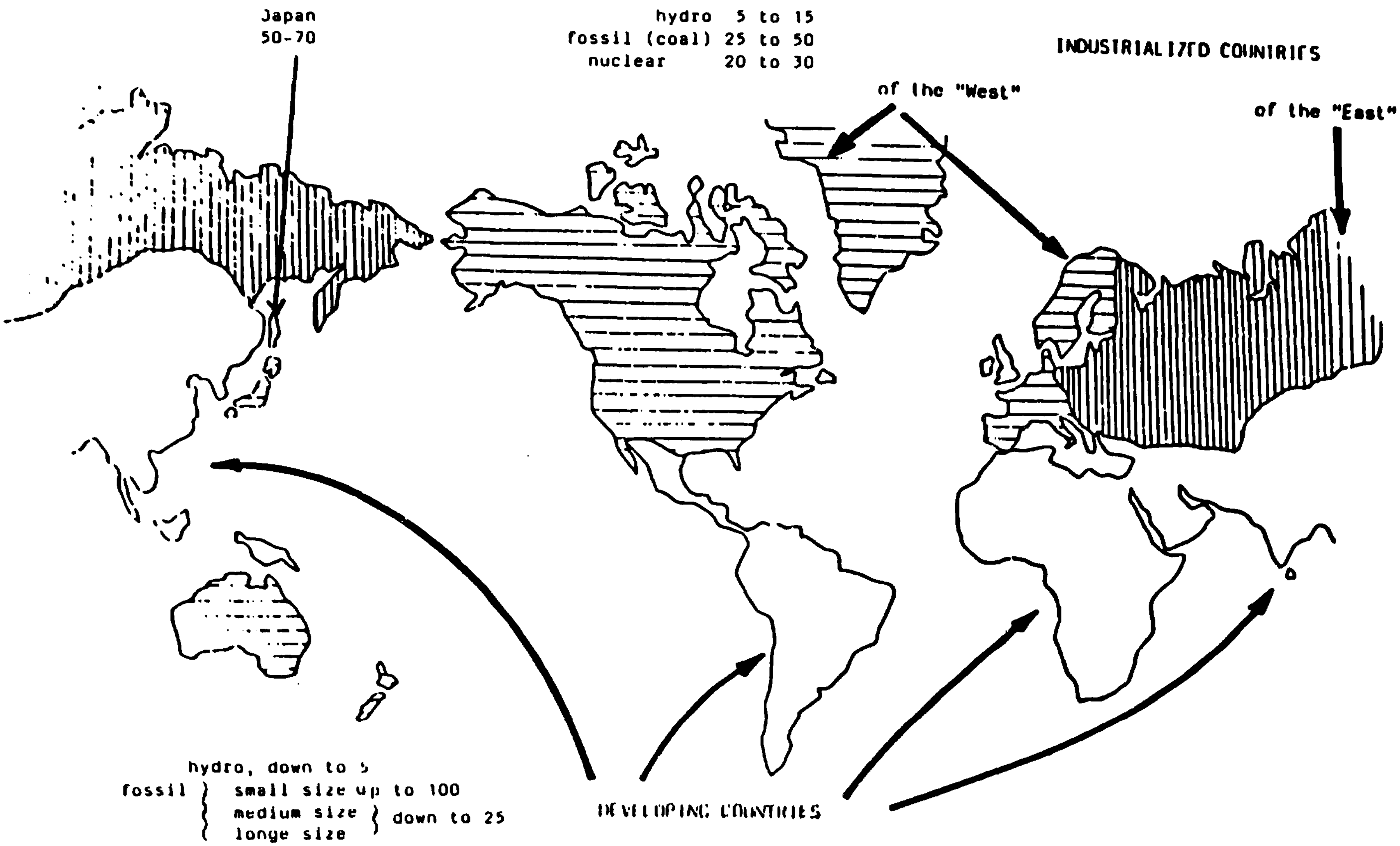


FIGURE 7

POSSIBLE EVOLUTIONS OF A MINIMILL TOWARDS CONTINUOUS OPERATIONS

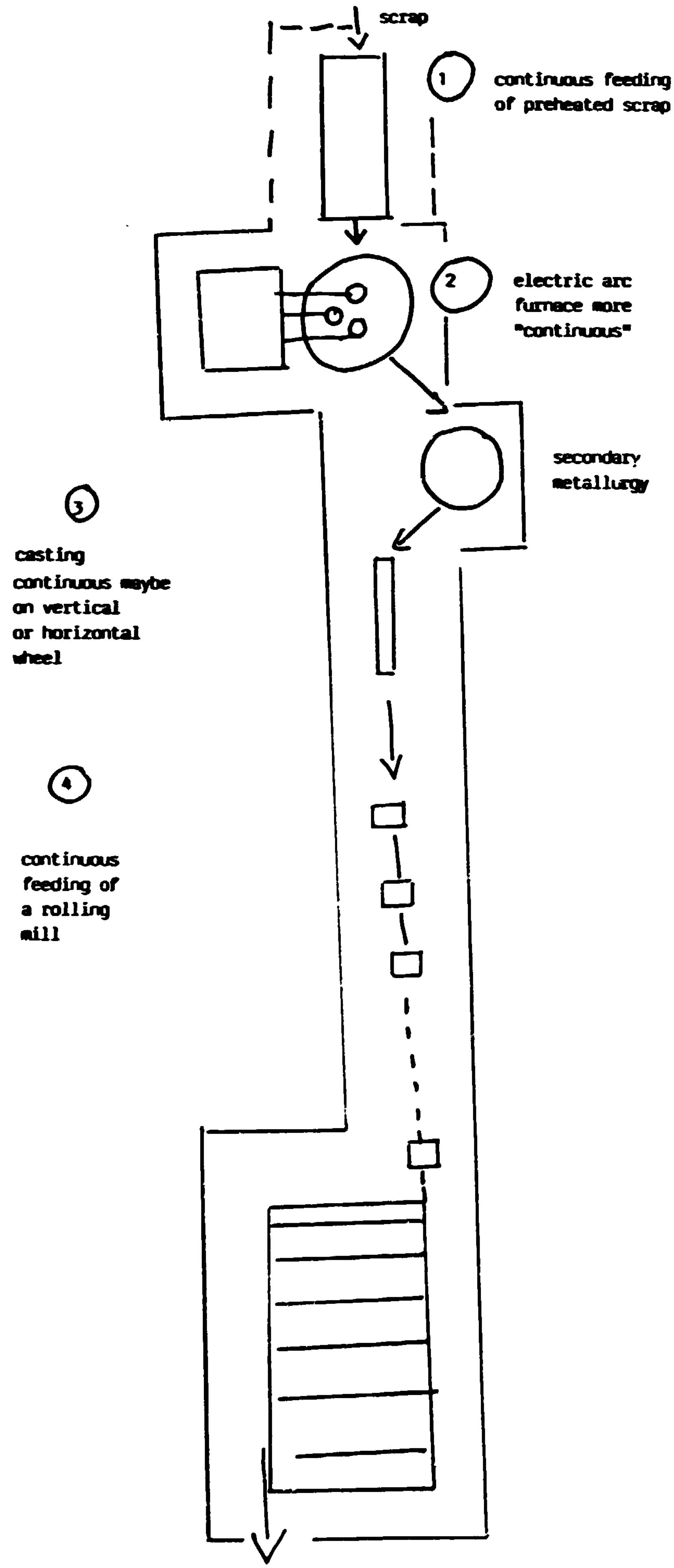
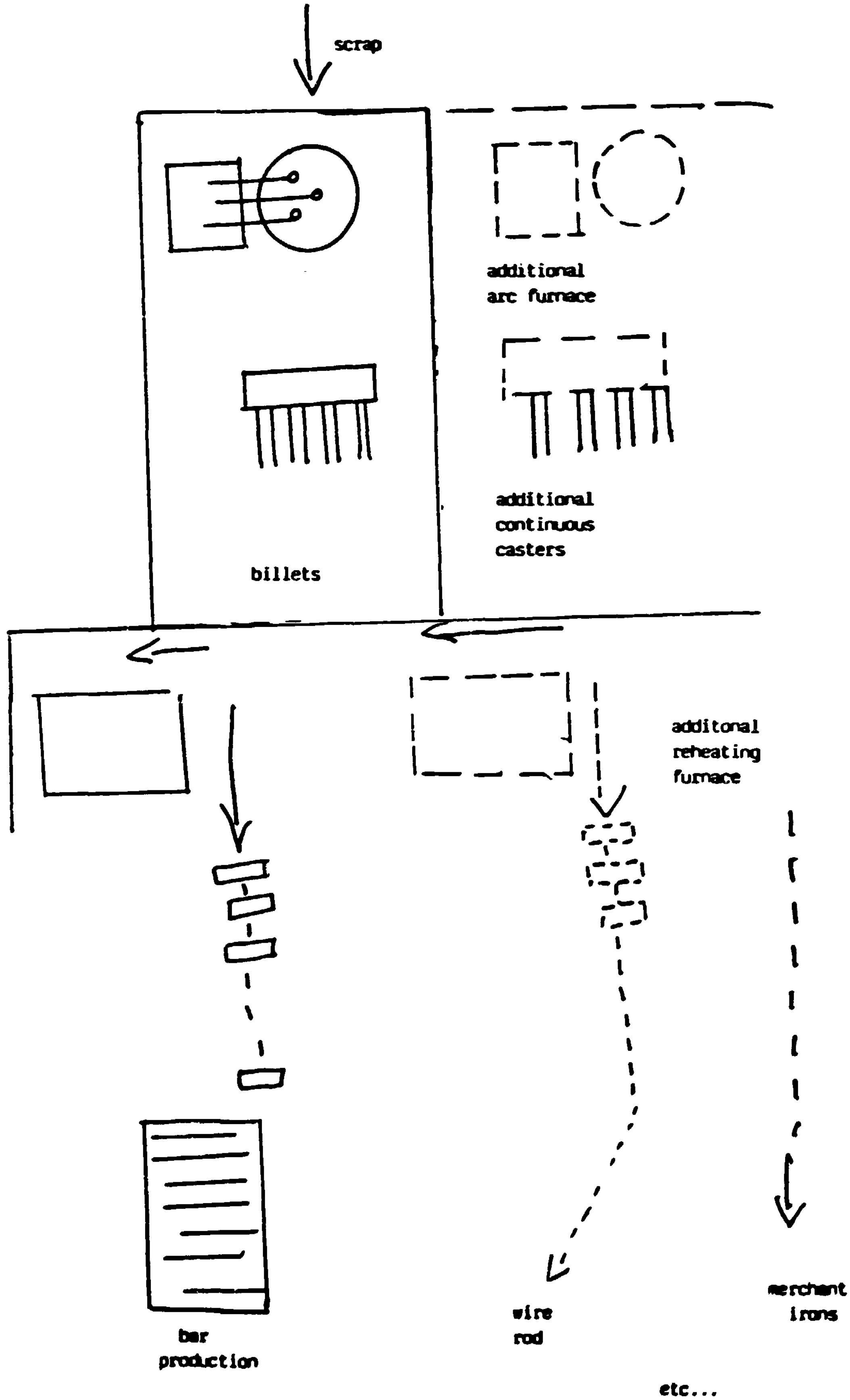
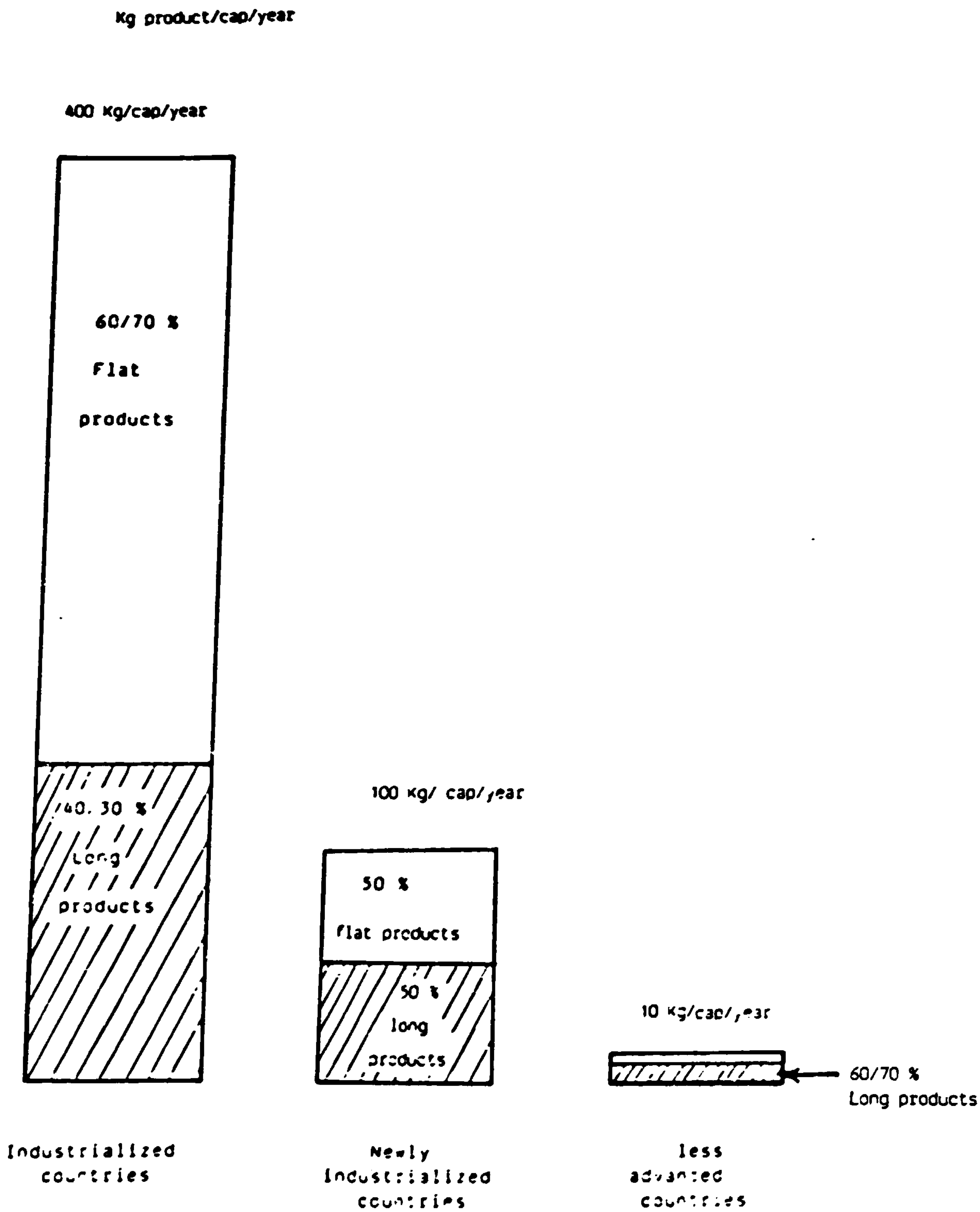


FIGURE 9

POSSIBLE EVOLUTION OF A MINIMILL TOWARDS MORE DIVERSIFIED PRODUCTIONS



STRUCTURE OF STEEL CONSUMPTIONS



THE VARIOUS ROUTES AND PROCESSES TO PRODUCE LIQUID STEEL

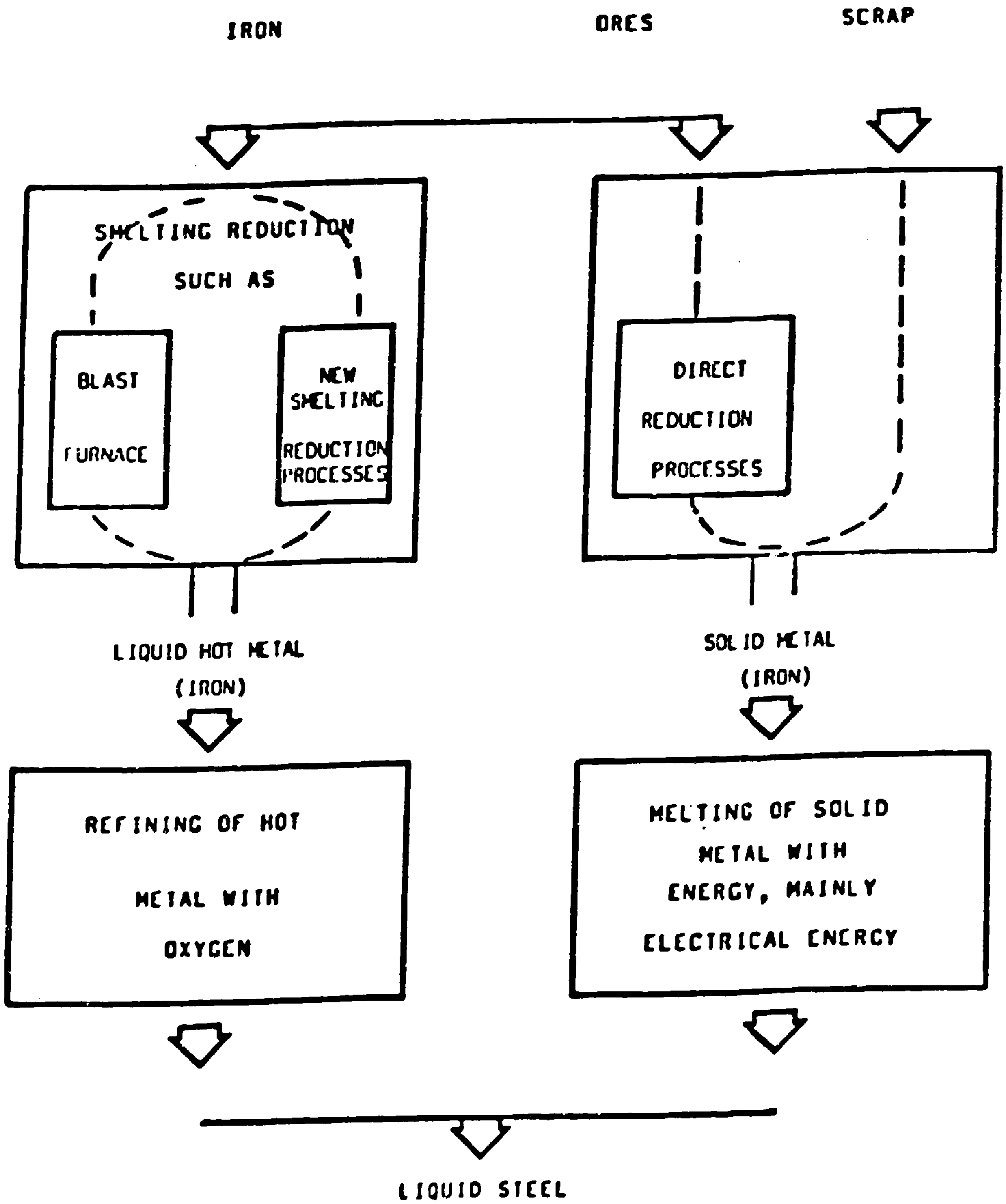


FIGURE 11b

MAIN PREREDUCTION METHODS OF IRON ORES

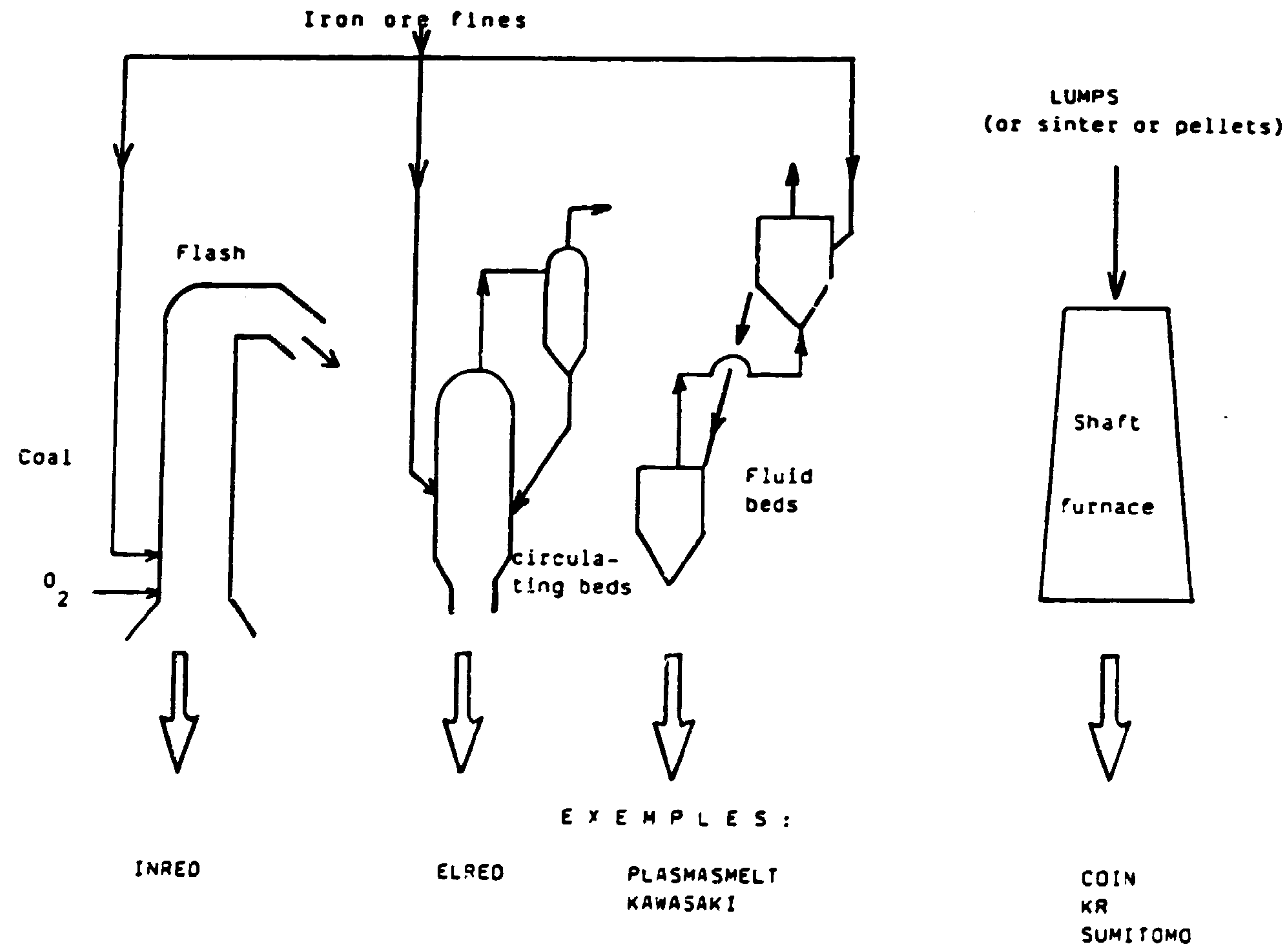


FIGURE 12

THE THREE TYPES OF IRON AND STEEL PLANTS
IN DEVELOPING AREAS

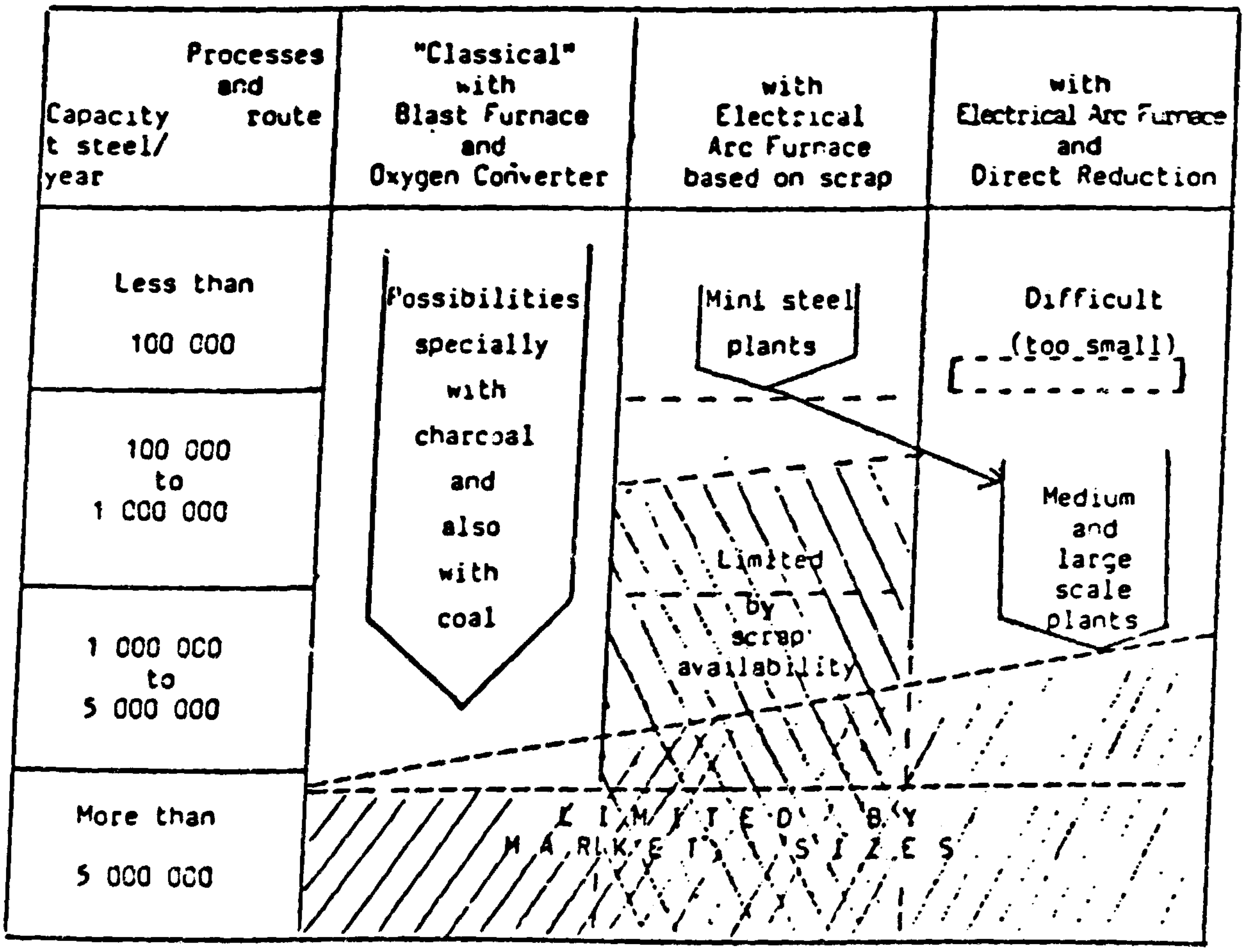


FIGURE 13

MINISTEELPLANTS OF U.S.A. AND JAPAN :

Comparaison of distribution of sizes

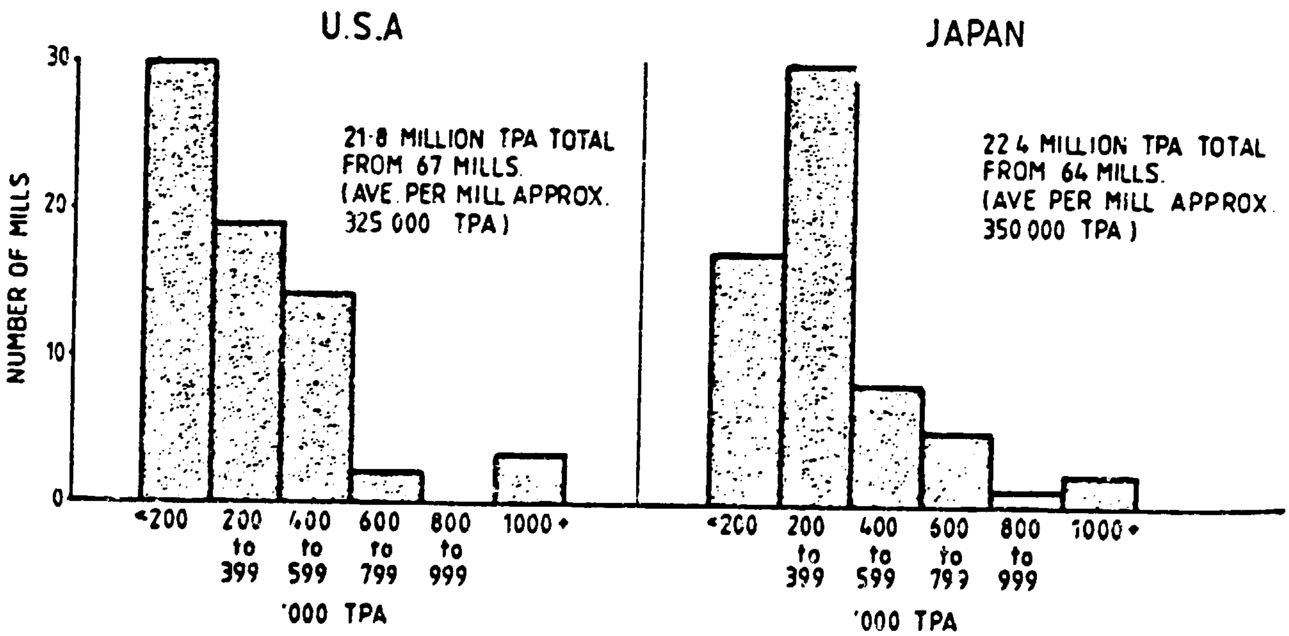


FIGURE 14

MINISTEELPLANTS OF SEAISI MEMBERS AND LATIN AMERICA

comparaison of distribution of sizes

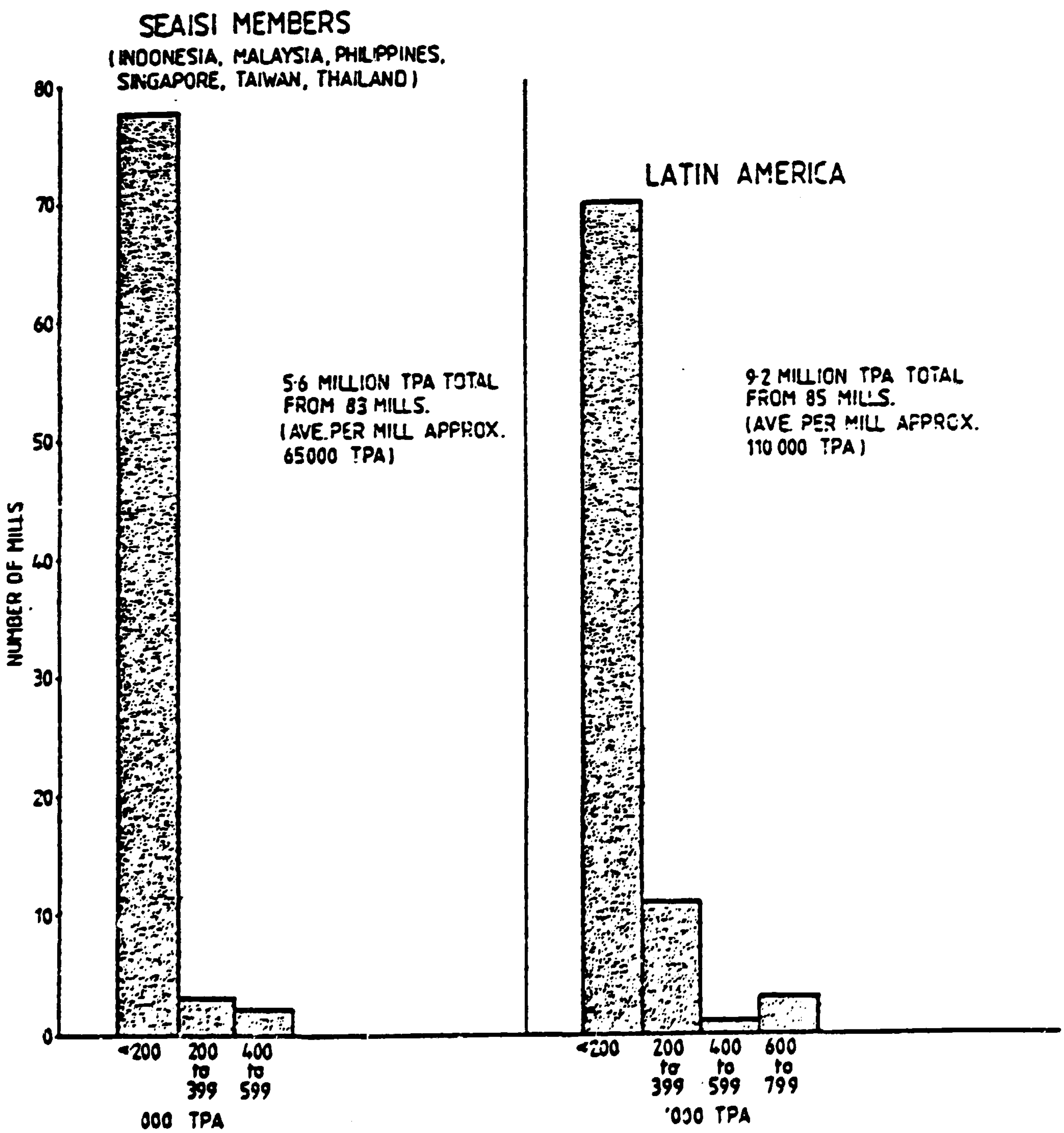


FIGURE 15

THE FOUR PARAMETERS REGULATING THE OPERATIONS

OF AN INDIVIDUAL FUNCTION

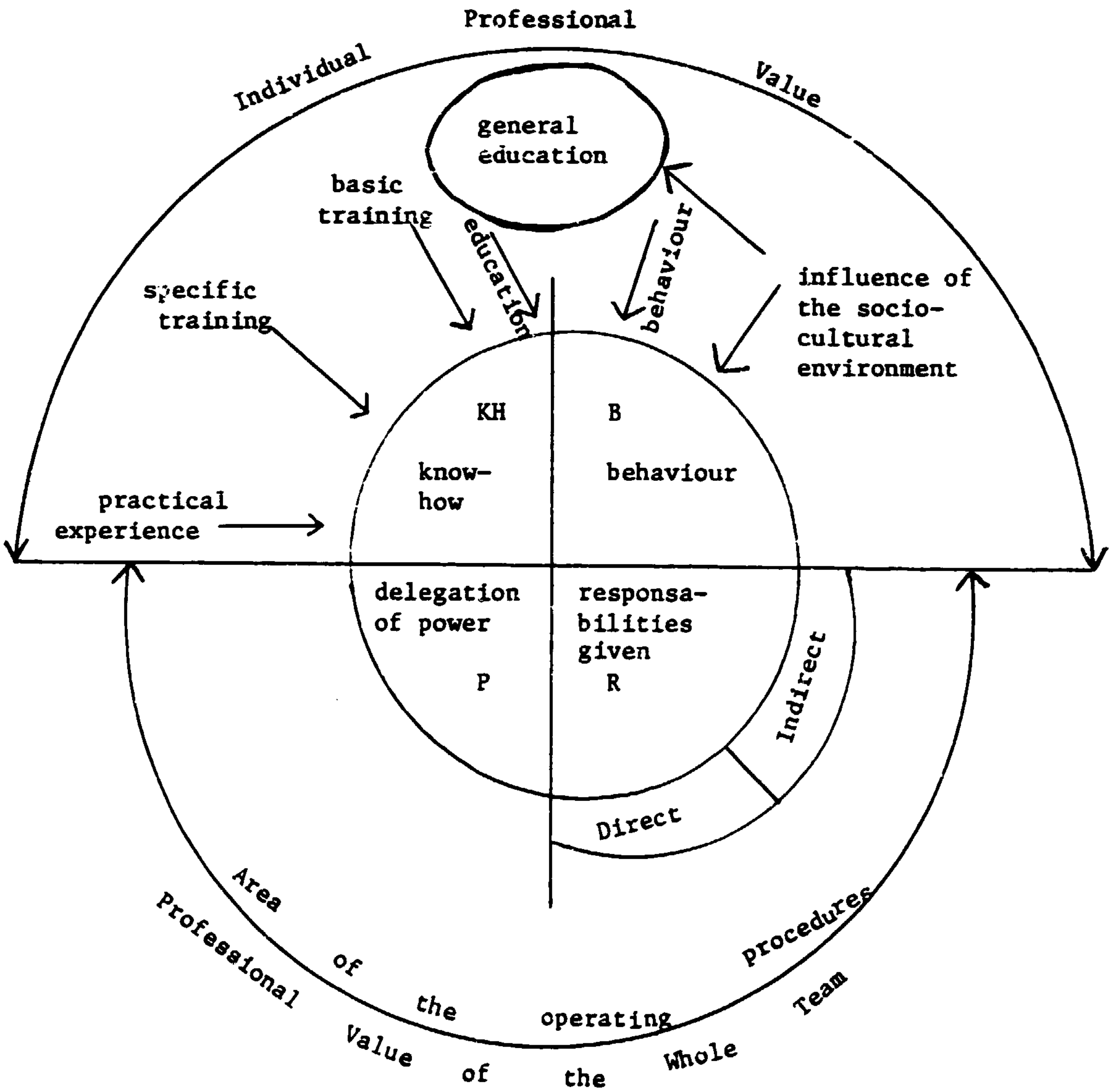
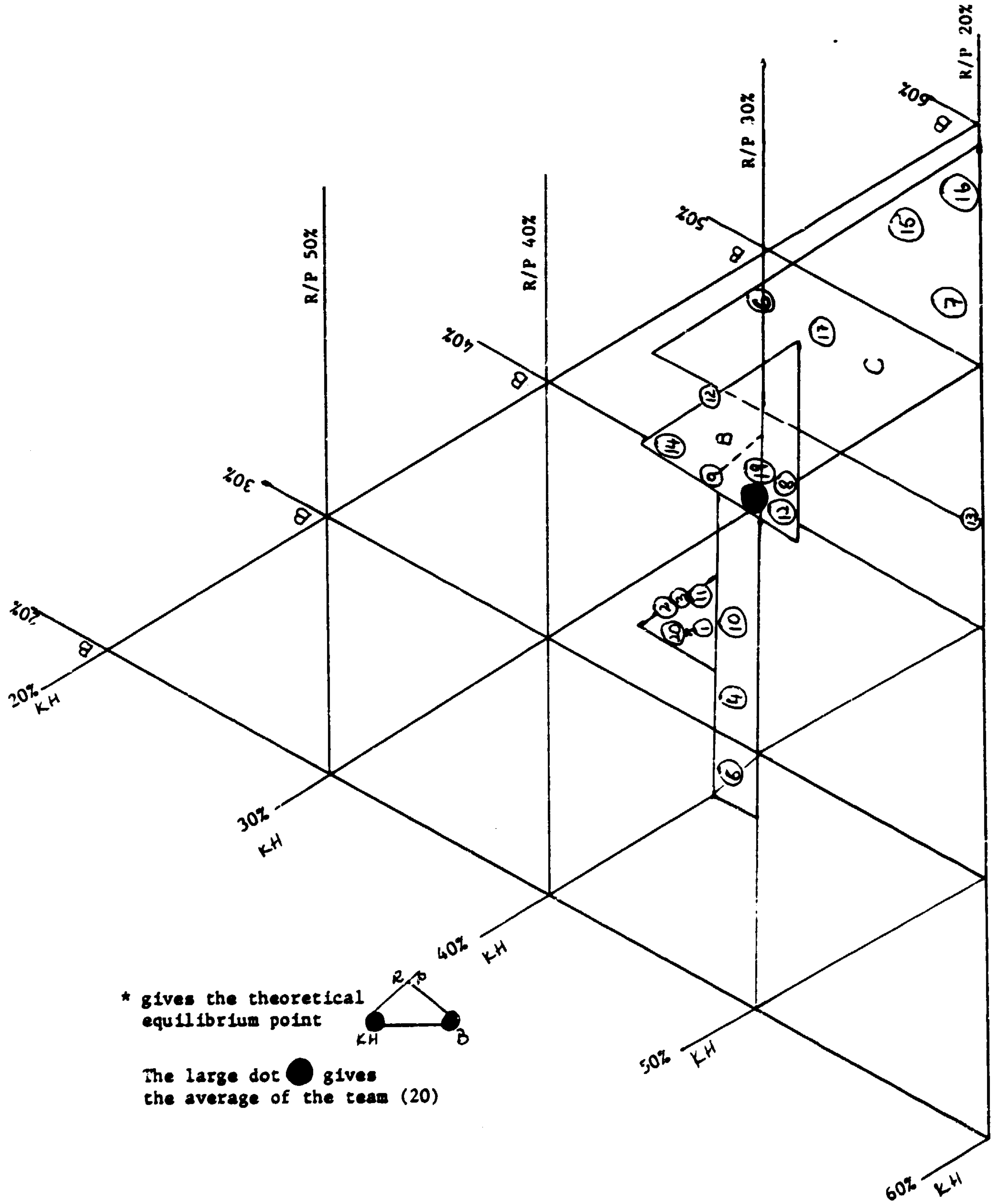


FIGURE 16

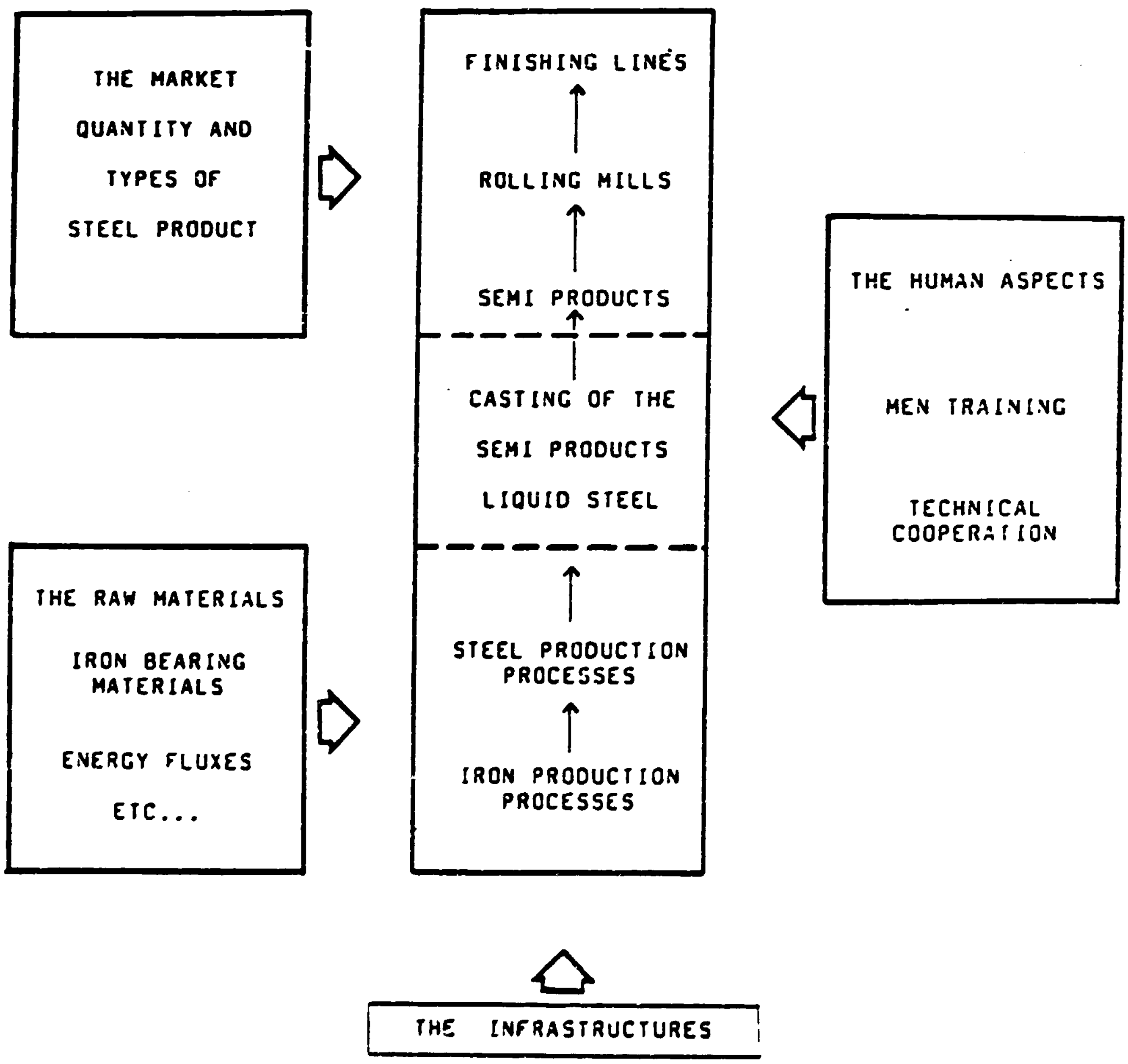
THE USEFUL RANGE OF THE PARAMETERS REPRESENTED IN A TRIANGULAR DIAGRAM



* gives the theoretical equilibrium point

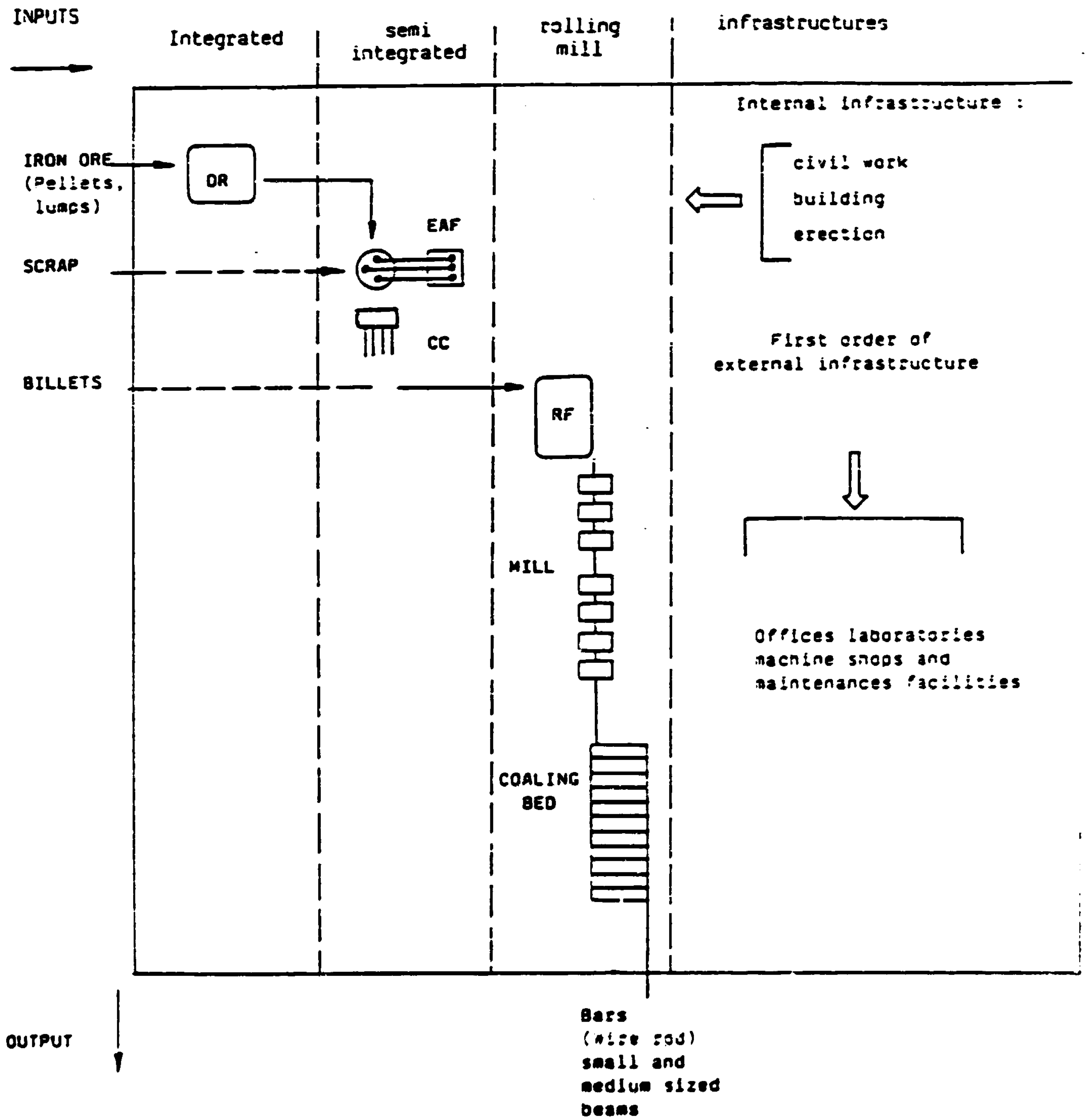
The large dot gives the average of the team (20)

THE DESIGN OF AN IRON AND STEEL PLANT



SCHEMATIC CONFIGURATIONS of

a MEDIUM SIZED IRON & STEEL PLANT



VARIOUS INFRASTRUCTURES NEEDED for a MEDIUM SIZED IRON & STEEL PLANT

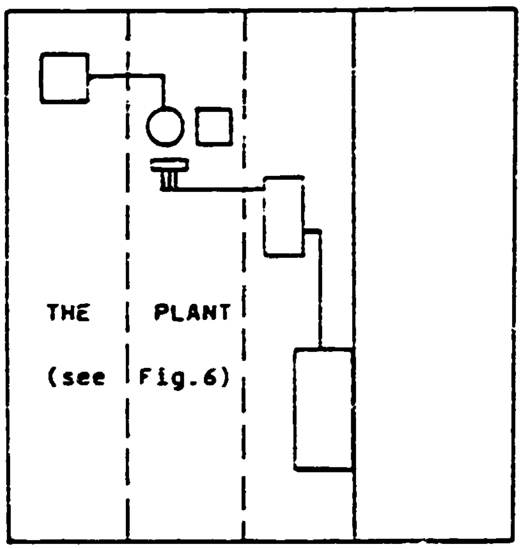
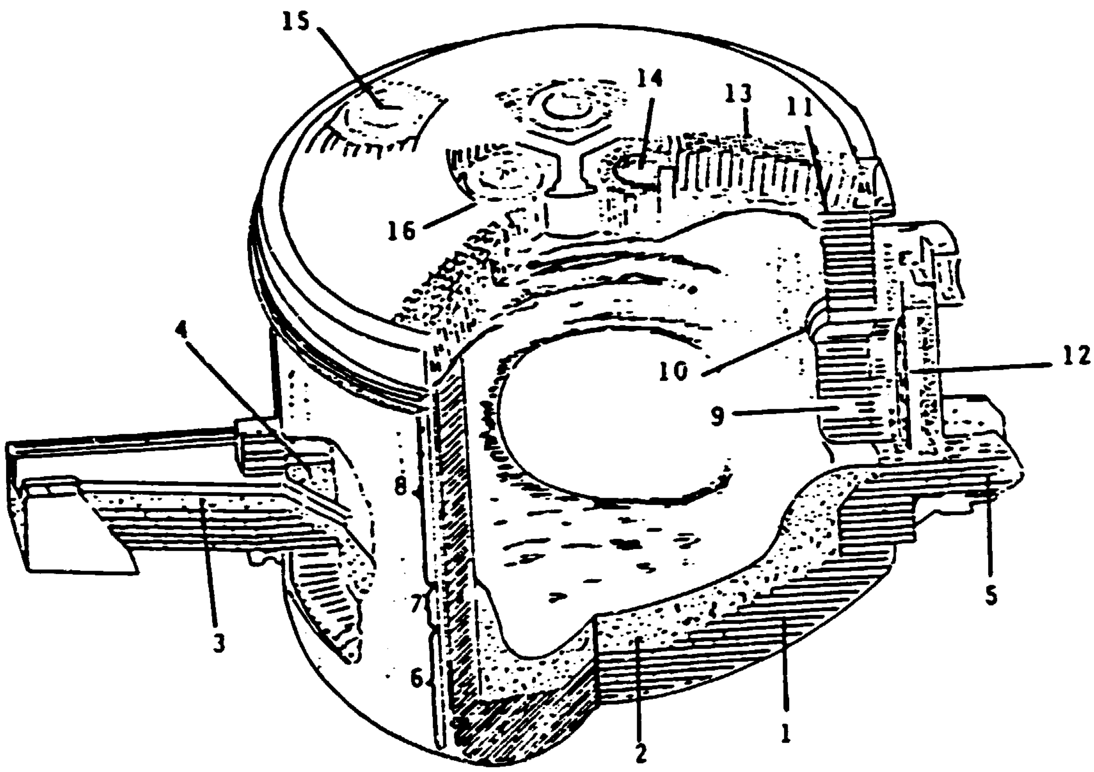
First order of infrastructure	Second order of infrastructure	Third order of infrastructure
	Facilities for : - water - gas - electricity	Production of : - gas ? - electricity - coal ?
	Facilities for : - transport	- Iron ore mines
	Housing (City and related facilities)	- Quarries for fluxes
		- Refractories

FIGURE 20

REFRACTORIES NEEDED IN AN ELECTRIC ARC FURNACE

(Note: The use of water cooled panels or roof will, of course, modify this basic scheme).



1. Sub-hearth
2. Working hearth
3. Pouring spout
4. Tap hole
5. Sill
6. Banks
7. Slag line
8. Sidewall
9. Doorway jambs
10. Doorway arch
11. Topwall seal
12. Door
13. Roof rings
14. Electrode port rings
15. Fume port ring (fume hole)
16. Delta section

BIBLIOGRAPHY

We shall list, first 5 international conferences on the subject of mini-mills:

(1) ILAFA Miniplantas
(Buenos Aires, 12 - 17 August 1979)
book of 250 pages with 30 papers

(2) SEAISI Prospects for Mini-Steel Mills
(Singapore, 8 - 12 September 1980)
book of 565 pages with 30 papers

(3) Metal Bulletin The market and the mini
(Milan, 31 March to 1 April 1980)
book of 167 pages with 14 papers

(4) Metal Bulletin Mini-mills: the way ahead
(Vienna, 8 - 9 March 1982)
book with 14 papers

(5) Metal Bulletin Mini-mills at the crossroads
(New Orleans, 19 - 20 March 1984)
with 14 papers
(to be printed in the near future)

(6) United Nations The evolution of the specific consumption of steel
(New York 1984)

(7) Miller, J.R. Giant Mini-mill companies
Iron and Steel Engineer (1984)

APPENDIX I

MINI-MILLS IN THE USA

It is quite interesting to compare the list from Metal Bulletin with the list of Jack R. Miller and data from MILLIN, which lists 67 mills producing 21.8 Mt/year.

1. The list from the Metal Bulletin (1974):

Country, company	Works	Arc furnace size and capacity (tons)	Continuous billet caster—no. of strands and capacity (tons)	Finishing mill(s)—capacity (tons)	Finished products
USA(3)					
Ameron—Steel Producing Division	Etiwanda, Calif.	2 × 10ft. dia. (100 000) 1 × 11ft. dia. (60,000)	1 × 2 (150,000)	Bar/rod (150,000)	Rebars, wire rods. Also wire and mesh
Armco Steel Corp.	Sand Springs, Okla.	1 × 70-ton	1 × 6 (350,000)	Merchant (140,000)	Billets, merchant products
Atlantic Steel Co.	Atlanta, Ga.	2 × 85 (450,000)	No	Bar, rod, strip	Wire rods, rebars, heavy and light sections, tubes, hot and galv. strip
	Cartersville, Ga.(8)	1 (200,000) (two more planned)	1 × 4	Bar & strip (150,000)	Bars, strip
Auburn Steel Co. Inc.(4)	Auburn, NY	1 × 50 (150,000)	1 × 3 (150,000)	Merchant (150,000)	Rebars, merchant bars, light sections
Bethlehem Steel Corp.	Los Angeles, Calif.	1 × 75; 1 × 100	No	Bar (230 000) Bar,rod (245 000)	Rebars, wire rod (also wire fasteners, fabricated reinforcement)
Border Steel Rolling Mills Inc.	El Paso, Texas	2 × 25	1 × 3 (140,000)	Bar (130,000)	Bars, rebars, sections
Cascade Steel Rolling Mills Inc.	McMinnville, Ore.	2 × 25 (150,000)	1 × 2 (150,000)	Bar (148,000)	Rebars
The Ceco Corp.					
Lemont Mfg. Co.	Lemont, Ill.	3 × 30	No	Bar (240,000)	Light sections, bars, rebars
Milton Mfg. Co	Milton, Pa.	3 × 20	No	Bar (130 000)	
Southern Electric Steel Co.	Birmingham, Ala.	2 × 14	No	Bar (148,000)	
Chaparral Steel Co.	Midlothian, Tex.	1 × 18ft. dia (200,000)	1 × 4 (200,000)	Bar (400,000)	Rebars, rounds, angles
Florida Steel Corp.	Tampa, Fla. Indiantown, Fla. Croft, NC	1 × 39, 2 × 15 2 × 35 (180,000) 1 × 25, 1 × 15	1 × 2 1 × 3; 2 × 2(9) No	Bar (240 000) Bar (150 000) Bar (140 000)	Rebars, light sections
Georgetown Steel Corp (1, 6)	Georgetown, SC Beaumont, Tex.(8), (6)	2 × 60 (450,000) 2 × 90 (500,000)	2 4-strand (500,000)	Rod/bar	Rebars, rounds, wire rods
Hawaiian Western Steel Ltd.	Ewa, Hawaii	1 × 15	No	Bar (104,000)	Rebars
Intercoastal Steel Corp.	Chesapeake, Va.	2 × 11ft. (100,000)	No	Merchant (100,000)	Rebars, structural and light sections, rounds
Judson Steel Corp	Emeryville, Calif.	1 × 50	No	2 bar (130,000)	Rounds, rebars
Kentucky Electric Steel Co.	Coalton, Ky.	2 × 15	1 × 2 (120,000)	Section (140,000) Bar (140,000)	Structural and light sections, flats and angles
Knoxville Iron Co.	Knoxville, Tenn.	—	1 × 2	Bar	Bars
Marathon Steel Co., Rolling Mill Div.	Tempe, Ariz.	3 × 25 (150,000)	No	Bar (150,000)	Rebars
Minimet Industries	Erie, Pa.	2 × 35	2 × 2	Rod (200,000)	Billets, wire rod
Mississippi Steel Div., Magna Corp.	Flowood, Miss.	2 × 10 (1 × 35-ton planned) (Total 180,000)	Planned	Bar (45,000)	Rebars
National Metal, Toshin Steel, Marubeni-Iida	US West Coast (planned)	—			Billets
New Jersey Steel & Structural Corp.	Sayreville, NJ	2 × 60	1 × 5 (300,000)	Bar/rod (250,000)	Rebars
North Star Steel Co.	St. Paul, Minn.	2 × 60 (330,000)	2 × 3 (330,000)	Bar (350,000)	Rebars, angles, channels
Nucor Steel	Darlington, SC Norfolk, Neb. Jewett, Tex.	2 × 20 2 × 35 —	1 × 2 (120,000) 1 × 2 (160,000) —	Bar Bar Merchant (200,000)	Bars, rebars, light structurals Rounds, angles
Oregon Steel Mills Inc (6)	Portland, Ore.	3 (400,000)	No	Bar, plate	Rebars, merchant bars, plates
Pollak Steel Co.	Marion, Ohio	—	1 × 3 (180,000)	Bar, section	Rebars, rounds, light sections, fence posts
H. K. Porter Co. Inc., Connors Steel Div	Birmingham, Ala Huntington, W Va.	1 × 9; 1 × 30 2 × 30	2 × 2 No	Bar Bar (150,000)	Merchant bars, rebars. Also bright bars
Roanoke Electric Steel Corp	Roanoke, Va.	2 × 11ft., 1 × 9ft. dia. (180,000)	1 × 2 (75,000) 1 × 3 (120 000)	Merchant bar (180,000)	Rebars, merchant bars
Roblin Steel Co.	Dunkirk, NY	2 × 12.5ft. dia. (100,000)	1 × 2 (100,000)	At another works	Billets, incl. alloy
Ross Steel Works Inc.	Amite, La.	3	None	Bar	Rebars
Schnitzer Steel Corp (8)	Portland, Ore.	2 × 75 (200,000)		No	Billets
Soulé Steel Co.	San Francisco, Calif.	2 × 15	2-strand	Bar (80,000)	Rebars, merchant bars, fence post sections
Southern Scrap Material, Kawasaki Steel Corp., Yamamoto Industry	New Orleans	—		Merchant	Rebars, sections
Southwest Steel Rolling Mills Inc.	Los Angeles, Calif.	1 × 18; 1 × 15; 1 × 30	None	Bar and strip (130,000)	Light structurals, bars, rebars, fence posts, hot strip
Structural Metals Inc.	Seguin, Tex.	2 × 40 (125,000)	None	Merchant (100,000 and 30,000)	Rebars, angles, rounds
Tennessee Forging Steel Corp.	Harriman, Tenn.	2 × 25	None	Bar (120,000)	Rebars, angles, merchant bars, squares. Also forging billets

2. The list from Jack R. Miller (1984) as of 1 January 1984

No.	COMPANY & Location (1), (10), (11)	Annual Capacity — Net Tons x 1000	Steel Making — No. of Electric Furnaces x N.T./Heat	Con't Casting — No. of Units x No. of Strands (Bloom / Billet / Slab)	Ingots, Blooms, Billets, Slabs	Wire Rods	Reinforcing	Merchant Bars	Light Sections	Heavy Sections	Pipe & Tubes	Plates	Other	Steel Quality: Carbon Steel	Steel Quality: Merch. & S.B.Q.	Steel Quality: Alloy & Other	Reference No.
1.	Northwestern St. & Wire Sterling IL	2,400	3 × 400 NT	1 × 6, 1 × 8	●	●	●	●	●	●			●	●			2.12
	Nucor Corp. Charlotte SC	(2,100)			●		●	●	●	●				●		●	
2	i) Darlington, SC	525	5 × 32 NT	2 × 2													
3	ii) Norfolk, NE	575	< 4 × 50, 1 × 35	2 × 2													
4	iii) Jewett, TX	550	5 × 50	2 × 2													
5	iv) Plymouth, UT	450	2 × 60	1 × 3													
	North Star St. Co. Minneapolis MN	(2,050)					●	●	●					●		●	
6	i) St. Paul, MN	450	2 × 75 NT	2 × 3													
7	ii) Monroe, Mich	600	1 × 120	1 × 4													
8	iii) Wilton, IA	300	1 × 80	1 × 3													
9	iv) Beaumont, TX	700	2 × 120	2 × 4													3
	Co-Steel Int. Ltd. - Whitby, Canada	(1,500)															
10	i) CHAPARRAL St. Co. - Midlothian TX	900	2 × 130 NT	1 × 5, 1 × 4			●	●	●	●				●	●	●	
11	ii) RARITAN River St. Co. - Perth Amboy NJ	600	1 × 150	1 × 5		●								●			
	FLORIDA St. Co. - Tampa FL	(1,455)			●		●	●	●	●				●			
12	i) Tampa, FL	285	2 × 35 NT	2 × 2													
13	ii) Charlotte, SC	200	2 × 35	2 × 2													
14	iii) Indiantown FL	170	< 1 × 35, 1 × 30	1 × 3													4
15	iv) Jacksonville FL	400	1 × 85	1 × 4													
16	v) Jackson, TN	400	1 × 135	1 × 4													
17.	LUKENS St. Co. - Coatesville, PA	1,240	2 × 150 NT, 2 × 100	1 × 1	●							●	●	●	●	●	12
18.	LACLEDE St. Co. - Alton, IL	717	2 × 225 NT	1 × 6				●			●		●	●	●	●	12
19.	BAYOU St. Co. LaPlace - LA	700	2 × 65 NT	2 × 4	●			●	●	●				●			
	ATLANTIC St. Co. Atlanta, GA	(700)				●	●	●	●				●	●	●		12
20	i) Atlanta, Ga	450	2 × 55 NT	1 × 6													
21	ii) Cartersville, Ga	250	1 × 100	1 × 4													
22	GEORGETOWN St. Co. - Georgetown SC	700	2 × 75 NT	2 × 4		●	●	●					●	●	●	●	5
23	BETHLEHEM St. Corp. - Seattle, WA	650	2 × 120 NT	—			●	●		●		●		●	●		
24	KEYSTONE St. & Wire - Peoria, IL	650	2 × 175 NT	1 × 6	●	●							●	●			
25	CONTINENTAL St. Co. Kokomo, IN	630	2 × 175 NT	—	●	●	●						●	●	●	●	6

26. Roanoke Elect. St. Co - Roanoke VA	500	1×15'φ, 1×[illegible], 1×11'φ	1×[illegible], 1×2°				•	•					•			7
27 Oregon St. Mills - Portland, OR	500	2×80 NT	—								•	•				8
28 Hunt St. Co - Brier Hill, OH	360	2×60 NT	1×3°								•		•	•		
29 Structural Metals Inc - Seguin, TX	350	1×90 NT	1×3°			•	•	•					•			
30 Sheffield St. Co - Sand Springs OK	350	2×75 NT	1×6°			•							•			
31. Tamco, Inc. - Etiwanda, CA	300	1×20'φ	1×5°	•	•	•	•						•			
32 Cascade St. R.M. Inc. - McMinnville, OR	275	2×30 NT	1×3°			•	•	•					•			
33 Kentucky Elec. St. Co. - Coalton, KY	250	2×45 NT	1×3°	•				•					•		•	
34 Steel Co of West Va. - Huntington, WV	250	2×70 NT	1×3°					•				•	•			
35 Auburn St. Co - Auburn NY	240	1×16'φ	1×3°	•		•	•	•					•			
36. New Jersey St. Corp. - Sayreville, NJ	240	1×70 NT	1×5°	•		•	•	•					•			
37 Thomas St. Co - Lemont, IL	230	2×40 NT	—			•	•	•					•			9
38 Border St. Mills Inc - Vinton TX	200	2×20 NT	1×3°			•	•						•			
39 Marathon St. Co - Tempe, AZ	200	3×25 NT	—	•		•							•			
40. Mississippi St. Co - Flowood, Miss.	200	1×12.5'φ	1×3°			•	•						•			
41 Northwest St. R.M., Inc. - Kent, WA	200	2×35 NT	—	•		•	•	•					•		•	
42. Texas St. Co. - Ft. Worth, TX	200	1×30 NT, 1×25, 1×15, 1×8	—			•	•						•		•	
43. Tennessee Forging St. - Harriman, TN	200	3×25 NT	1×3°			•	•	•					•			
44 Roblin St. Co - Dunkirk, NY	180	2×25 NT	2×2°	•			•						•		•	
45. Green River St. Corp - Owensboro, KY	175	2×65 NT	1×3°	•			•		•				•		•	
46 Razorback St. Corp. - Newport, AR	160	2×25 NT	1×2°	•			•	•	•				•		•	
47 Knoxville Iron Co - Knoxville, TN	160	1×30 NT	1×3°, 1×2°			•	•						•			
48 Judson St. Co. - Emeryville CA	160	1×60 NT	1×3°	•		•						•	•			
49. Quanex Corp - Jackson, Mich	160	2×40 NT	2×2°				•			•			•		•	
50. Calumet St. Co - Chicago Hts, IL	150	2×30 NT	2×2°			•	•	•					•			
51. Soulé St. Co - Carson, CA	120	2×11'φ	1×2°			•	•						•			
52. Birmingham Bolt Co - Birmingham AL	100	2×25 NT	1×3°	•		•	•						•	•		
53. Birmingham Bolt Co - Cairbonnus, IL	100	2×15 NT	—	•		•	•						•	•		

54 Owen Elec. St. Co. Cayce SC	100	1x23"	–	• •	•	
55. Intercoastal St. Co Chesapeake VA	100	2x11'ø	–	• • •	•	
56 Hurricane Industries Inc. Sealy TX	90	1x16"	–	• •	•	
57 Hawaiian Western St. Co. Ewa HI	60	1x20"	–	• •	•	

NOTES:

(1) SOURCE: - "IRON AND STEEL WORKS OF THE WORLD", 8th Edition; Nov. 1983; Published by Metal Bulletin Books, Ltd.

(2) NORTHWESTERN STEEL & WIRE Co. – Probably the first US minimill, started c. 1935, by Paul Dillon using EF to melt scrap heats to produce carbon steels.

(3) was GEORGETOWN – TEXAS ST. CO. until AUG. 1983

(4) INDIANTOWN plant closed 1982; startup expected 1984/1985

(5) GEORGETOWN ST. Co - generally omitted from minimill lists due to DR production in Midrex plant, and sales of – [illegible].

(6) CONTINENTAL St. Co. Continuous caster [illegible] installed; scheduled to operate in 1984

(7) ROANOKE ELEC. ST. CO – FIRST CONTINUOUS [illegible]llet caster in US. installed in 1962

(8) OREGON STEEL Co - PERHAPS the leading innovator among miniplant operators. Installed first commercial DR [illegible]nt (MIDREX) in 1969; initial trials of horizontal slab casting; among first to extend "standard" minimill product-mix (bars, rods, small sections) in U.S., specifically to medium and heavy plates

(9) THOMAS STEEL Co – A 3-strand continuous billet caster reported on order

(10) Three (3) fully operable minimills are not included in Table:

58- PHOENIX St. Co - CLAYMONT NJ 400,000 NT/yr - Chapter 11
59- MARION St. Co - Marion, OH 250,000 " - Chapter 11
60 - CONNERS St. Co - Birmingham, AL 270,000 " - Offered for Sale.

(11) Six (6) non-integrated plants, presently with rolling mills only, can readily be back-integrated to minimill status by installation of EF-CC additions

61 - Ohio River St. Co - Calvert City, KY - 400,000 NT/yr - Program to add steel plant and raise output to 750,000 NT/yr in progress.
62 - McDonald St. Co - McDonald, OH - 145,000 NT/yr
63 - MISSOURI Roll. Mills, St. Louis, MO. - 120,000 "
64 CALIFORNIA St. Works, LIVERMORE CA - 75,000 "
65 - AB St. Mill Inc - CINCINNATI OH 30,000 "
66 - OKLAHOMA St. Mill, Inc - Oklahoma City, OK 18,000 "

(12) See Text

By: Jack Robert Miller II / Feb. 1984.

APPENDIX II

MINI-MILLS IN CANADA
(From Metal Bulletin 1974 and 1984)

Country/Company	Works	Arc Furnace Size and Capacity (tons)	Continuous billet caster - no of strands and capacity (tons)	Finishing Mill(s) capacity (tons)	Finished Products
Burlington Steel Div., Slater Steel Industries Ltd.	Hamilton	1 x 40 ton:2 x 20 ton (320 000)	3-strand (250 000)	Merchant (300 000)	Bars, re-bars, light sections in carbon and low-alloy
Industrial Fasteners Ltd*	L'Original	(150 000)	(150 000)	Wire rod (250 000)	Wire rods
Lasco-Lake Ontario Steel Co. Ltd.	Whitby	2 x 65(330 000) +1	2 x 3(330 000)	Bar light structural (900 000)	Re-bars, light sections
Manitoba Rolling Mills	Selkirk	2 x 40	2 x 2	Merchant (250 000)	Re-bars, light sections, merchant bars
Planet Steel Ltd.	Octagon Pond	1 x 25(60 000)	1 x 2(100 000)	Bar (100 000?)	Re-bars, rounds
Questeel Div. of QSP Ltd. (1)**	Longueuil	1 x 50(40 000)	1 x 3(140 000)	Merchant (250 000)	Flats angles, channels, rounds

APPENDIX II continued

Country/Company	Works	Arc Furnace Size and Capacity (tons)	Continuous billet caster - no of strands and capacity (tons)	Finishing Mill(s) capacity (tons)	Finished Products
Steel Co. of Canada Ltd.	Edmonton	2 × 75	1 x 4	2 bar (250 000)	Bars
Western Canada Steel Ltd.	Vancouver	1 x 40(110 000) (To be 200 000) (5)	No	Merchant(50 000) Rod (50 000)	Merchant bars re-bars, light structurals, rods
	Calgary	1 x 20(50 000) (To be 100 000)	No	-	Merchant bars re-bars, light structurals, rods

(1): Expansion planned or in progress. (2): Expansion planned or in progress beyond mini-scale.
(3): Short tons. (4): Due to start up 1974. (5): Due to start up 1975. (6): Works has direct reduction plant.
(7): Under construction. (8): Due to start up 1976. (9): Due to start up 1977.

+ COURTICE	Cambridge			85 000 Total around 2 500 000	Billets, re-bars

* This is now IVACO (in operation)

** This is now SIDBEC DOSCO

APPENDIX III

MINI-MILLS IN WESTERN EUROPE
(From Metal Bulletin 1984)

Country, company	Works	Arc furnace size and capacity (tons)	Continuous billet caster—no. of strands and capacity (tons)	Finishing mill(s)—capacity (tons)	Finished products
ITALY					
Acm—Acc. di Carrù Sas in Accomandita di Ing. Mario Beltrandi & C	Carrù	—	—	No	Ingots
Afem—Acc. Ferr. Mediterranee	Palermo	1 × 35 (100,000)	1 × 2	Bar	Rebars
Afim—Acc. Ferr. Industrie Metallurgiche di Fenotti e Zanola	Brescia	2 × 35 (150,000)	1 × 4	Merchant	Rebars, sections
Alfa—Acc. Lam. Fond. Affini Srl	Brescia	1 × 15; 2 × 30	1 × 3; 1 × 2	Bar	Billets, tube rounds, rebars, merchant bars, wire rods
Acc. Ferr. Alpine SpA	Borgone di Susa	1 × 25 (70,000)	1 × 2	No	Billets
Acc. e Ferr. Vicentine A. Beltrame	Vicenza	—	—		Merchant bars, special sections
Off. Fratelli Bertoli fu Rodolfo SpA	Udine	2 × 30 (80–90,000) 1 × 6 (15,000) 1 × 3 (6,000)	No	Rounds	Rounds. Also forged balls and castings
Bussani F.lli Ferr. Snc.	Brescia	1 × 50	No	Bar	Bars
Acc. e Ferr. Catania SpA	Catania, Sicily	1 × 10 (25,000) 2 × 20 (170,000)	No	Merchant	Bars, angles, channels
SpA Industriale Pietro Maria Ceretti	Villadossola	1 × 10 (25,000) 1 × 20 (50,000) 1 × 20 (120,000)	No	Two merchant (70,000 and 50,000)	Merchant bars, angles, channels. Also castings.
Acc. Ferr. Trafilerie Cravetto SpA	Bruzolo	2 × 45 (250,000)	1 × 2	No	Billets
	San Didero	—	—	—	Rebars, merchant bars, tube strip
FAS—Ferr. Acc. Sarde SpA	Cagliari	1 × 30 (100,000)	1 × 2	Bar	Rebars
Ferr. Fenotti & C	Brescia	1 × 40	—	Bar	Rebars
Fenotti & Comini SpA Acc. e Ferr.	Brescia	1 × 20, 1 × 25	1 × 3	Bar	Rebars
Acc. Ferrero SpA	Turin	1 × 20	1 × 2	Bar	Rebars
SpA Off. e Fonderie Galtarossa(1)	Verona	Yes	1 × 3	Merchant	Rebars, merchant bars, sections
Ilfo—Industria Laminati Ferrosi Odolesi Srl	Brescia	1 × 15; 1 × 40; 1 × 50	2 × 3	Bar	Billets, rebars
Impa—Industrie Meccaniche e Siderurgiche SpA	Naples	—	—	Bar	Rebars, merchant bars
Iro—Industrie Riunite Odolesi	Brescia	2 × 25	1 × 2; 1 × 3	Bar	Rebars
Acc. Ferr. del Lazio(1)	Pomezia	1 × 30 (100,000)	1 × 3	Bar	Rebars
Acc. e Ferr. Luigi Lusk SpA	Brescia	3 × 22 (150,000)	2 × 4 (140,000)	2 bar (200,000)	Rebars
Acc. di Lonato SpA	Brescia	2 × 15	—	Bar	Rebars, merchant bars
Acc. e Ferr. Lucchini di Lucchini Luigi & C Sas(1)	Settimo Torinese	—	2 × 4	—	—
	Sarezzo	—	2 × 4	Bar	Rebars, merchant bars
Acc. Megara	Augusta	—	1 × 3	—	Billets
Metallurgica Marzoni SpA	Erbe	1 × 10 (20,000)	None	Merchant (20,000)	Bars and wire rods, bright bars; also forgings
Acc. Ferr. e Fonderie di Modena SpA(1)	Modena	—	None	Merchant	Rebars, merchant bars, sections
Siderurgica Mancinone SpA	Brescia	1 × 50	1 × 4	No	Billets
Ferr. e Acc. Napoletane SpA	Naples	—	None	Bar	Rebars, merchant bars
SpA Ferr. di Nembro	Bergamo	—	None	Bar	Rebars
Ola—Off. Laminazioni Sabine Srl	Brescia	3	Being installed	At another works	Ingots
Ori—Martin Acc. e Ferr. di Brescia SpA	Brescia	1 × 16; 1 × 25, 1 × 30 (130,000)	2 × 2; 1 × 3 (130,000)	Bar and rod (70,000)	Rebars, wire rod
Fratelli Orsenigo SpA	Milan	1 × 30 (50,000), 1 × 50 (90,000)	1 × 4 (150,000)	2 bar (110,000 and 160,000)	Rebars, wire rods, merchant bars. Also wire and wire mesh
Ferr. di Portovesme Srl	Caronno Pertusella	3 × 25; 2 × 50	1 × 6, 1 × 4	Merchant	Merchant bars
Pietra SpA. Acc. Ferr. Tubifici(1)	Brescia (3 works)	4 × 20, 1 × 40	1 × 4(5)	Merchant	Rebars, merchant bars, sections, wire rods, tubes
Prodalva Acc. e Ferr. Srl	Brescia	2 × 18	2 × 4	Bar	Rebars, merchant bars
Ferr. Ermenegildo Pras & Figli Snc	Venice	—	1 × 2	Merchant	Rebars, merchant bars
Profafer di Milani Remo & C Sas	Trino	—	1 × 4	Bar	Rebars
Premider	—	—	1 × 3(5)		
Acc. di Rubiera Sas	Reggio Emilia	—	1 × 3	No	Billets
Metallurgica L. Romi SpA(1)	Sorresa	—	1 × 6	At another works	Billets
Siderurgica S. Stefano Acciai SpA	Milan	—	No	No	Ingots
Ferriera Sarda SpA	Sassari	1 × 20 (50,000)	1 × 2	Bar	Rebars
Sidermar	Grottammare	—	1 × 3	Associated company	Billets
Sr. Mo Siderurgica Monfalcone SpA	Monfalcone	2 × 25 (120,000)	1 × 3 (120,000)	No	Billets
Sideral SpA	Brescia	1 × 20; 2 × 30, 1 × 60	2 × 3; 1 × 4	No	Billets
Siomo—Sao Industrie Siderurgiche Piemontesi e Affini SpA(1)	Villadossola	2 × 40 (180,000) 1 × 30 (70,000)	1 × 4	3 merchant	Bars and sections. Also bright bars, bolts and nuts
Acc.-Ferr. Antonio Stefana & C Sas	Brescia	1 × 18; 1 × 20	1 × 2	Merchant	Rebars, merchant bars
Acc. e Ferr. Stefana Fratelli fu Girolamo SpA	Brescia	2 × 12, 1 × 70	2 × 2; 1 × 4	Bar	Rebars
Acc. del Sud	Casoria Napoli	—	1 × 3		
Ferr. del Sud	Modica Ragusa	—	1 × 2		
Acc. del Tanaro SpA	Lesegno	1 × 35 (100,000)	1 × 4	Merchant	Merchant bars
Acc. Ferr. Valsabbia	Brescia	1 × 40 (150,000)			
Acc. Fond. Veneta di Bertazzo Marcello(1)	Padua	1 × 24 (70,000)	2 × 4	No	Billets

Country, company	Works	Arc furnace size and capacity (tons)	Continuous billet caster—no. of strands and capacity (tons)	Finishing mill(s)—capacity (tons)	Finished products
AUSTRIA					
Stahl- und Walzwerk Marienhütte Ges mbH	Graz	1 x 10, 1 x 20 (80,000)	1 x 2 (60,000)	Bar/rod (100,000)	Rebars, wire rods
FINLAND					
Ovako Group	Imatra	1 x 60 (110,000) 1 x 40 (90,000) 1 x 20 (40,000)	1 x 3 (80,000)	Merchant (185,000)	Med sections, light bars, rebars, wire rods (Carbon and alloy)
FRANCE					
Alpa—Aciéries et Laminoirs de Paris(4)	Porcheville	1 x 60 (180,000)	1 x 4 (180,000)	Bar (250,000)	Rebars
SA Iton-Seine	Bonnières-sur-Seine	1 x 40/45 (130,000)	1 x 3	No	Billets
Sté des Aciéries de Montereau(5)	Montereau Due to start up at end of 1974/early 1975	1 x 70 (170,000)	1 x 4	Bar (150,000)	Rebars
Sudacier SA(4)	Toulon	2 x 65 (250,000)	1 x 4	Bar/rod	Bars and wire rods
WEST GERMANY					
Badische Stahlwerke AG	Kehl	1 x 60; 1 x 70 (420,000)	2 x 4 (420,000)	Wire rod (300,000) Bar (130,000)	Bars and wire rods
Best—Bayerische Elektrostahlwerke GmbH	Herbertshofen	1 x 60; 1 x 65	2 x 4	Bar	Merchant bars, wire rods (incl alloy)
Hamburger Stahlwerke GmbH(6)	Hamburg	1 x 80; 1 x 90 (600,000) 3rd planned (total 750,000)	2 x 4 (600,000)	Bar/wire rod	Rebars, wire rods
Moselstahlwerk GmbH & Co. KG	Trier	1 x 25/30 (65,000)	1 x 3	Wire rod	Wire rods
Walbec—Walzwerk Becker—Berlin Verwaltungs-ges.mbH & Co. Stranggus KG	Berlin	1 x 30 (60,000)	1 x 3 (60,000)	No (Another company in same group has mill)	Billets
GREECE					
Metallurgiki Halyps SA	Tsingeli	2 x 24/20MVA	3-strand	—	Billets, blooms
Halyvourgia Thessalias SA(1)	Volos	2 x 35-ton (150,000)	3-strand (200,000)	Merchant. New mill (300,000) to start 1975	Round bars, wire rods, sections, flats
Steel Works of Northern Greece SA	Salonica	2 x 16-ton; 2 x 40-ton (350,000)	2-strand 3-strand	Bar/strip	Rebars, wire rods, skelp; Also wire and tubes
NORWAY					
Elkem-Spigerverket A/S	1 x 25 (40,000) 1 x 50 (130,000)	Oslo	1 x 4 (140,000)	Merchant	Rebars, bars, wire rods. Also wire and wire products
PORTUGAL					
Siderurgia Nacional Sarl(5)	Oporto	1 x 65	1 x 4	Merchant (250,000)	Rebars, wire rods, sections
SPAIN					
José María Aristrain SA	Olaberría	1 x 80 (180,000) 3 x 15 (70,000)	No	Section (233,000)	Sections. Also mill roll foundry
Arregui SA	Vitoria	1 x 50	1 x 4	Merchant	Sections, flats, wire rods
Aceros y Forjas de Azcoitia	Azcoitia	1 x 8.5; 1 x 11.2 1 x 12.3; 1 x 30	1 x 3	Merchant	Bars
Azma SA	Madrid	1 x 30	1 x 3	Merchant	Sections, rounds, wire rod
Industrias del Besos SA	Barcelona	3 x 15/18 (111,300)	1 x 1; 1 x 2	Universal	Flats, angles, bars
Aceros Bueno de la Cruz SA	Sevilla	1 x 30	1 x 3	Section	Sections
Megasa—Metalurgica Galaica SA	Galicia	1 x 30	1 x 2	Bar	Bars
Nervacero SA	Portugalete	—	2 x 4	Merchant	Sections, rounds, wire rod
Aceros y Fundiciones del Norte, Pedro Orbegozo y Cia SA	Hernani	1 x 5-ton (8,000) 1 x 20 (30,000) 1 x 40 (60,000) 1 x 70 (110,000)	No	Bar	Bars, flats
Siderurgica Sevillana	Sevilla	—	1 x 4	Bar	Bars
Rico y Echeverria SA	Zaragoza	1 x 20; 1 x 25 (100,000)	1 x 3 (90,000)	Light section (120,000)	Angles
Torras SA	Barcelona	2 x 30	1 x 3	Bar	Bars
Marcial Ucin SA	Azpeitia	—	1 x 3; 1 x 2	—	Sections, rounds, wire rod
Union Cerrajera	Vergara	2 x 40	1 x 2; 1 x 4	Merchant	Sections, flats
SWITZERLAND					
Ferrowohlen AG	Wohlen	—	2 x 2	Bar	Rebars
Monteforno, Acciaierie e Laminatoi SA	Bodio	1 x 60	1 x 5	Merchant	Rebars, bars, special sections
Von Roll Ltd.	Gerlafingen	2 x 45	—	Bar and rod	Rebars, bars (incl. alloy)
TURKEY					
Metas-Izmir Metalurji Fabrikasi TAS	Izmir	1 x 10 (20,000) 2 x 15 (60,000) 2 x 35 (180,000)	1 x 2 (50,000) 2 x 6 (300,000)	Bar and merchant	Rebars, merchant bars, wire rods. (Also alloy)
UK					
British Reinforced Concrete Engineering Co(5)	Birkenhead	1 x 60	1 x 4	Bar/rod (150,000)	Reinforcing bars, rods
Cambois Rebar Co(8)	Blyth	1 x 25	1 x 3	Bar (75,000)	Rebars
Cosmos(5)	Newport	2 x 100 (500,000)	—	Strip	Light plate
GKN(9)	Cardiff	2 x 100 (400,000)	2 x 6	No	Billets
Lloyd-Cooper Ltd.(4)	Dudley	1 x 30 (80,000)	1 x 3 (80,000)	No	Billets
Manchester Steel Ltd.(5)	Manchester	1 x 50 (130,000)	1 x 4 (130,000)	Bar mill planned	Billets in first stage
Sheerness Steel Co (1)	Sheerness	1 x 80 (180,000) 1 x 90(4) (250,000)	1 x 4 1 x 4(4)	Bar (400,000)	Rebars, merchant bars
YUGOSLAVIA					
Jadranska Zeljezara Split(1)	Split	1 x 20 (55,000)	1 x 2 (90,600)	Wire rod	Wire rod. Also wire

APPENDIX IV

MINI-MILLS IN JAPAN
(From Metal Bulletin 1974 and 1984)

Company	Works	Arc furnace size and capacity (tons)	Continuous billet caster —no. of strands and capacity (tons)	Finishing mill(s) —capacity (tons)	Finished products
Dowa Denki Seiko KK	Amagasaki	—	2 x 2	Bar	Bars
Funabashi Steel Works Ltd.(2)	Funabashi	1 x 60 (216,000) 2 x 15 (144,000) 1 x 100 (900,000—being installed)	1 x 4 1 x 8	Bar New mill (600,000)	Rebars, rounds, flats
Hokuetsu Metal Co. Ltd.	Nagaoka-shi	1 x 5.5 metres dia. (180,000)	1 x 4	Bar/rod (180,000) Merchant bar (30,000)	Rebars, channels, angles, wire rod. Also ferro-alloys, wire
Japan Iron-Sand steel Co. Ltd.	Himeji-City	1 x 60 (216,000) 1 x 70 (240,000)	1 x 4 (bloom) (276,000)	Merchant	Rebars, sections, rounds, rails
Kansai Steel Corp	Sakai-City	—	None	Merchant	Bars, flats
Kokan Kogyo KK	Yokohama	1 x 40	1 x 3	—	—
Kokko Steel Works Ltd.	Osaka	1 x 20 (72,000) 2 x 30 (252,000)	1 x 2 (bloom)	Bar (170,000 and 190,000)	Rebars
Kyoei Iron Mfg Works Ltd.	Tsukuda	2 x 20 (120,000)	1 x 2 (140,000)	At another works	Billets
Kyoei Steel Works Ltd.	Hirakata	1 x 60 (300,000)	1 x 4 (300,000)	Bar (300,000)	Bars
Nakayama Steel Products Ltd.	Osaka	1 x 50 (252,000)	1 x 4 (252,000)	Bar (252,000)	Bars. Also coated strip
Rinko Steel Works Ltd.	Osaka	1 x 15 (60,000) 1 x 30 (120,000)	—	Bar (36,000, 84,000, 144,000)	Flats, squares, rounds
Tokyo Kohtetsu Co. Ltd.	Oyama	1 x 20 (85,000) 1 x 50 (240,000)	1 x 4 (500,000)	Section (300,000)	Angles
Tose Steel Works Ltd.	Kagawa	2 x 50 (420,000)	2 x 3 (420,000)	Bar (540,000)	Rebars
Toyo Kohan Co. Ltd.	Ishioka(5)	1 x 70 (240,000) 1 x 70 planned (240,000)	—	Bar	Bars
Yamaguchi Kogyo Ltd	Onoda City	1 x 55	1 x 2	—	—

APPENDIX V

MINI-MILLS IN LATIN AMERICA
(From Metal Bulletin 1974 and 1984)

Country, company	Works	Arc furnace size and capacity (tons)	Continuous billet caster—no. of strands and capacity (tons)	Finishing mill(s)—capacity (tons)	Finished products
ARGENTINA					
Gurmendi SA	Avellaneda	2 65 (255,000)	2 8 (255,000)	Bar/rod (285,000)	Rebars, wire rods, engineering rounds
BRAZIL					
Siderurgica Aconorte SA	Recife	2 18 (132,000)	No	Rod (120 000)	Wire rod, wire and wire products
Aços Anhanguera SA(1)	Mogi das Cruzes	2 4.5 metres (130,000)	No	Med. section (72,000)	Billets, bars (Special C and low alloy)
Cofavi—Cia Ferro e Aço de Vitória(2)	Vitória	1 12, 1 15 (100,000)	1 2 (100,000)	Merchant, wire rod	Rounds, flats, rebars, sections
Siderúrgica Coferraz SA	Sao Paulo	1 15 (54,000) 1 12 (43,000)	No	4 merchant (210,000)	Rebars
	Sao Paulo	1 15 (54,000)	No	No	Ingots
	Sao Paulo	1 8 (28,800) 1 6 (21,600)	No	No	Ingots
Cosigua—Cia Siderurgica da Guanabara(2)	Santa Cruz	1 60 (250,000)	Planned	Bar, wire rod	Rebars, wire rods, wire
Cosinor—Cia Siderurgica do Nordeste	Recife	Yes	No	Bar	Rebars, rounds
Constructora José Mendes Junior SA	Juiz de Fora (planned)	(340,000)	Planned	Wire rod, bar	Wire rods, bars
Usina Santa Olimpia—Industria de Ferro e Aço SA	Sao Paulo	1 15, 1 6 (55,000)	No	Bar (70,000)	Rounds, squares, flats
Usiba—Usina Siderúrgica da Bahia SA(1)		1 100 (300,000)	1 6 (300,000)	Rod/bar (commissioning 1975)	Billets, rods and bars
DOMINICAN REPUBLIC					
Metaldom—Complejo Metalurgico	Santo Domingo	1 x 8 (24,000)	1 x 2 (100,000)	Bar (75,000)	Rebars. Also tubes
Dominicano C por A		1 x 12 (36,000)			
MEXICO					
Aceros Nacionales SA	Tlalnepantla	1 x 11ft. dia.; 1 x 13ft. dia.; 1 x 15ft. dia. (243,000)	1 x 4 (202,000)	Rod (282,000)	Wire rods, wire and wire products
Aceros Corsa SA(1)	Mexico City	1 x 9ft. dia. (30,000) 1 x 35-ton planned (80,000)	1 x 2 planned (80,000)	Merchant (70,000)	Angles, flats, rounds
Aceros de Mexico SA	Apodaca	2 x 10ft. dia. (60,000)	No	Bar (100,000)	Rebars, merchant bars, wire rods
Laminadora Atzcapotzalco SA	Mexico City	1 (60,000)	No	—	Rebars, wire rods, sections
Aceros de Chihuahua SA	Nombre de Dios	2 x 10 (70,000)	2 x 1 (70 000)	Rod/bar (75,000)	Rebars, rods, Torbars, also drop forgings
Aceros Ecatepec SA	Tulpetlac	2 x 10 (70,000) 1 x 15 (45,000)	2 x 1 (70,000) 1 x 2 (70,000)	Merchant	Bars, sections, Torbars. Also screws and bolts
Cia Siderúrgica de Guadalajara SA	Guadalajara	2 x 25 (110,000)	1 x 2 (110,000)	Medium section (100,000) Light section (100,000)	Rebars, joists, channels
Hylsa de Mexico SA	Xoxtla	3 x 17ft. dia. (450,000)	2 x 4 (600,000)	Rod/bar (360,000)	Rebars, wire rods, merchant bars, wire
PANAMA					
Aceros Panama	—	1 x 20	No	Bar	Rebars
EL SALVADOR					
—	San Salvador	1 x 40/45 (100,000)	1 x 3	Bar	Rebars
VENEZUELA					
Acero Electrico del Caroni(4) (planned)	Matanzas	3 x 75 (500,000)	No	Bar	Bars
Siderúrgica del Turbio	Barquisimeto	(90,000)	None	Merchant	Angles, flats, bars
Sivensa—Siderúrgica Venezolana SA	Caracas	2 x 23, 1 x 6 (195,000)	2 x 2 (150,000)	Merchant bar/rod (165,000)	Rebars, wire rods, flats

APPENDIX VI

MINI-MILLS IN ASIA

1. From Metal Bulletin (1974)

Country, company	Works	Arc furnace size and capacity (tons)	Continuous billet caster—no. of strands and capacity (tons)	Finishing mill(s)—capacity (tons)	Finished products
HONG KONG					
Shun Fung Iron Works Ltd	Kowloon	—	1 × 1	Bar	Rebars
INDIA					
KR Steelunion Pvt Ltd	Kalyani	1 × 15 (30,000) 1 × 14 (30,000)	1 × 2 (60,000)	Bar	Rebars
Krishna Steel Industries Pvt Ltd.	Nr Bombay	2 × 15 (50,000)	None	Roughing only, finishing mill at another works	Billets
Modi Industries Ltd.	Modinagar	3 × 5; 3 × 10 (108,000)	None	Wire rod merchant	Wire rods, flats, rounds, squares, sections. Also wire.
Rainbow Steels Ltd.	Muzaffarnagar	2 × 10,14-ton (50,000)	None	Bar (within group—9,500)	Bars (rounds, squares, flats)
Baba Rainbow Ispat Ltd.(7)	—	4 × 20/25 (100,000)	2 × 2 (120,000)	Bar (within group—9,500)	Billets
SINGAPORE					
National Iron & Steel Mills Ltd(1)	Jurong	2 × 20 (100,000) 1 × 40 (100,000); 2 × 50 under construction (180,000)	2 × 4(7)	Merchant (167,500)	Rebars, bars, wire rods, sections
TAIWAN					
Dey Yung Steel Mfg Co. Ltd.	Kaohsiung	1 × 20 (55,000) 2 × 10 (45,000)	No	Bar (50,000); Bar (25,000); Rod (20,000) Section (30,000)	Bars, rods Sections, bars
	Taipeh	1 × 20 (55,000) 1 × 3 (5,000)	No	Bar (25,000) Merchant	Angles, rebars
Feng Hsin Iron & Steel Co. Ltd.	Taichung Hsien	1 × 4.3 metres (100,000); 1 × 30(4)	1 × 2(4)	Bar (55,000)	Rebars
Nan Feng Steel Enterprise Co. Ltd.	Chien Jonn	2 × 20 (90,000)	No		
THAILAND					
Bangkok Iron & Steel Works Co. Ltd.	Samutprakarn	3 × 6 (50,000)	No	Bar (60,000)	Rebars
Bangkok Steel Industry Co. Ltd.	Samutprakarn	1 × 20	No	Bar (40,000)	Rounds
GS Steel Co. Ltd.	Samutprakarn	3 × 20 (144,000)	No	Rod and bar (120,000)	Wire rod, deformed bars

2. From AGRAWAL and BASU for India

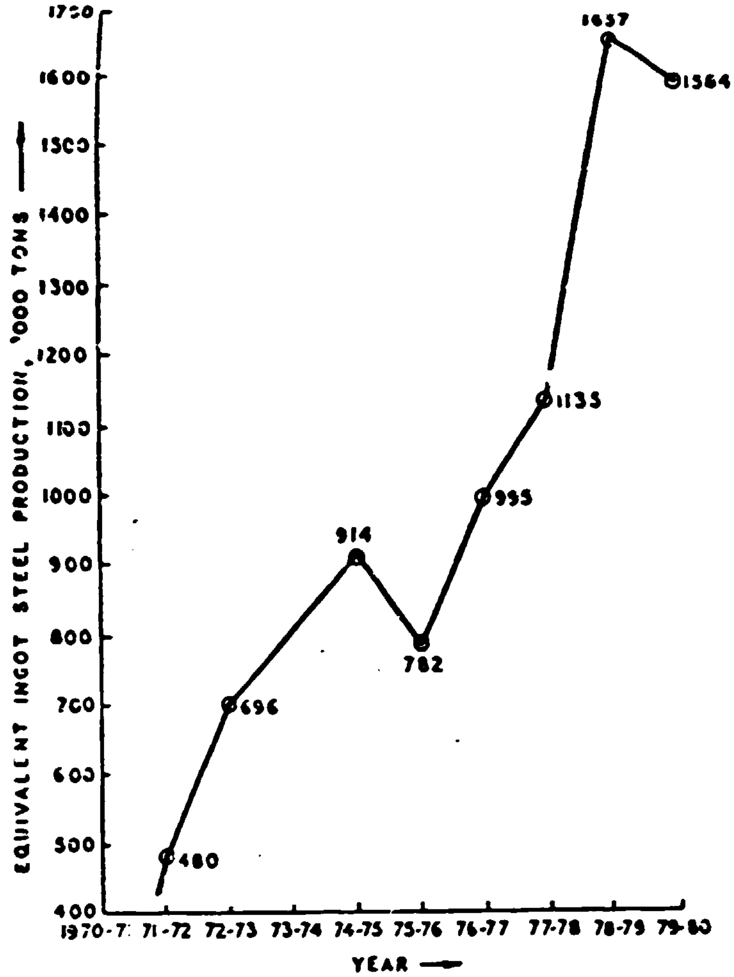


FIG. 1 PRODUCTION OF STEEL BY MINI-STEEL PLANTS

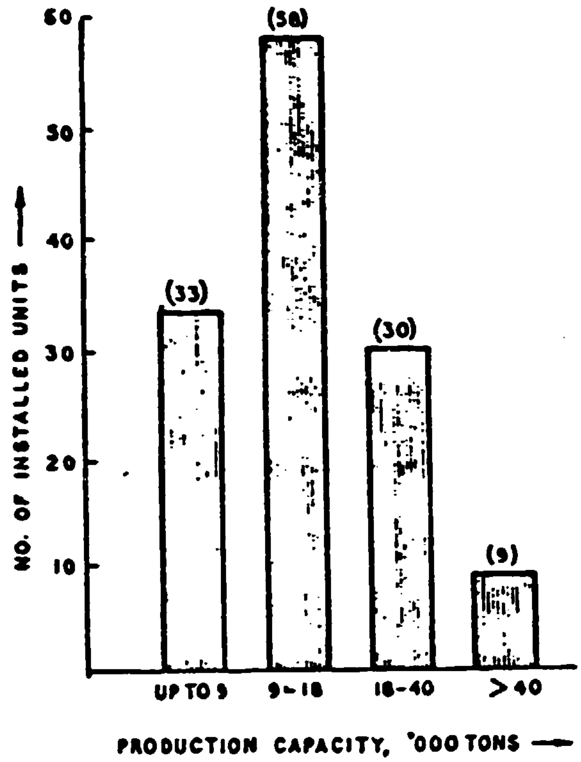


FIG. 2 CAPACITY-WISE DISTRIBUTION OF PLANTS

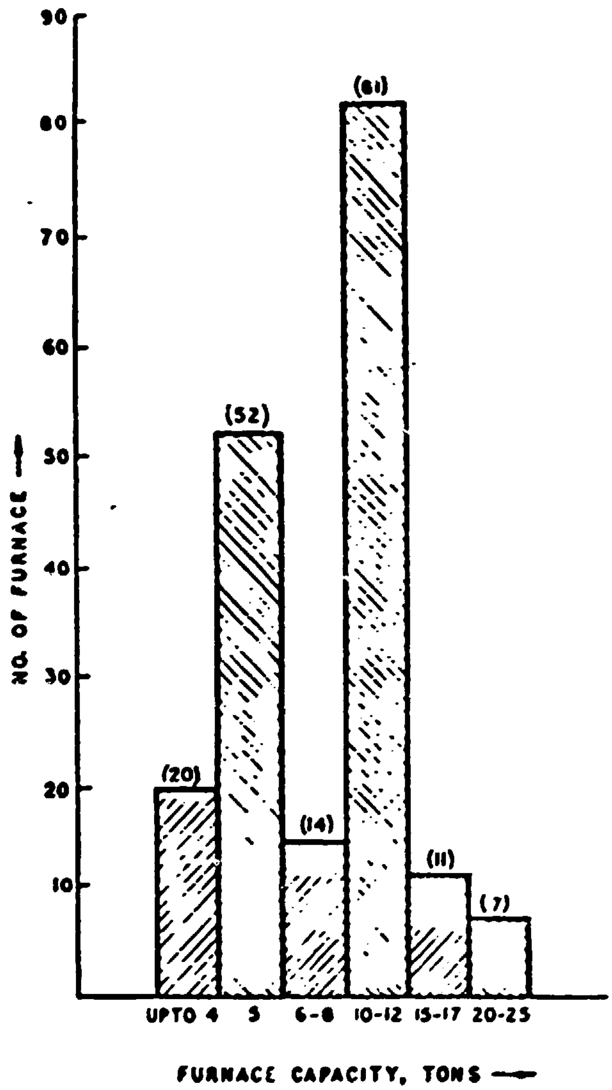


FIG. 3 CAPACITY-WISE DISTRIBUTION OF FURNACES

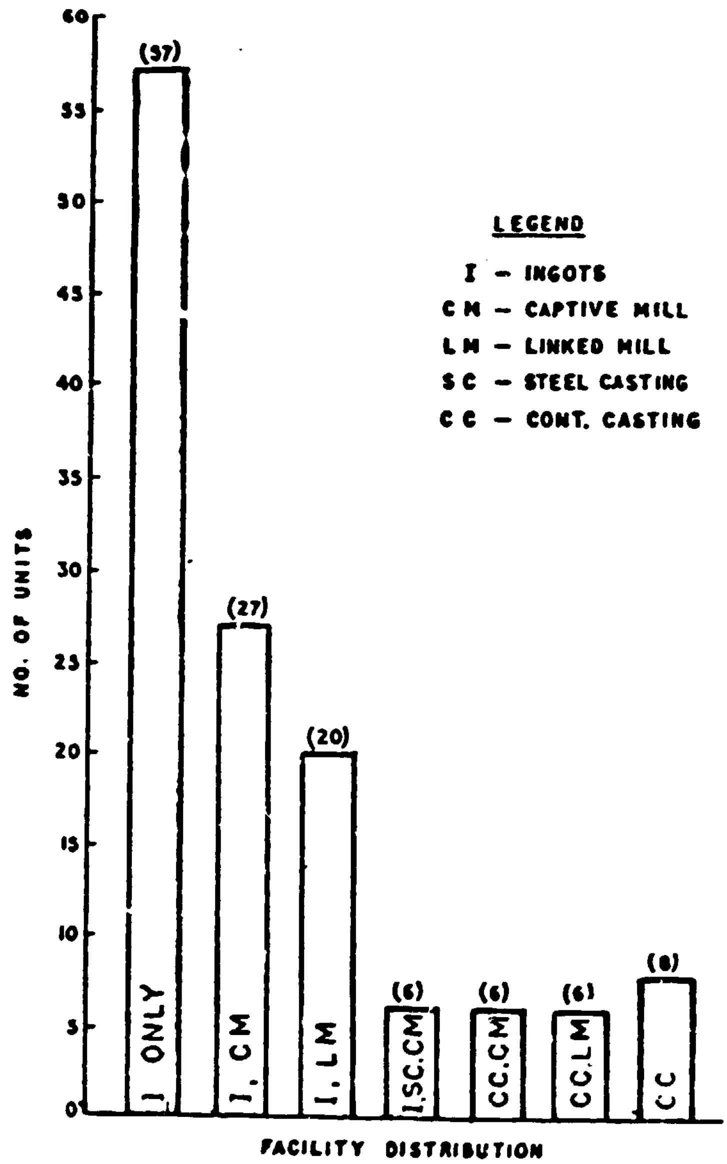


FIG. 4 FACILITY-WISE DISTRIBUTION OF PLANTS

3. From MILLIN for South East Asia

FIG.1 : MINI STEELWORKS —— AVERAGE CAPACITY.

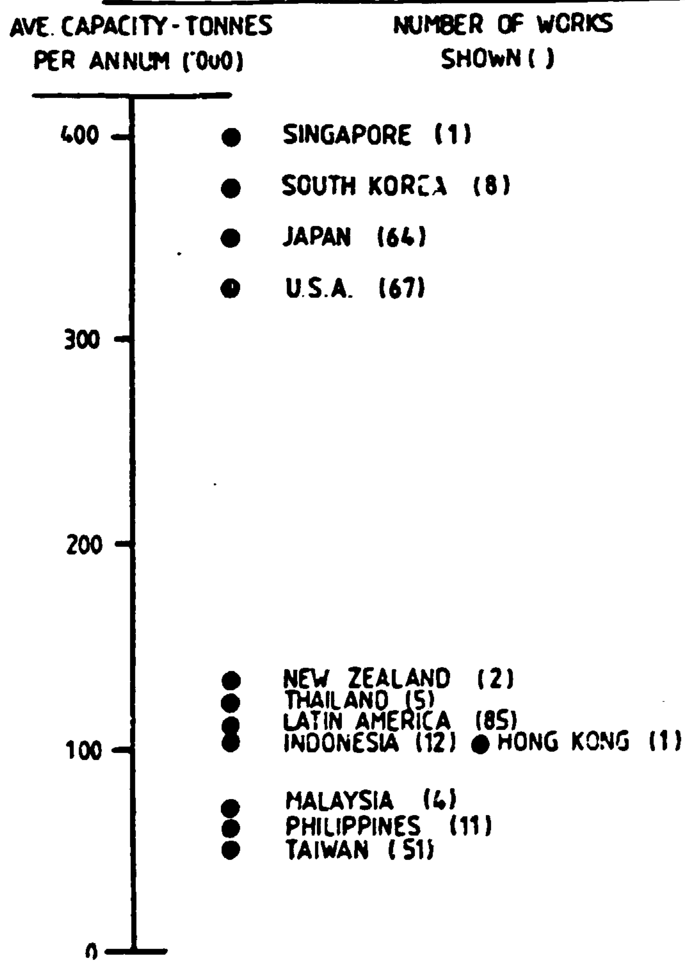


TABLE NO. 4 - INDONESIA

MINI STEEL MILLS	RAW STEEL CAPACITY TPY
INDONESIA	
PT BUDIDHARMA JAKARTA	90,000
PT DJATIM UTAMA STEEL MANUFACTURING	20,000
PT GUNUNG GAHAPI	30,000
PT INTI GENERAL YAJA STEEL	40,000
PT IROSTEEL WORKS	70,000
PT ISPAT INDO	200,000
PT KRAKATAU STEEL*	540,000
PT MASTER STEEL	20,000 (e)
PT MAXIFERO (STEEL) INDUSTRY CO. LTD.	30,000
PT PULOGADUNG STEEL MANUFACTURING CO. LTD.	30,000
PT TOYOGIRI IRON AND STEEL	20,000 (e)
PT BAJA INDONESIA (currently in liquidation)	(150,000)

* included at its present size only for completeness.

TABLE NO. 5 - MALAYSIA

MALAYSIA	
DAH YUNG STEEL MANUFACTURING CO.	40,000
MALAYAWATA STEEL BHD.	170,000
MALAYSIA STEEL WORKS (K.L.) SDH BHD.	30,000
UNITED MALAYSIAN STEEL MILLS BHD.	30,000 (e)

TABLE NO. 6 - PHILIPPINES

PHILIPPINES	
ALLENCO STEEL CORP.	60,000
APOLLO STEEL MILLS	60,000
ARMCO MARSTEEL ALLOY CORP.	60,000
ARMSTRONG INDUSTRIES, INC.	30,000
GLOBE STEEL CORP.	21,000
MASTER STEEL PRODUCTS INC.	12,600
MARCELO STEEL CORP.	54,000
MARSTEEL CORP.	30,000
NATIONAL STEEL CORP.	42,000
PHILIPPINE BLOOMING MILLS CO. INC.	250,000
UNION STEEL MANUFACTURING CO. INC.	7,500

(e) = estimated

TABLE NO. 7 - SOUTH KOREA

MINI STEEL MILLS		RAW STEEL CAPACITY - TPY	
SOUTH KOREA			
Carbon Steel:			
DAE HAN SANG SA CO. LTD.	PUSAN	120,000	
DONG KUK STEEL MILL CO. LTD.	PUSAN	685,000	
" " " " " "	INCHON	120,000	
" " " " " "	MASAN	290,000	
INCHON IRON & STEEL CO. LTD.	INCHON	600,000	(Jan.81 1,000,000)
KANGWON INDUSTRIAL CO. LTD.	POHANG	500,000	(End 81 1,000,000)
KUMHO INDUSTRIES INC.	PUSAN	550,000	(by Aug. 80)
SEOUL STEEL MANUFACTURING CO. LTD.	INCHON	45,000	
CARBON STEEL - Total		2,910,000	
Speciality Steel:			
KOREA HEAVY MACHINERY IND. LTD.	SEOUL	100,000	
KOREA INTEGRATED SPECIAL STEEL CO. LTD.	MASAN	225,000	
PUSAN STEEL CO. LTD.	PUSAN	50,000	

TABLE NO. 8 - SINGAPORE

SINGAPORE	
NATIONAL IRON & STEEL MILLS	400,000

TABLE NO. 10 - THAILAND

MINI STEEL MILLS	RAW STEEL CAPACITY TPY
THAILAND	
THE BANGKOK IRON & STEEL WORKS CO. LTD.	150,000
BANGKOK STEEL INDUSTRY CO. LTD.	100,000
G.S. STEEL CO. LTD.	160,000
THE SIAM IRON & STEEL CO. LTD.	140,000
THAI - INDIA STEEL CO. LTD.	45,000
	595,000

TABLE NO. 11 - HONG KONG

HONG KONG	
SHIU WING STEEL LTD.	180,000
SHUN FUNG IRON WORKS LTD.	100,000
	280,000

TABLE NO. 9 - TAIWAN

MINI STEEL MILLS	RAW STEEL CAPACITY TPY
TAIWAN	
CHIA HSIN METAL INDUSTRY CO. LTD.	15,500
CHIN TAI STEEL ENTERPRISE CO.	60,000
CHING SANG IRON WORKS CO. LTD.	25,000
CHIN YUNG SHENG STEEL MANUFACTURING CO. LTD.	40,000 (e)
CHOU'S IRON & STEEL CO. LTD.	N.A.
DAH YUNG SHENG STEEL MANUFACTURING CO. LTD.	110,000
EAST ASIA STEEL CORP.	54,000 (e)
FENG HSIN IRON & STEEL CORP.	80,000
FU SING STEEL MFG. CO. LTD.	5,000
HAI KWANG ENTERPRISE CORP.	90,000
HSINKO STEEL CO. LTD.	N.A.
HSIN YEE METAL INDUSTRY CO. LTD.	20,000 (e)
HWEITAI STEEL CO. LTD.	30,000
JIN TAY SAN STEEL MANUFACTURING CO. LTD.	50,000
KAOH SIUNG IRON WORKS LTD.	10,000 (e)
KIM HO SHENG INDUSTRIAL CO. LTD.	7,000
KINGSAN IRON WORKS CO. LTD.	14,000 (e)
KINHSIN IRON & STEEL CO. LTD.	20,000 (e)
KINTAISAN STEEL CO. LTD.	N.A.
KINYANG STEEL CO. LTD.	N.A.
KINYUENSEN STEEL CO. LTD.	N.A.
KUO MING STEEL MFG. CO. LTD.	N.A.
LI CHONG STEEL & IRON WORKS CO. LTD.	20,000 (e)
NAN FENG STEEL ENTERPRISES CO. LTD.	80,000
NAN KWANG STEEL & IRON CO. LTD.	30,000 (e)
NAN LUNG STEEL & IRON CORP.	12,000
SINFA STEEL CO. LTD.	20,000 (e)
SINTAIYANG MACHINE CO. LTD.	N.A.
SONG SHAN STEEL CO. LTD.	10,000
SOUTH CHINA STEEL CORP.	N.A.
SUANCHIN STEEL INDUSTRY CO. LTD.	100,000
TAI LI STEEL & MACHINES CO. LTD.	20,000
TAILI INDUSTRIAL CO. LTD.	40,000 (e)
TAIWAN MACHINERY MFG. CORP.	30,000 (e)
TAIWAN STEEL & MINING CORP.	N.A.
TANG ENG IRON WORKS LTD.	200,000
TONG SHEN STEEL & IRON CO. LTD.	180,000
TUNG HO STEEL ENTERPRISE CORP.	60,000
TUNG KWAN STEEL & MACHINERY CO. LTD.	20,000 (e)
YA CHOU STEEL MANUFACTURING CO. LTD.	24,000
YUENSEN INDUSTRY CO. LTD.	N.A.
YUNG TAI STEEL & IRON WORKS CO. LTD.	30,000

(An additional nine plants exist, but no details available)

(e) = estimated

APPENDIX VII

MINI-MILLS IN THE MIDDLE EAST
(From Metal Bulletin 1974 and other sources)

Country/Company	Works	Arc Furnace Size and Capacity (tons)	Continuous billet caster - no of strands and capacity (tons)	Finishing Mill(s) capacity (tons)	Finished Products
IRAN Irmco - Iranian Rolling Mills Co.	Ahwaz	-	1x4	Section(65 000) Merchant(85 000) Wire rod	Light sections, wire rods, rounds and flats, re-bars
IRAQ Khor Al Zubair (planned)	Khor Al Zubair	4x70(400 000)	2x6	Merchant	Rounds, wire rods, sections
JORDAN Jordan Steel Co.	-	1x20	1x2	Bar	Re-bars
LEBANON Lebanon Steel Mill Co. SAL	Tripoli	1x7;1x30	1x2 planned	Bar	Re-bars
UNITED ARAB EMIRATES Ahli Steel	Dubai	-	-	(36 000)	Re-bars

APPENDIX VII continued

Country/Company	Works	Arc Furnace Size and Capacity (tons)	Continuous billet caster - no of strands and capacity (tons)	Finishing Mill(s) capacity (tons)	Finished Products
QATAR QASCO	Doha	2x70 t	Yes Billets	(400 000)	Bars
SAUDI ARABIA HADEED	Al	3x80 t	Yes Billets	Merchant mill wire rod (850 000)	Merchant iron wire rod
SYRIA GECOSTEEL	Hama	-	-	-	Merchant bar galvanized tubes and pipe, longitudinal welded pipes and tubes

APPENDIX VIII

MINI-MILLS IN AFRICA

LIST OF MINI STEEL PLANTS IN AFRICA

This list is based on the principle it includes all plants producing Iron Steel rolled products with a capacity of less than 300 000 t/year . It incluted the countries and the enterprises given on table I and figures 1 and 2.

These plants can be suodvided in :

1 plant based on blast furnace and oxygen steelmaking (150 000 t/year) in TUNISIA

3 plants based on OPEN HEARTH FURNACES in ALGERIA (1) and EGYPT (2)

11 plants based on ELECTRIC ARC FURNACES (EGYPT, LIBYA, MAURETANIA, ANGOLA, GHANA, KENYA, NIGERIA (2), TOGO, OUGANDA, ZAIRE)

6 plants with only ROLLING MILLS (IVORY COAST, CAMEROON, NIGERIA (3), MOROCO)

PROVISIONAL LIST OF MINISTEELPLANTS COUNTRIES
AND POSSIBLE REPRESENTATIVES

COUNTRY	ENTERPRISE	MAIN DATAS	REMARKS
ALGERIA	ENS at ORAN	45000 t/year in expansion 1 (+2) OPEN HEARTH FURNACE	
TUNISIA	at MENZEL-BOURGUIBA ELFOULADH	In fact integrated with small BF + EOF and one EAF 150 000 t/year	
EGYPT	NATIONAL METAL INDUSTRIE at ABOU ZAABAL	200 000 t/year with OPEN HEARTH FURNACES	
"	DELTA STEEL MILLS at MOSTOROD	80 000 t/year with EAF	
"	EGYPT COPPER WORKS NEAR Alexandria	150 000 t/year with EAF and OPEN HEARTH FURNACES	
MAURETANIA	SAFA at NOUADHIBOU	14/36 000 t/year with one EAF	
LIBYA	LIBYAN METAL INDUSTRIES at TRIPOLI	20 000 t/year with two EAF	
ANGOLA	SIDERURGICA NATIONAL at LUANDA	50 000 t/year with one EAF	
GHANA	TEMA STEELWORKS at TEMA	30 000 t/year with one EAF	
KENYA	KENYA UNITED STEEL at MOMBASA	30 000 t/year with one EAF	
TOGO	SOCIETE NATIONALE DE SIDERURGIE	20 000 t/year with one EAF	
OUGANDA	STEEL MANUFACTURE of EAST AFRICA	24 000 t/year with one EAF	
ZAIRE	SOCIETE NATIONALE DE SIDERURGIE at MALAKU	120 000 t/year with one EAF	

NIGERIA	CISCO at IKEJA	36 000 t/year with one EAF	
"	NIGERSTEEL at ENUGU	34 000 t/year with two EAF	
"	BATA GARAWA steel at KATSINA	210 000 t/year re-rolling plant for bars wire rod and merchant iron	linked with WARRI direct Reduction and Steelmaking plant which delivers the billets
"	JOS STEEL at JOS	- idem -	
"	OSHOGBO STEEL at OSHOGBO	- idem -	
IVORY COAST	IMCI at VRIDI	20 000 t/year bar mill	
CAMEROON	SOLADO at DOUALA	40 000 t/year bar and wire rod mills	
MOROCCO	SOMETAL at Casablanca	40 000 t/year bar and merchant iron mill	

Without forgetting:

EGYPT	ALEXANDRIA NATIONAL STEEL: EL DEKHILA	800 000 t/year steel with direct reduction	
NIGERIA	DELTA STEEL: WARRI	1 000 000 t/year of steel 400 000 t/year rolled product with direct reduction	

FIGURE I

MINI ET MICRO-USINES

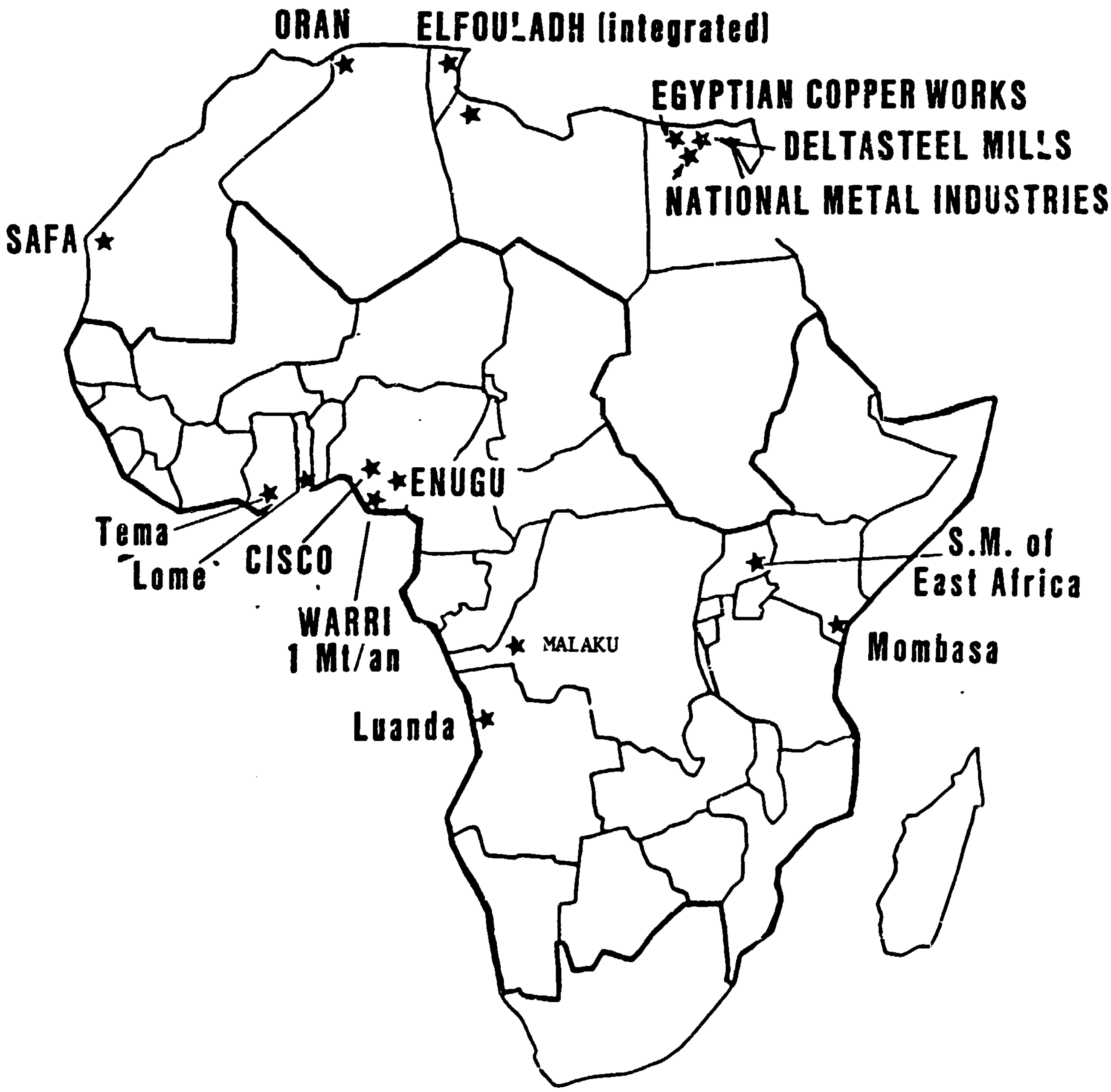
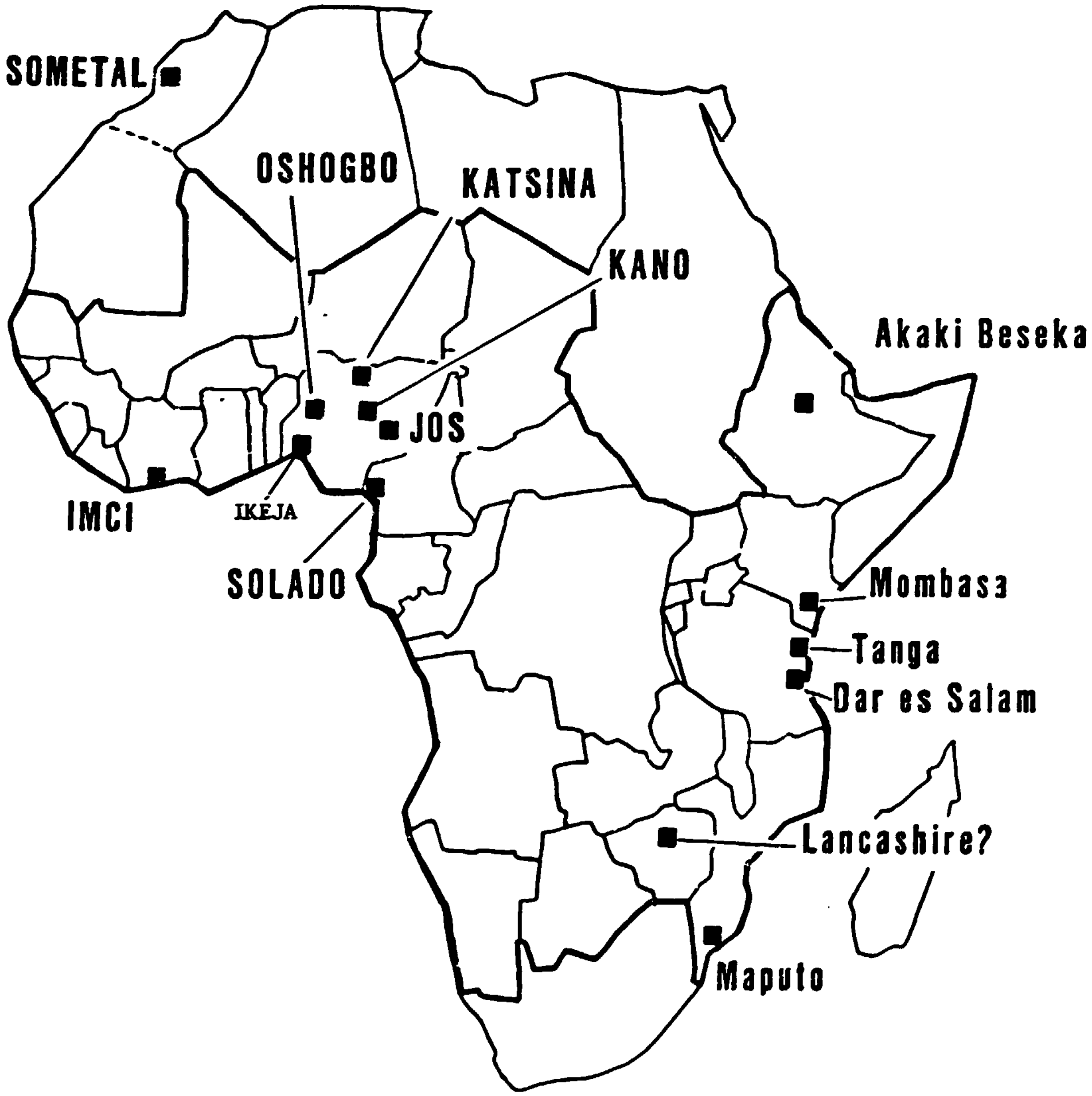


FIGURE II

LAMINOIRS



APPENDIX IX

MINI-MILLS IN AUSTRALIA*, NEW ZEALAND AND SOUTH AFRICA
(From Metal Bulletin 1974)

Country, company	Works	Arc furnace size and capacity (tons)	Continuous billet caster —no. of strands and capacity (tons)	Finishing mill(s) —capacity (tons)	Finished products
NEW ZEALAND					
New Zealand Steel Ltd.(6)	Glenbrook	2 x 22MVA (120–150,000)	1 x 4	Tube only	Billets. Also tubes, galv. strip
Pacific Steel Ltd.	Otahuhu	1 x 40 (100,000)	None	Merchant bar (130,000) Wire rod (140,000)	Rebars, light angles, flats, wire rods
SOUTH AFRICA					
Dunswart Iron & Steel Works Ltd.(6)	Benoni	1 x 45 (150,000) 1 x 20 (70,000) 1 x 15 (96,000) 2 x 10 (65,000)	1 x 4 (260,000)	Section	Bars and sections
Scaw Metals Ltd.	Germiston	1 x 7 SMVA 3 - SMVA 2 x 2 SMVA (205,000) 1 x 50 planned (175,000)	2 x 2 (200,000) 1 x 3 planned (160,000)	Rod/bar (300,000) Merchant bar (64,000)	Rebars, bars, sections, wire rods
Union Steel Corp. (of South Africa) Ltd.	Vaal	3 x 45 (250,000) 3 x 4.5 (25,000)	2 x 4 (240,000)	Section	Bars and sections

* AUSTRALIA: Projects in Queensland