SPECIAL REPORT

Level of costs in the international steel industry

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The production of steel is today increasingly located in the so called Newly Industrializing Countries of the Third World. At the same time the industry is in a period of rapid technological change. This is the background to the following analysis of some important trends in the steel industry.

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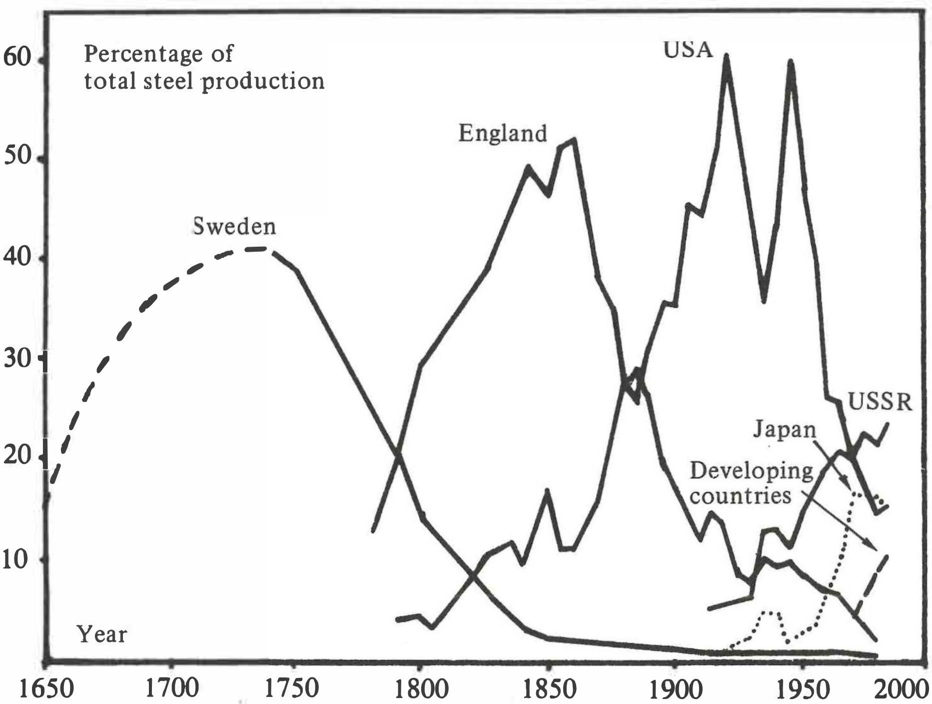
All industrial countries produce steel, and most other countries do too. Today, however, few of them do so profitably.

The reason why so many countries engage in steel manufacture is easy to understand. Metals and metal alloys are the most important group of materials for the manufacturing industry. And for many reasons, ferrous alloys — steels — are the dominant metals in terms of volume. The strength and adaptability of steel in combination with its low price make it a leading construction material. The world produces around 700 million tonnes (Mt) of steel annually. The next metal in terms of production volume is aluminium, with around 15 Mt. In 1980 steel accounted for approximately 70 per cent of the value of the world production of all metals. For the purpose of comparison, the value of plastics and elastomers produced in 1980 is estimated at 20 per cent and the value of ceramics at 1 per cent of the total metal production value.[1] Steel is easily the dominant construction material and is going to remain so for a long time to come.

A country in the process of rapid economic development has an urgent need of steel products for its growing construction and engineering industries (Figure 1). Industrial development and also the building of towns and transport systems demand large quantities of steel. If a country is entirely dependent on imported steel it will find this a heavy burden on its balance of payments, and therefore developing countries try to produce a large part of their needs themselves. Of the volume of steel produced in 1982, 27 per cent was traded between countries[2], as compared with 19.7 per cent in 1970 and 10.7 per cent in 1950.

This being so, why do so few countries produce steel profitably? One of the reasons is that it is difficult to match investments in steel-mills to a gradually increasing domestic consumption. The economies of scale are considerable,

Figure 1
Dominant steelmaking countries, 18th to 20th century



and the investments often result in excess capacity. The marginal costs of exporting are comparatively low, and under normal economic conditions there is a surplus of steel on the world market. It is only for brief periods at a time that shortages occur and peak prices are recorded.

Generally speaking, however, steel prices follow the world economic cycles. Before the oil crises, i e before 1974, the cycle for steel, as for other base industries, was of approximately four years, with one or two good years followed by two or three bad ones.

Since 1974 the cyclical pattern has been less distinct (Figure 2). We have been living through a recession ever since then, with an upward movement in 1979—80, and only now (1984) does a real improvement seem to be on the way. We must hope it will last, even though the steel industry can probably look forward to generally unfavourable economic conditions throughout the 1980s, with no help to be expected from vigorous economic upswings. Cyclical peaks tend to coincide with the US presidential elections and the present one looks like being true to pattern, though the US steel industry in particular will need a very big growth in volume over 1983 if 1984—1985 are to be even normal years.

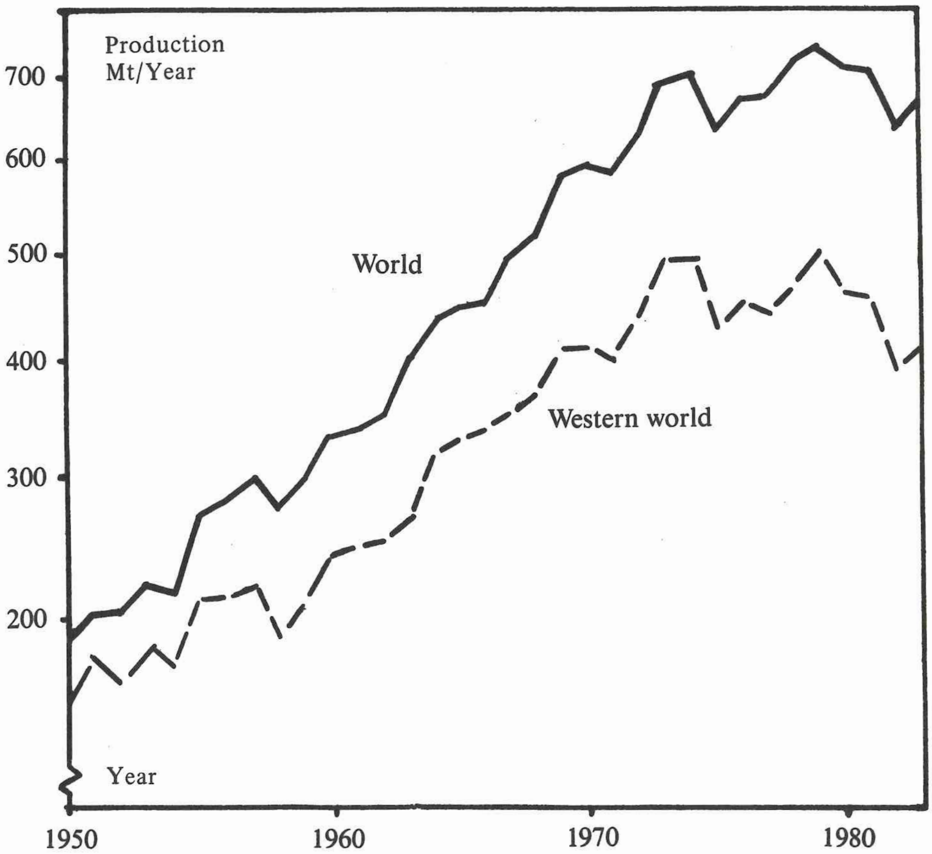
New technology

The steel industry is often reckoned among the "mature" industries with little scope for development. In fact, however, it is not by any means at a standstill, technologically at any rate. Process innovation and product innovation have been progressing very rapidly in the past decade. A competitive steelmill in 1985 is quite different from a competitive steelmill in the early 1970s.

Steel is manufactured today in a single hot stream from the blast furnace, via hot metal refining to remove sulphur and phosphorus, steel making in top-blown and bottom-blown oxygen converters, and steel refining to remove sulphur, gases, and slag inclusions, to continuous casting in "sequences" of thousands of charges in succession. The semis are reheated to rolling temperature — sometimes, indeed, they are not even cooled down to room temperature — and shaped into finished products in high-production rolling mills. Modern blast furnace technology in combination with oxygen steelmaking and continuous casting makes a remarkably efficient process route which, managed by skilled personnel and properly controlled, yields high-quality products at a very low processing cost compared with other metals and base products. This process route accounts for some 80 per cent of the world's commercial steel production from ore. Scrap-based steel production, with a simpler production line using high-efficiency arc furnaces, steel refining equipment, and continuous casters, is quite comparable in cost-effectiveness with the ore-based route.

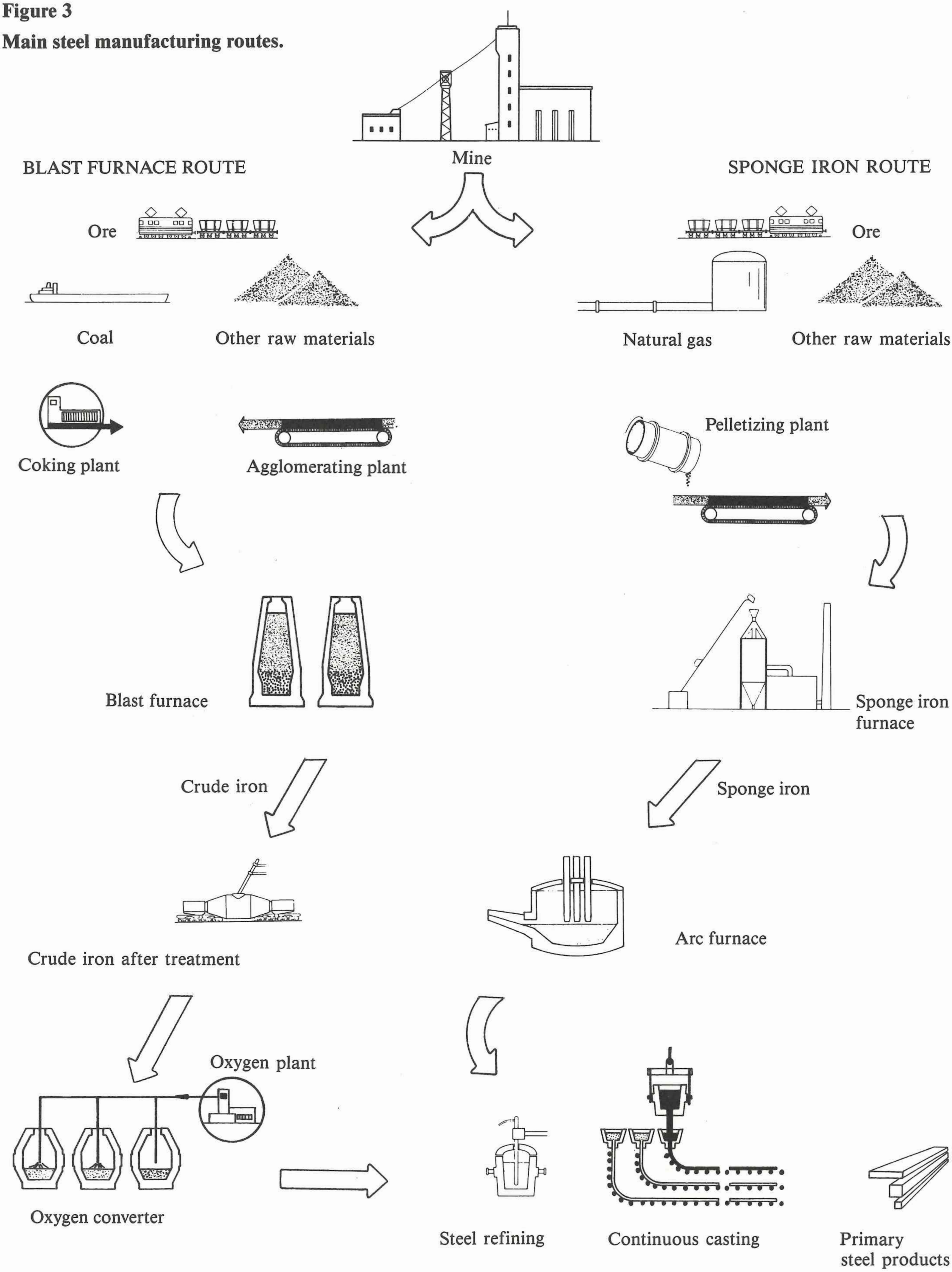
Evolved in Western Europe, the new technology of steel manufacture from ore was developed to its present pitch of efficiency mainly in Japan. Japan was far ahead in the latter half of the 1970s. In the 1980s some West European countries have started catching up. Sweden, with ore-based facilities at SSAB and scrap-based facilities at this and other mills, e g SKF Steel, has worked its way up to a good position in the high-technology field that economical steel manufacturing has become today. The USA and USSR, surprisingly enough, have dropped behind. Still, the USA at

Figure 2
World crude steel production 1950–1983



Source:
World steel in figures (and previous issues), IISI, Brussels

Figure 3
Main steel manufacturing routes.



least is now modernizing its own commercial steel industry at a rapid pace, though in 1983 only 31 per cent of its output was being continuously cast. In the USSR 12.4 per cent of steel was produced by continuous casting in 1983. In Sweden in the same year, 80 per cent of all steel and 100 per cent of commercial steel produced was continuously cast.

The main technological choices available for steel manufacturing today are outlined in Figure 3. In all cases, the steel-making units followed by continuous casters. If a country possesses suitable iron ore and coking coal, the obvious choice for large-scale steel production will be the blast furnace route. Given suitable iron ore and cheap natural gas, it will be the sponge-iron route. Steelmaking from scrap is the simplest metallurgical processing route and is used in all countries.

A country that wants to start manufacturing steel often begins by buying semis for rolling, and then progresses to making its own semis by scrap melting. If it has iron ore resources of its own or if the home market is big enough for operations on a scale that will justify the importing of ore, the blast furnace or sponge-iron route will be chosen, depending on whether coal or gas is the cheaper energy source. In some cases, coal-based sponge iron may be feasible.

New steel producing countries

The developing countries began expanding their steelmaking operations in the 1960s and 1970s. After an initial phase devoted to the development of consumer products, a country will enter a stage where it requires steel in large quantities for the construction of towns, means of transport, and industry. In the past decade, steel production has been growing faster in the developing countries than in the industrialized countries, as will appear from Figure 4. The developing countries have increased their production by 180 per cent since 1971, while the production volume in the industrialized countries has been nearly unchanged. The countries of Eastern Europe occupy an intermediate position with an increase of around 40 per cent.

The allocation of countries to different categories in this figure conforms with that used by the International Iron and Steel Institute (IISI) of Brussels in its statistics of world steel production, namely:

Industrialized countries:
Western Europe, USA, Canada, Japan, South Africa, Australia, New Zealand

Planned economies:
USSR and CMEA, China, North Korea

Developing countries:
Other countries, i e Latin America, Africa (except South Africa), the Middle East, Asia (except Japan, China and North Korea)

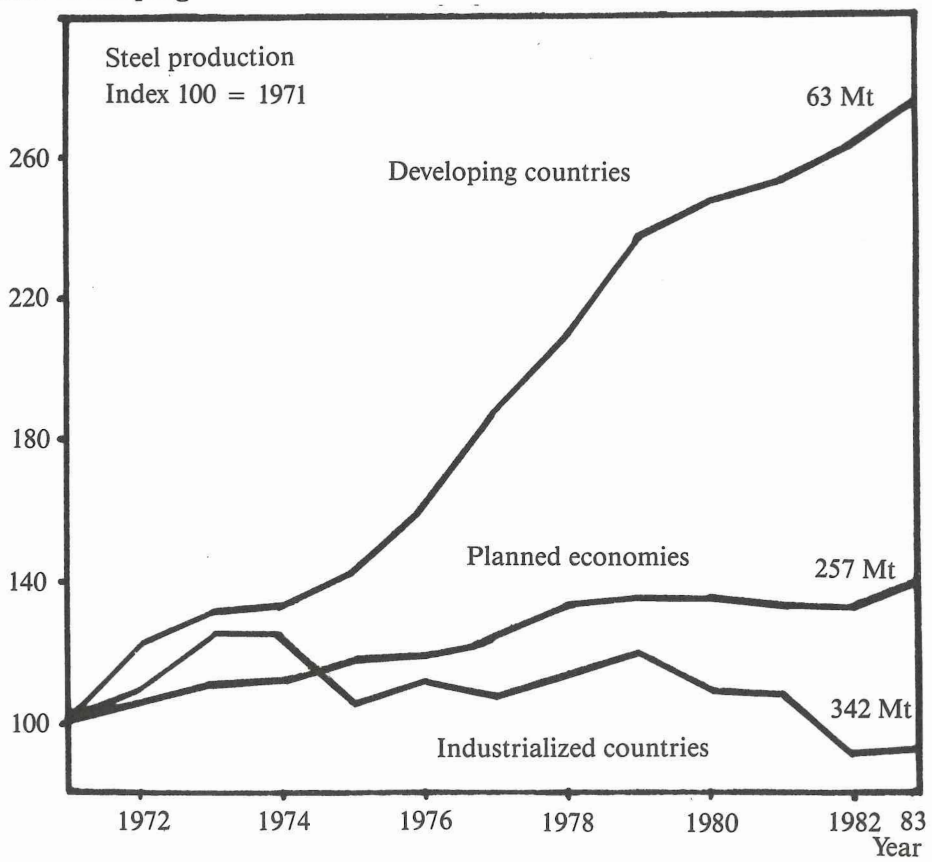
Thus IISI includes among developing countries what are usually termed the Newly Industrializing Countries (NIC), such as South Korea, Taiwan, Mexico, Venezuela, Brazil and Argentina, which have come quite a long way on the road to industrial development. In the NIC group, Brazil produced 14.7 Mt of crude steel in 1983, South Korea 11.9, Mexico 7.0, Taiwan 5.0, Argentina 2.9, and Venezuela 2.3, or altogether 43.8 Mt or 69 per cent of the total of 63.4 Mt produced by all the developing countries.

In 1982 the production of the newly industrializing countries in the western world was 41.3 Mt, which was 68 per cent of the total produced in the developing countries.

The implications of the production growth in the developing countries for these countries' self-sufficiency in steel

Figure 4

Changes in steel production in industrialized countries, planned economies, and developing countries



are shown in Table 2. Taken as a group, the developing countries have raised their degree of self-sufficiency since the mid 1970s from 44 to 67 per cent. However, the growth in the steel consumption of this group has had the effect that their imports of steel, in absolute terms, are still at the level of 35 Mt per year. Probably the economic growth of the developing countries has enabled them to import larger quantities of high-grade steel products (special steels) from the industrial countries.

Although it can hardly be asserted that the export pressure from the developing countries as a group has increased, NICs as *South Korea, Taiwan,* and *Brazil* have built modern facilities that have given them export capacity:

- South Korea, with its highly efficient steel industry, produced 11.8 Mt in 1982 and 11.9 Mt in 1983. With a net export of 2.5 Mt in 1982, South Korea is a serious competitor to Japan on local markets — and even within Japan itself for ordinary products.

- Brazil, with a steel capacity of 20 Mt, produced 14.7 Mt in 1983, up 12.8 per cent on 1982. Brazil's net export in 1983 was 1.9 Mt. By way of comparison. Japan reported a production of 99.5 Mt in 1982 and 97.2 Mt in 1983. Its exports amounted to 29.5 Mt in 1982 and 26.6 Mt in 1983. Japan's production capacity is around 137 Mt of crude steel per year.[3]

The USA is the world's biggest steel importer. It may be interesting to note which countries have had the competitive strength to break into the US commercial steel market. South Korea occupied third place and Brazil fifth place in 1983, with sales of 1.6 and 1.1 Mt respectively, representing increases of 63 and 108 per cent over 1982. Japan is still the leading exporter but has lost 0.86 Mt in sales, while South Korea and Brazil have increased their exports to the USA by a total of 1.3 Mt.

Forecasts of steel production

The steel industry is a slow-moving one, in the sense that capacity takes a long time to build up. Establishment costs are high. In 1984 the process route from ore to rolled products costs 1 200—1 500 USD per annual tonne for a fully integrated "green field" plant with a capacity of the order of 2 Mt per year of rolled products, i e 2.4—3 G USD. An ore-based production plant for rolled steel products takes between six and eight years to plan, build, and run in. Economies of scale are significant, and a 6 Mt plant should be possible to build at a cost of 5.25—6 G USD, or 900—1 050 USD per annual tonne, which gives capital charges of around 165 USD per tonne of rolled steel as against some 225 for the 2 Mt mill. The big economies of scale also tend to make the decision-making process a slow one: who dares to tie up such amounts of capital so far in advance?

In the first half of the 1980s there is a great deal of over-capacity. In 1982 the EEC had an over-capacity of 51 per cent, Japan 40 per cent and the developing countries 26 per cent[4]. This sort of data is no encouragement to tie up large amounts of capital in the modernization and expansion of production capacity.

The industry has to rely on long-range forecasts. These are often prepared by central, authoritative organizations such as IISI. As we propose to compare the competitive ability of different industries on an international scale, we shall reproduce here some forecasts of the world's steel consumption and steelmaking capacity published in 1983.

At the IISI's annual meeting in Vienna in October 1983[5] the Secretary General presented a forecast of steel consumption and steelmaking capacity for 1990. Table 2 shows the predicted world consumption up to 1990 and Table 3 the world capacity. According to this forecast, the western world's steel consumption will increase from 394 Mt in 1983 to 483 Mt in 1990, or by some 23 per cent,

Table 1

Self-sufficiency in steel in the developing countries (incl NICs)

Year	World production Mt	Developing countries production Mt	%	Developing countries consumption Mt	%	Imports[1] Mt	Degree of self-sufficiency[2] %
1974	704	30.6	4.4	68.8	9.7	38.2	44
1975	643	32.6	5.1	69.4	10.8	36.8	47
1979	747	54.5	7.3	92.0	12.3	37.5	59
1980	716	56.8	7.9	93.5	13.0	36.7	61
1981	708	58.2	8.2	97.7	13.8	39.5	60
1982	645	60.4	9.4	92.9	14.4	32.5	65
1983	662	63.4	9.6	95.3	14.4	31.9	67

Source:
Data extracted from IISI statistics.

Notes:

[1] Imports are calculated as consumption less production.
[2] Degree of self-sufficiency is production expressed as a percentage of consumption.

while its production capacity will remain more or less unchanged at today's figure of around 600 Mt, thus reducing the overcapacity from around 50 per cent to around 25 per cent. The developing countries will still have a net import of 35—40 Mt in 1990.

A well-known consultant in the field of steel forecasting, Peter Marcus of Paine Webber Mitchell Hutchins Inc, New York, in April 1983 published another study of the estimated steel consumption in 1990 and 2000. For the world as a whole he predicts an increase in steel demand averaging 2 per cent per year between 1982 and 2000 and a capacity increase averaging 0.57 per cent per year. In 1990 the world as a whole will have a steel demand of 795 Mt and a production capacity of 845 Mt, i e an over-capacity of only 7 per cent, which in practical terms means balance between supply and demand. This balance would subsist to the year 2000, with a consumption of 925 Mt and a production of 932 Mt. The developing countries will require 144 Mt in 2000, i e these countries' net imports will be zero[6].

Thus, according to thes forecasts by authorities in the steel sector, we may expect surplus steel capacity to exist in the world throughout the 1980s at least.

Steelmaking costs in different countries

In order to compare the competitiveness of steel industries in different countries, calculations have been made of steel manufacturing costs in a number of countries in different parts of the world and at different stages of technical development.

The cost comparisons presented refer to liquid commercial carbon steel in the ladle. The cost of steel at this point in the process, some 70—75 per cent of the production cost of the final rolled product, is convenient for comparison. The costs of casting and rolling vary less than those of crude steel manufacture.

Comparisons of the cost of special steels would be very difficult to make, given the great variety in composition. However, a favourable level of costs for the smelting metallurgy part of commercial steel production does place a country in a good position for competitive special-steel production. Pure and cheap iron as base raw material and joint operation with efficient commercial steel facilities will soon be a prerequisite for profitable special steel production. One might point to the development that has taken place in the Japanese steel industry, which in 1983 produced 97 Mt of crude steel, of which 16.4 Mt was special steels. A very high percentage of the special steel is made by the big commercial steel groups in the same facilities as carbon steel[7].

The cost estimates refer to 1983. Those for countries other than Sweden were calculated in dollars. The Swedish figures were converted to dollars at the rate of 1 USD = 7.60 SEK, this being taken as an average rate of exchange for 1983. The estimates are based on real consumption figures and prices for raw materials, energy, labour etc as compiled on visits to leading steel companies in the countries compared. In the case of fixed overhead costs, however, certain schematizations have been made. The capital charges are calculated on the real or estimated capital investment cost of new plants in the country in question, assuming depreciation over 15 years and an interest rate of 15 per cent, which gives a capital overhead equal to 17.1 per cent of the capital investment. To allow for the cost of working capital, a charge

Table 2

**World steel consumption.
Forecast by IISI 1983. Calculated as liquid crude steel (Mt)**

	1980	1982	1983	1984	1985	1990
Western world						
Industrialized countries	365	308	301	326	350	346
Developing countries	98	93	95	92	112	137
Western world total	463	401	396	418	462	483
CMEA	256	201	211	206	263	275
China and North Korea		47	55	53		
World total	**719**	**649**	**662**	**677**	**725**	**758**

Table 3

**Western world's steel capacity.
Forecast by IISI 1983. Calculated as liquid crude steel (Mt).**

	1974	1980	1990
Western Europe	203	223	175-192
North America	156	152	128-146
Japan	126	142	140
Developing countries	33	60	112
Others	15	18	20
Western world total	**553**	**595**	**575-610**

"Over-capacity 1983" ≙ 195 million tonnes ≙ 50 %
"Over-capacity 1990" ≙ 120 million tonnes ≙ 25 %

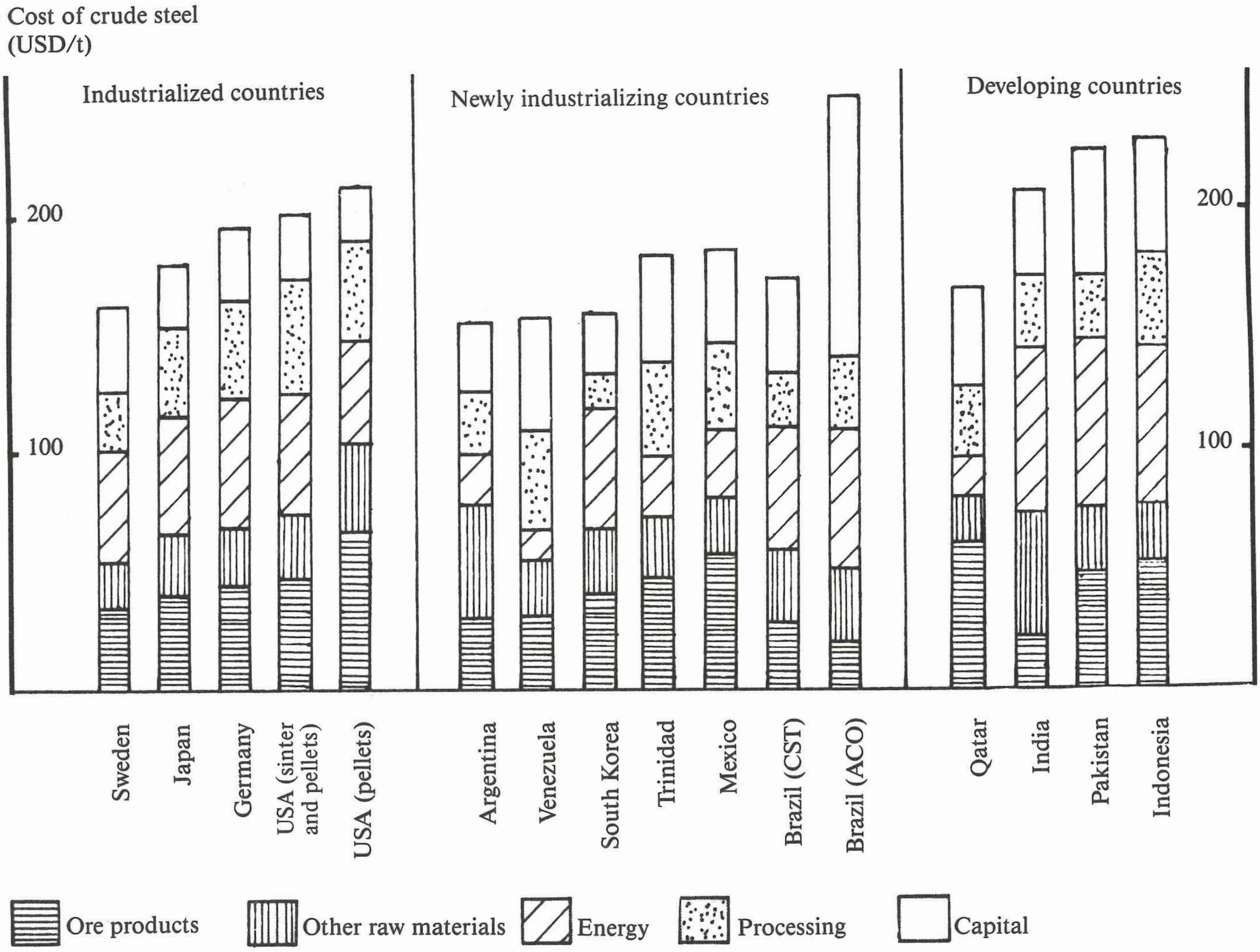
has been made equal to the interest on two months' turnover. Maintenance, internal handling etc has been estimated at 3 per cent of the capital investment plus direct labour costs.

If a country's actual production differs substantially from normal production in an industrial country, a "productivity correction" has been made for capital charges and other costs. Thus, even though certain schematizations have been resorted to for fixed overheads, the estimates are tied to the countries and companies concerned and should reflect the actual cost conditions in these countries. It must be pointed out that the comparisons are made between estimated values, not true plant cost estimates, and that they refer to liquid steel, not a commercial product.

For the purposes of comparison the countries are divided into three groups: industrialized countries, newly industrializing countries, and developing countries (Table 6). In order to shed further light on the cost advantages and disadvantages of steel production in different countries, a histogram (Figure 5) has been drawn showing the proportions between the elements of cost: ore product, other raw materials (including scrap), energy, processing (direct labour, refractories, electrodes, maintenance, internal handling etc), and capital. An estimate has been made of the freight cost to a European port, Rotterdam, to permit comparisons of competitiveness on the

Figure 5

Estimated cost of producing liquid crude steel in selected countries.



continent. Assuming equal casting and rolling costs, we obtain for steel products free Rotterdam the cost differentials shown in Table 4.

Industrialized countries

For industrialized countries, generally speaking, the blast furnace — oxygen converter route is the most economical manufacturing line for an *ore-based* mill. Scrap-based mills have been excluded from the comparison. In most countries scrap melting is made competitive with ore-based steelmaking by means of export barriers and price controls. However, the greater part of the world's steel must still be manufactured out of iron from ore, and the cost comparisons are between ore-based mills using generated scrap and merchant scrap in amounts determined by local practice.

The industrialized countries compared below are the USA, Japan, West Germany, and Sweden.

The *American* steel industry is struggling with serious cost problems due to largely obsolescent production apparatus, very high labour costs, and very expensive domestic ore. Labour costs are in the range 24—28 USD per hour, twice the Swedish level, and pellets from domestic ores of the taconite type cost 60 USD per tonne fob the Great Lakes, as against the Swedish pellet price of around 26 USD per tonne fob Luleå. Moreover, American pellets are of poor quality compared with Swedish and

Table 4

Cost comparison: Crude iron/sponge iron, liquid crude steel, steel freight.

Country	Country's production 1983 Mt	Processing route[1]	Size of mill Mt	Crude iron/ sponge iron USD/t	Liquid steel in ladle USD/t	Freight to Rotterdam[2] USD/t	Differential at Rotterdam[3] (Sweden = 0) USD/t	Remarks
Industrialized countries								
Sweden	4.21	BF-BOF(C)	1.5	128	162	10	0	Coastal mill. Pellets.
USA	75.6	BF-BOF(C)	5.5	158	200	16	44	Coastal mill. 75% sinter, 25% pellets.
		BF-BOF(C)	5.5	182	211	18	57	Great Lakes. Pellets.
Germany	35.7	BF-BOF(C)	4.0	157	195	5	(28)	Ruhr. 75% sinter, 25% pellets. Freight addition improper.
Japan	97.2	BF-BOF(C)	8.5	138	180	30	38	Coastal mill. 100% sinter.
Newly industrializing countries								
South Korea	11.9	BF-BOF(C)	8.5	124	157	30	15	Coastal mill. Sinter.
Brazil	14.7	BF-BOF	3	137	172	20	20	Coastal mill. Sinter.
		BF-BOF	2.	192	248	27	103	Inland mill without harbour. Sinter. True capital investment costs.
Mexico	6.9	DR-EAF	1	108	184	25	38	Inland mill without harbour. Pellets.
Argentina	2.9	DR-EAF	1	106	154	22	5	River harbour. Pellets and lump ore. 46% scrap in steel manufacture.
Venezuela	2.3	DR-EAF	1.8	72	157	19	4	River harbour. Pellets.
Trinidad	0.22	DR-EAF	0.7	102	181	17	26	Coastal mill. Pellets and lump ore.
Developing countries								
India	10.3	BF-BOF	4.	140	207	32	66	Inland mill without harbour. Sinter and lump ore. True capital investment costs.
Pakistan	0.50	BF-BOF	1.1	177	224	22	74	Coastal mill. Sinter and lump ore. True capital investment costs.
Indonesia	0.80	DR-EAF	1.6	124	227	26	82	Coastal mill. Pellets.
Qatar	0.47	DR-EAF	0.45	101	167	23	18	Coastal mill. Pellets.

Notes:

[1] BF = blast furnace — oxygen converter; BF-BOF(C) = blast furnace — oxygen converter, combined blowing; DR-EAF = sponge iron — electric furnace.

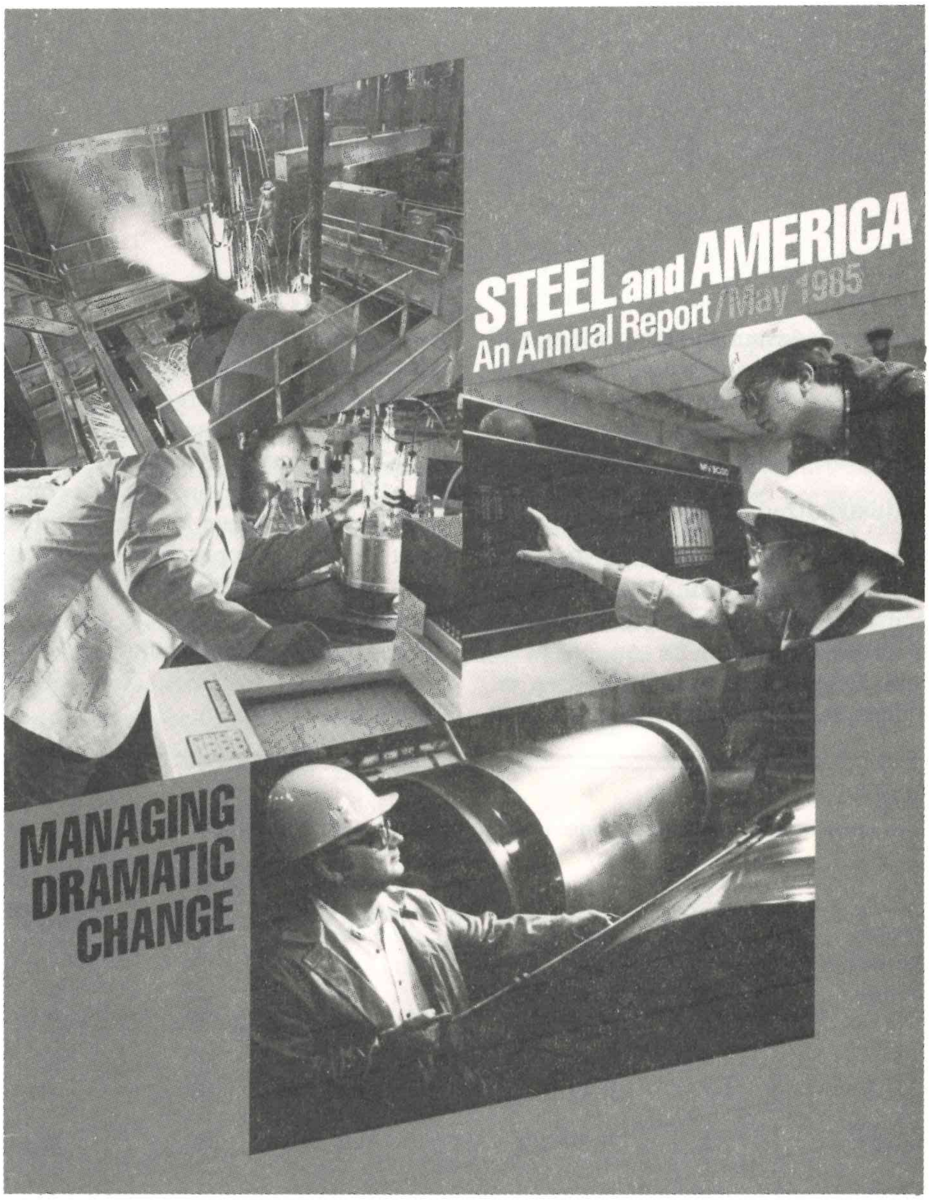
[2] Carrier size 17 000—20 000 dwt.

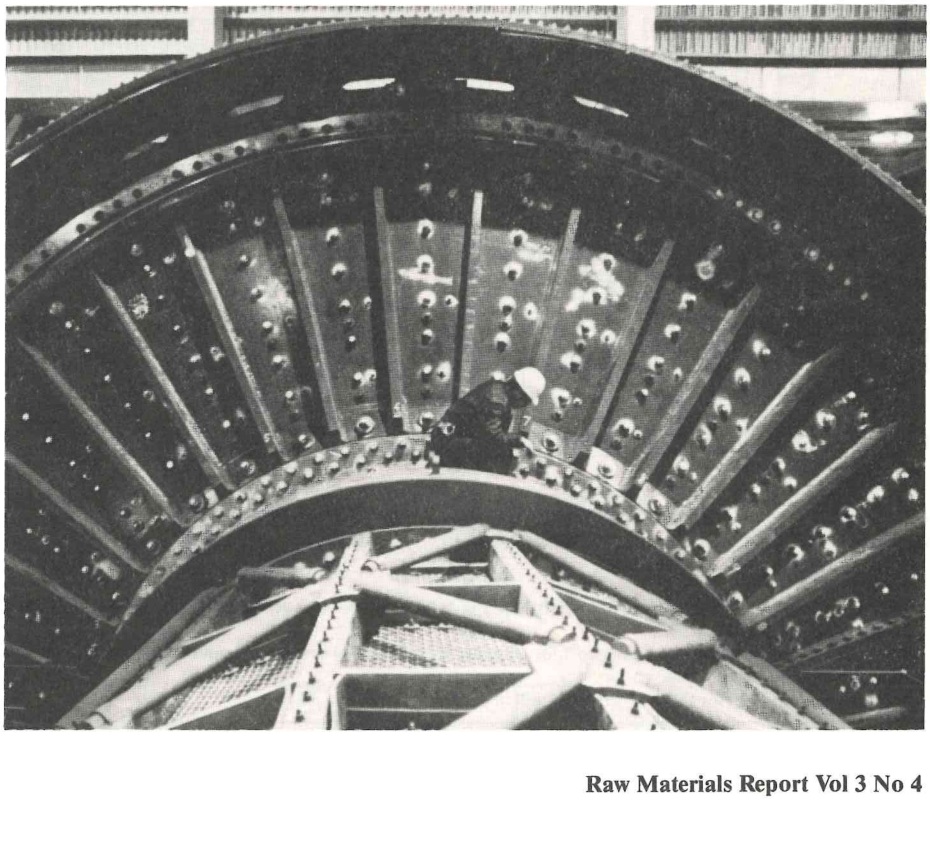
[3] Assuming the same casting and rolling cost for all mills, the differential cost at Rotterdam is obtained as the difference between the sum of crude steel and freight costs for the Swedish and the foreign mill.

[4] Estimates refer to 1983 for the most efficient mill in each country.

The crisis of the US iron and steel industry is reflected in the cover of the 1985 Annual Report of the American Iron and Steel Institute.

Crude taconite is upgraded from approximately 23 per cent iron to 64 per cent at Hibbing Taconite. The concentrate is then used for pellet production.





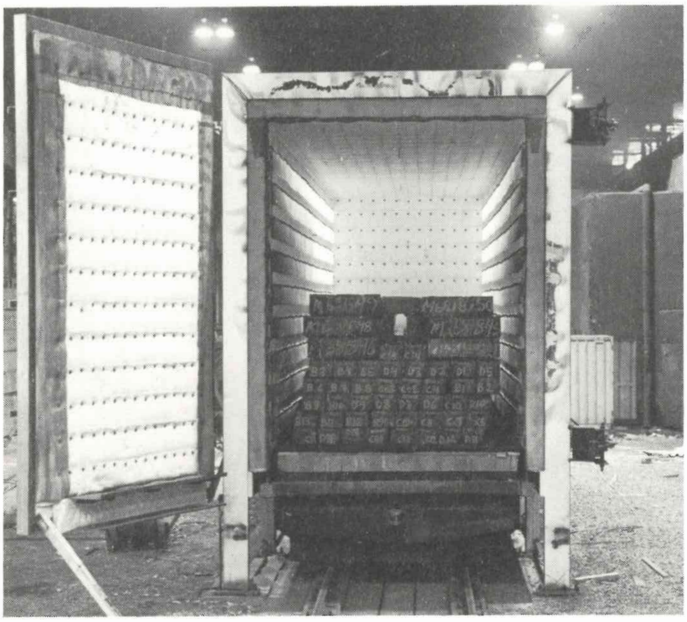
other pellets. The acid, high-quartz American pellets are difficult to reduce and require large additions of flux. The USA is represented in Table 6 by a mill on the Great Lakes using 100 per cent pellets in the blast furnace burden and an addition of 300 kg scrap in steel manufacture, and by a mill located on the Atlantic coast using 3/4 sinter and 1/4 pellets in the blast furnace burden and 175 kg scrap addition.

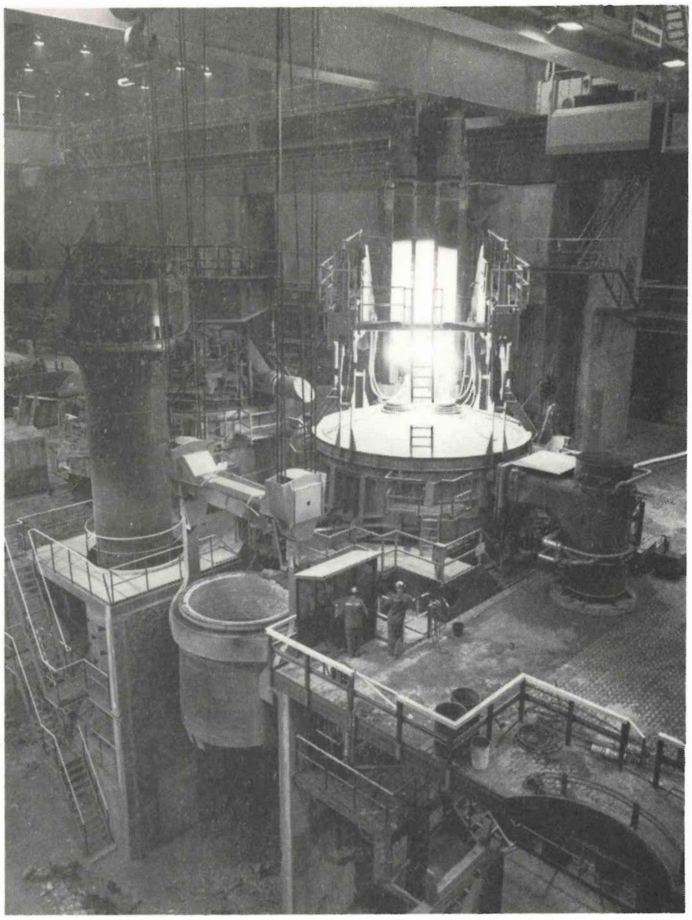
The sinter used by the latter mill is assumed to be made from concentrates imported at world market price and the pellets are assumed to be from Canada. The cost of steel at the inland mill is around 8 USD (4 per cent) higher than at the coastal mill.

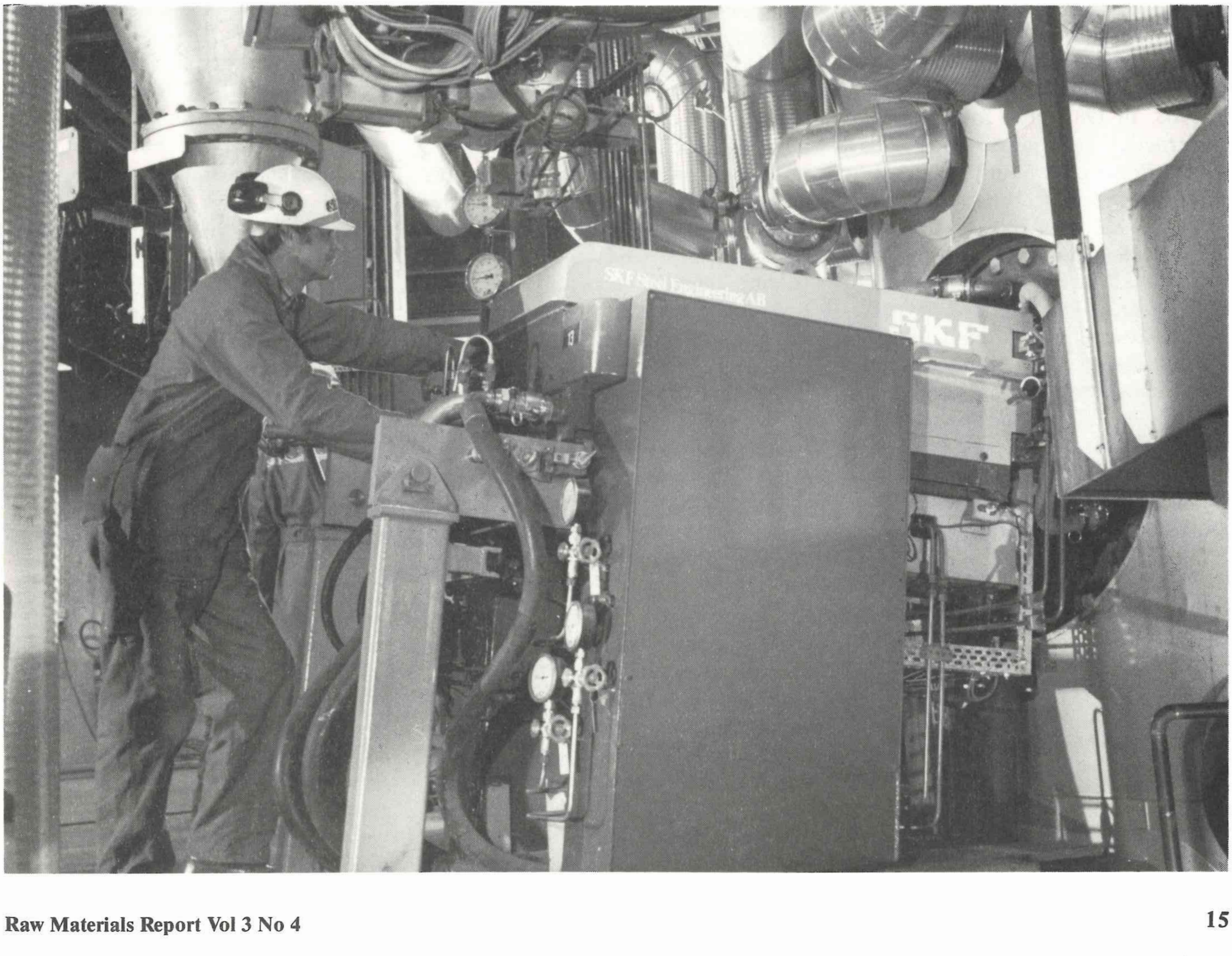
The *Japanese* steelmills depend on imports for 99 per cent of their ore and 91 per cent of their coal needs. The big groups of companies try to keep down the prices of ore and coal by pooling their purchases, but the long sea carriage inevitably has an effect. Japanese steel manufacturing costs are now higher than those at modern European mills. The orebased mills in Japan reported losses in 1983. Even in their own sphere of interest, Southeast Asia, and actually in Japan itself, the mills encounter hard competition in the commercial steel market from NIC countries such as South Korea and Taiwan. Japan's production volume is not being expanded today, all efforts being devoted to rationalizations and to improving the quality of production.

West Germany, taken alongside Sweden as the representative of the European steel industry, has production plants of varying quality. Eighty per cent of the total 1983 production of 35.7 Mt was blast furnace based. The costs shown in Table 6 refer to a modern plant in the Ruhr district with 73 per cent sinter in the burden, the rest being pellets and lump ore. The ore is purchased at international prices. The scrap addition in steel manufacture is 175 kg. Domestic

The diffusion furnace at SSAB, Luleå (top left).
The double furnace at SKF Steelworks No 4, Hofors (top right).
One of three 6 MW plasma generators at SKF Scandust, Landskrona.







coal is used for coking. The cost of the steel is a little higher than in Japan but a good deal lower than in the USA.

Newly industrializing countries

Many NICs have such cheap supplies of natural gas that the sponge iron — electric furnace route is preferable to the blast furnace route. The NICs chosen for comparison here are South Korea, Brazil, Mexico, Venezuela, Argentina and Trinidad, the last four being represented by sponge iron based plants.

South Korea is among the most expansive of all the NIC countries. The development of the country's infrastructure over the past ten years and the vigorous growth of its automotive and shipbuilding industries have been accompanied by heavy investments in a domestic steel industry. Pohang Iron and Steel Co (POSCO) was established in 1968. In 1981, after four phases of construction, the company completed a mill at Pohang on South Korea's west coast, which with a crude steel production of 8.4 Mt in 1983 occupied eleventh place among the world's biggest steel enterprises. The Pohang plant is a highly efficient, fully integrated blast furnace based mill incorporating the latest of West European and Japanese technology. Labour costs are low: workers earn around 330 USD a month. Ore is imported from Australia (40 per cent), Brazil (35 per cent), and India (20 per cent); coal from Australia (40 per cent), Canada (26 per cent), and the USA (19 per cent). Production consists mainly of flats but also wire and bar. Thirty per cent of production is exported, mainly to Southeast Asia. POSCO is at present constructing a fully integrated mill at Gwanyang. Stage I, to produce 2.7 Mt per year, is to come on line in March 1988. Gwangyang is to make a range of products rather more advanced than those made at Pohang.

Thanks to domestic natural gas resources and often also convenient access to suitable ore, several Latin American countries enjoy favourable conditions for sponge iron production and have been taking advantage of them to an increasing extent in recent years. Altogether Latin America accounts for more than half of the world's current output of sponge iron. The greater part of the sponge iron produced is used in the same country for steel manufacturing. Virtually all sponge iron production in Latin America is based on natural gas. Mexico and Venezuela have the biggest production capacities.

The conditions for the production of iron and steel in the Latin American countries dealt with herein are briefly as follows:

Mexico possesses ore resources of the order of 500 Mt. The deposits are rather small and the ore has to be concentrated before it can be used as burden in the blast furnace or sponge iron plant. The Government-owned blast furnace based mills will probably get most of their ore from their own mines for at least the next 15—20 years, while the direct reduction plants will experience an increasing import need if their production volume develops according to plan. Coking coal exists only in small deposits of poor quality in northern Mexico. A large part of the coal requirement is imported. On the other hand, the country is very rich in natural gas: the total resources in 1980 were 1,700 billion cubic metre (Gm^3), equivalent to some 40 per cent of Latin America's natural gas reserves. The annual gas production was equal to somewhat over one per cent of the country's resources in 1979.

Venezuela's own ore resources amount to around 2,000 Mt assaying over 55 per cent Fe. With present beneficiation methods, however, the ore products contain around 0.1 per cent P. Venezuela has extensive oil and natural gas resources. The latter were estimated in 1980 at 1,200 Gm^3 or approximately 30 per cent of Latin America's total reserves. The annual production in 1979 was around one per cent of the country's resources.

Trinidad lacks ore resources but has comparatively large amounts of oil and natural gas. In recent years natural gas has been of growing importance to the country's economy and resources are currently estimated at 500 Gm^3.

Brazil has rich iron ore deposits that are mainly concentrated in two areas, Minas Gerais with about 24 billion tonnes (Gt) of payable ore and Carajás with about 18 Gt assaying 66 per cent Fe on the average. The ores are of haematite type, low in phosphorus, and yield lump ore and sinter fines of high quality. Currently known oil and gas deposits are very small in relation to the size of the country. Coking coal is present in only small, low grade quantities, but there are good supplies of non-coking coal, around 10 Gt according to a 1979 estimate. The country also has the resources for cheap charcoal production.

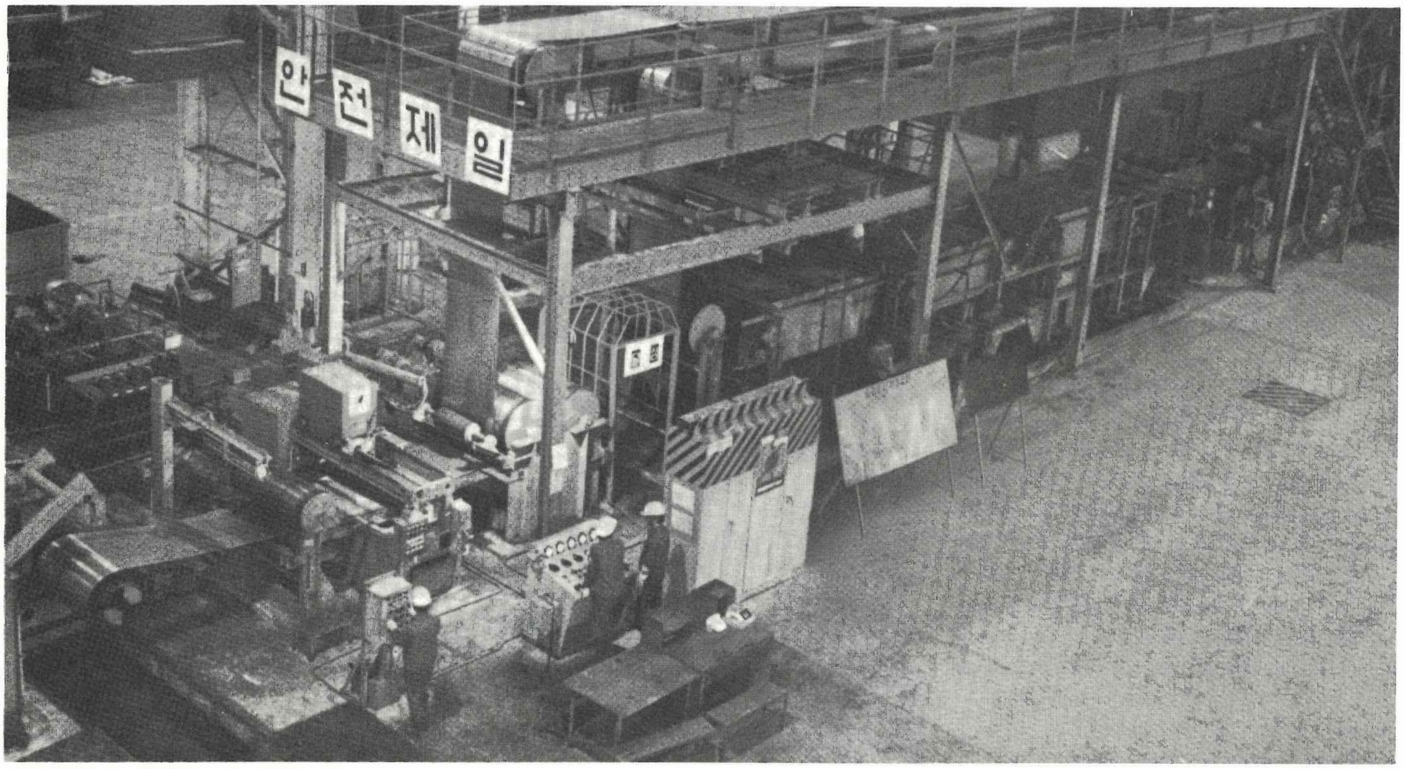
Argentina has ore resources totalling approximately one billion tonnes. However, the country's present iron ore production, from the Sierra Grande mine, is not very suitable for sponge iron manufacture due to its high phosphorus content, and therefore ore for sponge iron making is imported from Brazil. The country has relatively good supplies of oil and natural gas. The natural gas reserves were estimated in 1979 at around 400 Gm^3 and the annual production is about 2 per cent of this quantity.

The countries mentioned above accounted in 1983 for 95 per cent of Latin America's crude steel production of 29 Mt. The efficiency of the Latin American facilities varies rather widely:

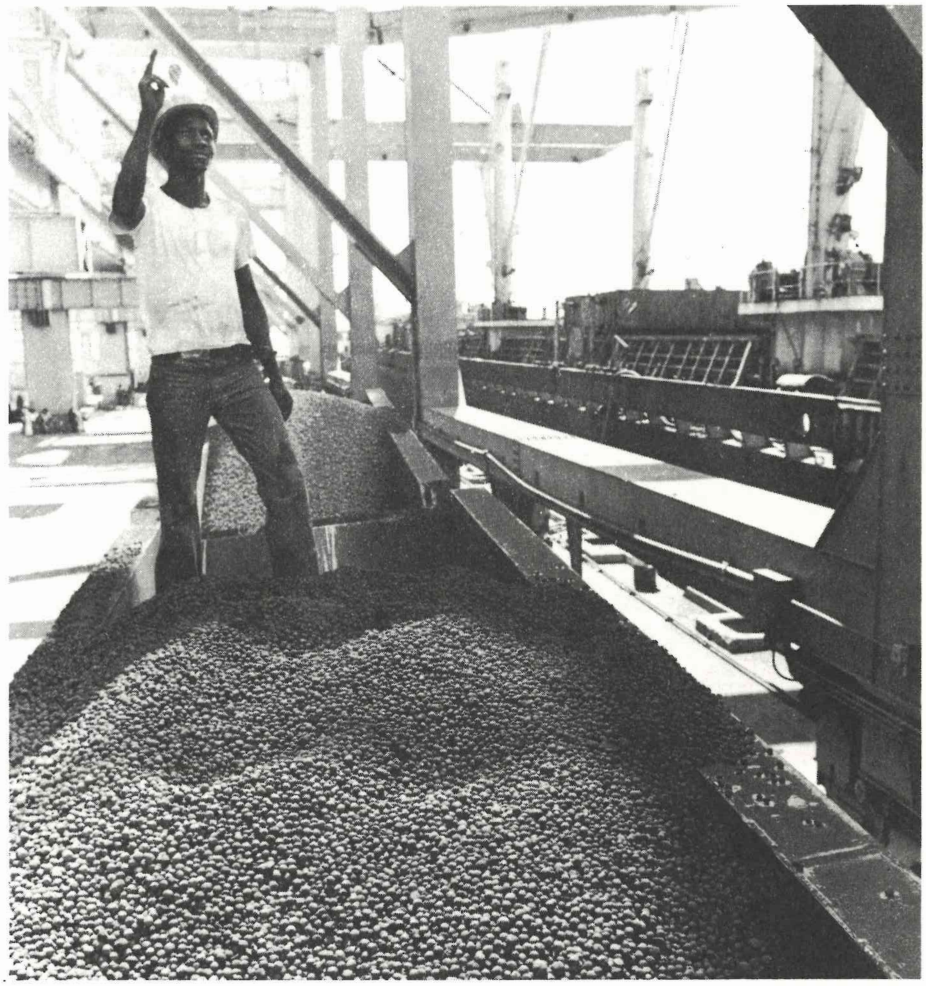
- ACINDAR, a sponge iron and scrap based mill in Argentina, is fully comparable with West European mills. Argentina's blast furnace based mills, on the other hand, are of poor standard.
- ISCOTT, the first integrated steelmill

From the silicon steel mill, completed in November 1979, of Pohang Steel Co, (POSCO) in South Korea.

Stripping at the Aguas Claras iron ore mine of Mineracoes Brasileiras Reunidas (MBR) in Brazil. The major part of the high quality ore is exported.



A load of sponge iron at Siderúgica del Orinoco, SIDOR, Venezuela.



in Trinidad, completed in 1981, is of good standard but can probably achieve better productivity.

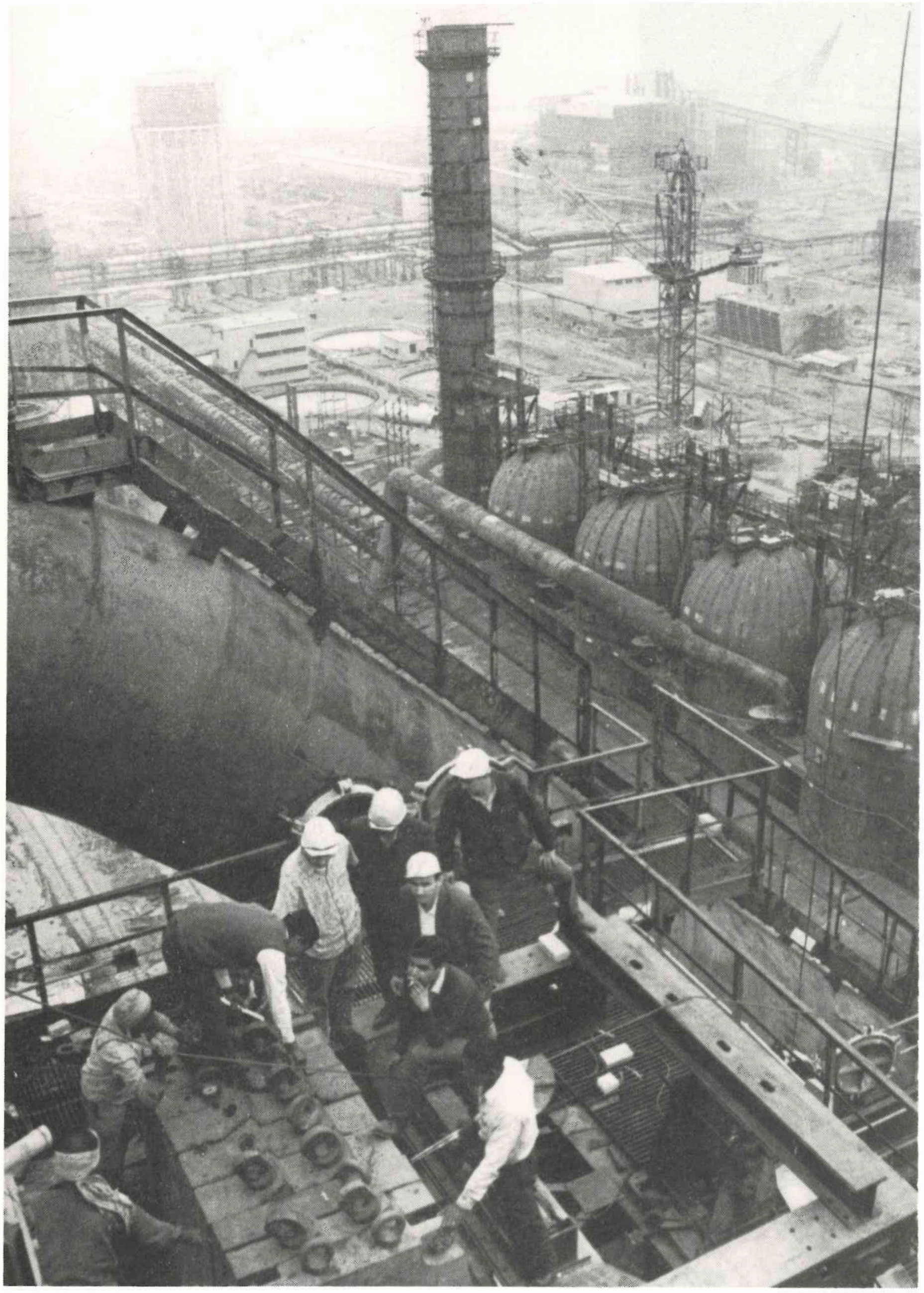
- HYLSA's steelmill at Monterrey, which serves as an example of the Mexican steel industry, was built in the 1970s and displays a barely middling standard of production. Due to a long railway haul the mill is handicapped by high ore costs even though it owns its own mines.
- SIDOR in Venezuela has low productivity and quite high steel costs considering its notable natural advantages in the form of cheap ore and energy. The 200 ton furnaces at SIDOR, the country's biggest steelmill completed in the early 1980s, are at present producing less than ACINDAR's 100 ton furnaces.
- Tubarão in Brazil is a coastal mill (built in collaboration with a Japanese and an Italian company), scheduled to reach full production in 1984, and Açominas, an inland mill currently under commissioning. The inland mill had a very high capital investment cost and a long construction time which, however, probably reflect the problems typically encountered by developing countries when building green-field plants under domestic management.

A factor that is obviously decisive in order for a new plant to quickly attain good productivity is the availability in the country of personnel with experience of process industry or the like. Trinidad, for example, has had a petroleum industry since the 1910s and the development of its steel industry was swift. On the other hand, major labour problems have been experienced in the rapid industrial expansion in the Puerto Ordaz region of Venezuela. Mexico's steelmills are having similar problems.

Developing countries

The developing countries are represented by two examples of blast furnace based production, India and Pakistan, and two examples of sponge iron based production, Indonesia and Qatar. It may be pointed out that India is also building sponge based mills of the rotary furnace type (coal-based sponge iron) — electric furnace, which are capable of producing steel at the same cost as the blast furnace route in that country.

The blast furnace mill that serves as an example for *India* was built to the Soviet pattern, like the mill in *Pakistan,* and the equipment is almost exclusively



The Indian iron and steel-works at Bokaro were built with assistance from the USSR. Photo shows Indian and Soviet experts at work during the construction of the blast furnace.

of Soviet design. The plants took about 10 years each to build and construction and commissioning were carried out with the aid of Soviet experts. Neither of the mills has reached full production yet and both have high running costs and capital charges. Production at the Pakistani mill is based on ore and coal imported at world market prices. The Indian mill has local iron ore and coal. The ore is of good quality, but the coal has a very high ash content, resulting in large quantities of slag and high coal consumption in the blast furnaces.

The sponge based plant in *Indonesia* has high gas consumption and low productivity. Notwithstanding cheap natural gas, the production costs are very high. The ore is imported pellets with high freight costs. *Qatar* has a modern sponge iron mill of Midrex type, built by Kobe Steel and still being run under Kobe's supervision. Production costs are comparatively low thanks to high productivity and low gas price.

Summary and conclusion

It will be seen from Table 4 and Figure 5 that in 1983 steel could be produced in an industrialized country like Sweden at a cost that could only be beaten by the best mills in Argentina, Venezuela and South Korea. The Argentine plant achieves low costs through cheap natural gas, electricity, and labour, a high proportion of scrap, and skilful use of facilities. The Venezuelan mill owes its low costs to exceptionally cheap ore and natural gas. South Korea's competitiveness can be attributed to a very large mill with cheap and efficient labour.

However, if for the purpose of argument we increase the cost of liquid crude steel by the freight for rolled steel products to a European continental port, eg Rotterdam, steel from the best mills in Venezuela will be 2 per cent, in Argentina 3 per cent, and in South Korea 9 per cent more expensive than steel from Sweden.

If we had chosen to compare rolled products, it is probable that Japan would also have shown lower ex-works costs than Sweden. We still have some way to go before we can catch up with the Japanese in the matter of rolling costs. With today's freight costs, however, the Japanese are no longer competitive in Europe, at least with commercial steel. South Korea has also withdrawn from the European market in 1984. Argentina and Venezuela have never been a factor on the steel export market, though Venezuela — and Trinidad — have exported sponge iron to Europe.

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